CHAPTER 1. INTRODUCTION

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1.1 Background and building concepts of Industrial Ecology

Over a period of time industrialisation has grown rapidly and has increased productivity, wealth and prosperity of the nation. However, this has also added a lot of unwanted externalities. One of the concerning externalities lingering across the world is pollution caused by these industries. The departure of various unwanted wastes in the form of gas, liquid and solid has led to the contamination of different environmental segments like atmosphere, lithosphere and hydrosphere.

In the light of above, it has become therefore, an urgent need to foster a new integrated industrial planning and management mechanism. Industrial Ecology/Ecosystem (IE) or Industrial Symbiosis (IS) is one such emerging concept in the evolution of environmental management paradigms (Ehrenfeld, 1995) and springs from interests in integrating notions of sustainability into environmental and economic systems (Ehrenfeld, 1995).

Industrial Ecology (IE) refers to the study of industrial activities to reduce, recycle, reuse, repair and recover the by-products thereby reducing the adverse environmental impacts (Graedel, 2002; Frosch and Gallopoulos, 1989; Ayres and Ayres, 1996; Graedel and Allenby, 1995). The concept of IE was first introduced in the year 1989 by Robert Frosch and Nicholas Gallopoulos of the General Motors Research Laboratory at Michigan. Since then the industrial development has entered into a new perspective and process system. IE states that industrial complexes should be designed to diminish the conflict between two systems i.e. the industrial subsystem; and the natural (mother) ecosystem, on which the entire industrial activities are dependent and imitate the natural ecosystem as closely as possible (Garner and Keoleian 1995).

An industrial process is composed of its own life cycle which constitutes of resource utilization process, primary process, complementary process and ultimately recycling and disposal (Graedel and Allenby, 2010). Even though every industrial life cycle process deals with the use of resources with an efficient implementation of technology and their interactions but at the same time it should also be linked with the impacts on social and environmental aspects (Barata, 2009). Past literature shows that there is a great deal of ignorance in regard to the impact of industrial activity on social and environmental aspects. This might be due to the lack understanding of the concept of IE.
Among several industrial categories, sugar manufacturing industry is one of the core examples of an initiative towards Industrial Ecology (Zhu et al., 2007). Empirical researches on sugar industry are considerable to confirm an evolutionary change in the implementation of technologies which can lead to a sustainable sugar industrial ecology. Graedel and Allenby (2010) have argued that IE should be linked with the relationship between society, environment and economy. Such practices are seen in China, Egypt, Brazil and South Africa. However, in Indian context there is a paucity of literature regarding industrial ecosystem for both agro based as well as non-agro based industries.

1.2 Importance of the Study
The present study focuses on the adoption of technologies (concerning production, energy and waste treatment and management based technologies) which has led to overall sustainability in the sugar industry. It is well known that sugar industry is bound with several regulations and policies which are essential for sustaining the industry. In the past, sugar industry has been a cause of concern in India due to its high energy requirement, waste generation, and environmental pollution. Hence, there is a paucity of research concerning development of industrial ecology model of sugar industry in India. This study thus undergoes exploration of the sugar industries in the sugar belt area and outlines the industrial ecology concept related to sugar. The study also comes up with a model for the sustenance of the sugar industry.

1.3 Motivation of the research
Industries, in the recent times, have started to realize that growth cannot happen alone by taking financial aspects or profit margins into account but essentially needs to inculcate the three pronged approach of sustainability (social, environment and economic parameters) in their actions for the overall development. The concept of reuse, recycle and recovery can benefit the industry and sustained its existence with the proper implementation of suitable technologies. This requires developing awareness among the concerns about the concept of Industrial Ecology. Sugar Industry, being one of the largest industries in terms of numbers and magnitude can sustain in future only through the concept of IE. It is well known that sugar industry consumes large quantity of water and emanates waste on grand scale. This has led to increase in the environmental pollution to its extreme level. In order to develop a model of sugar industrial ecology, extensive exploration of the industry was carried out. The model has been linked to sustainability concept to obtain long term goals instead of short term commitments.
1.4 Industrial Ecology Issues
Technology is considered as one of the most important aspects for building industrial ecology. Adoption of suitable technology is known to have an effect on sustainability of the sugar industry. In Indian scenario, the implementation of suitable technologies for promoting IE is lacking. Therefore the barriers of technology adoption need to be studied in detail in context to IE. Furthermore, the factors leading to a sustainable IE also needs exploration. The overall number of industries is very large those who have still not adopted the concept of IE in their activities and practices. Being an agro based industry; there is immense opportunities and scope for sugar industries in India to adopt IE concepts and practices for the betterment of not only to industry itself but also to the environment and society.

1.5 Theoretical view point
It has been realised that a theory based empirical research work in the area of Industrial Ecology is needed. Moreover, exploring research attempts based on Institutional theory is required. There are quite a few research papers, which emphasizes the need to have more empirical based research on Industrial Ecology. Literature review clearly indicates that there is a paucity of research on linkage of Institutional Theory with Top Management Commitment. The linkages between Institutional pressure, Top Management Commitment and Technology Adoption can lead to better and sustainable performance in any industry. In most of the researches, the theoretical model has ignored the theories from the seminal articles. This has led to the present research overcoming the limitations of the past researchers. The variables and constructs have been framed through extensive literature and expert opinion.

1.6 Theoretical framework
Theoretical framework is purely based on the well established linkages between the constructs which has an impact on a Sustainable Practices of Industrial Ecosystem. Six constructs were chosen from the literature review, theories and expert opinion. The construct were well defined and the factors have been selected defining the constructs. Variables from the Coercive pressure, Mimetic Pressure, Normative Pressure, Top Management Commitment, Technology Adoption and Sustainable Practices of Industrial Ecology has been chosen defining the particular construct. The linkage between the constructs has led to the
development of hypothesis. The hypothesis was validated empirically and the results have been discussed in the thesis.

1.7 Research methodology
The main objective of this research is to interlink Industrial Ecology practices with Sustainability. Extensive literature review was carried out to extract the variables for Sustainability of Industrial Ecosystem. The variables defining the concept have been classified into endogenous and exogenous variables. This has led to the development of a theoretical framework. This framework was then validated through Structural Equation Modelling. As discussed earlier, there has been a lack of technology adoption in India scenario thereby leading to Industrial Ecology. The barriers of technology adoption were mined from the literature and the factors have been constructed through Exploratory Factor Analysis. These factors were then further linked to the Technology Acceptance Model.

1.8 Scope of the Study
The focus of this research was to study the Sugar Industries located in Maharashtra State, India with special reference to Pune, Kolhapur, Sangli and Satara districts. The prime aim of the present study was to develop a sugar industrial ecosystem model. The concept of industrial ecology has been discussed in the literature review. Studies of this nature are highly beneficial in the current era of climate change for the sustainable management of wastes and by-products, which if exposed to environment can cause pollution affecting the society and environment. So the major issue of concern in the present study is the sustainability of sugar industry. The scope of present investigation was limited to Maharashtra State because of the presence of large number of sugar industries and several of them have adopted suitable technologies to bring in sustainability.

1.9 Research Limitations
There were certain limitations identified by the investigator – (i) The study is limited to only Maharashtra State as it has got highest number of sugar industries and one of the developed states of India; and (ii) The study is restricted to only sugar industry.

1.10 Thesis chapter plan
The thesis is organized into the following seven chapters. A brief summary of the chapter is given below. References and appendices are additional attachments.
In Chapter One, research motivation, limitations and scope of the study is discussed. The chapter attempts to exemplify the growing importance of Industrial Ecology and Sustainability in sugar industry. The scope of the study has been discussed. Motivation of the study has also been elaborated. The last section of this chapter describes the manner in which the subsequent chapters are organized.

Chapter Two attempts to introduce sugar industry with special focus on reuse and recycling of by-products. The status of sugar industry and production of sugar has also been discussed. An overview of sugar industry in India has also been given in today’s context. In this chapter, history of the sugar industry is discussed and the organization structure of the industry has been elaborated. The chapter proceeds with listing the various by-products that can be reused or recycled to attain sustainability. This chapter also illustrates the growth and importance of the sugar industry in recent years.

Chapter Three focuses on literature review in context to definition of Industrial Ecology. Further, the investigator has introduced the subject of Industrial Ecology and Sustainability. The concept of IE has been related to agro based industry with reference to sugar industry. The research gaps have been discussed in a detail which has concluded to the statement of the problem. Based on the literature gaps research questions were formulated. The chapter also focuses on the distribution of the peer reviewed research papers in journals and the need of the study. The history and evolution of industrial ecology have been discussed in detail. The section has also focused on the input-output analysis and their types. The barriers of technology adoption in enhancing sustainable practices in agro based industries through literature review have been elaborated. At the end of the review, several research gaps have been presented in a tabular form followed by the research questions and research objectives.

Chapter Four addresses the theoretical framework and the hypothesis derived. Each construct of the theoretical framework has been discussed in details. The chapter also elaborates the definition of the constructs and the items included. The items have been presented in a tabular manner with respect to the authors. A detailed discussion has been enclosed regarding the relevance of the construct with the model.
Chapter Five discusses the research methodology in detail. This includes questionnaire development, pretesting, reliability and validity tools and data analytical tools. The chapter discusses the tools for statistical analysis and the mode of data collection. The chapter also deliberates on the measurement instrument development (i.e. questionnaire development). Further, the chapter discusses pilot testing of questionnaire administration. The pretesting and pilot study conducted before final survey is deliberated. A research sampling method has been elaborated to provide insight into research strategies deployed by the researcher to accomplish the objectives of the study. Data adequacy assessment was made and a non-response bias test was conducted.

Chapter Six presents the primary and secondary data analysis. The chapter deliberates on Factor Analysis and its application in barriers of technology adoption. Before proceeding to the data analysis reliability of the data was checked. Normality and outlier test was performed to ensure that Factor Analysis output can be used in performing Covariance Based Structural Equation Modeling. Mediating Regression was used as given by Baron and Kenny (1986). For each of the statistical tools used, their justification of use, advantages, their basic output tables and an explanation of the tables along with their inferences are discussed in detail. The developed research framework was validated empirically and the consequent results are given.

Chapter Seven focuses on the findings and conclusions drawn from the study. It further synthesizes the managerial implications from the study. Various observations from primary and secondary study have also been explained. The summary of the main findings along with suggestions are presented. The chapter also dedicates the novel contributions of the research further extending to limitations of the research and future research directions.

1.11 Chapter Summary
In the present chapter, the background of the study, scope of the study, importance of the study for the sugar industry and motivation of the research is discussed. Finally, the complete outline of the dissertation is discussed. The next chapter will comprehensively give an overview of sugar industry proceeding to review literature to build the conceptual base of the current study. Based on the literature review, the research gaps will be identified.
1.12 Scope for Further Research

The study can be extended to different sectors and a comparative study could be done for the sustainable practices in developing a sugar industrial ecosystem in developed and underdeveloped countries. The study can also be extended to other industries in regards to Industrial Ecology.