EXECUTIVE SUMMARY

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. This process may result into significant economic losses and lead to adverse impacts on health thereby reducing overall human working capacity. Wastes cause detrimental impacts on various life forms which leads to loss of biodiversity and overall ecological balance. This process has resulted to myriad problems ranging from very local level issues (like for example, solid waste disposal) to global issues (like for example climate change). Overutilisation of the natural resources has resulted into a growing interest in the issues like “sustainable development” and “ecological rejuvenation / revival”. One of the concerning issue for sustainable development is to break the linkage between continuous growth of waste and their magnitude of releasing pollutants to the environment. This may reduce the pollution intensity of industrial production. This has inbuilt the policies for reducing the pollution level spanning from local to global level.

Industries with the growing awareness have been trying to adopt the best way to prevent pollution through adopting technologies to reduce the emission of wastes to the environment and zero defects quality which are the integral part of ISO 14001/ Environmental Management System (EMS) to improve environmental performance. However, such practices are restricted to few very large scale industries who are aware of the concept. Unfortunately there are several large scale industries (LSIs) and small and medium scale enterprises (SMEs) which do not have high technology for the production process and waste management. Such industries are mostly located in developing and underdeveloped nations. Lack of space, capital and unavailability of suitable treatment technology, expertise in waste management practices, monitoring and knowledge are dominant in such industries (Patil and Rao, 2015). The concerned question that spews out is - what happens to the waste once they are emanated from the industries? According to Daniels and Daniels (2003) for some industries, waste, time and again is a case of “out of sight, out of mind”. Currently, in most of the developing and underdeveloped countries the waste disposal is done by several methods as given by several authors (Patil, 1999; Patil, 2014; Patil and Paknikar, 2000; Tolentino et al., 1990) which are as follows: (i) storage and/or burial on-site; (ii) direct discharge of untreated
wastes to water courses and land; (iii) discharge of untreated wastes to drains or sewers; (iv) collection and illegal discharge to open land, drains or watercourses; (v) collection and disposal with domestic waste in a solid waste dump site or landfill; and (vi) incineration on-site or off-site. These approaches, nevertheless, are not enough to embark upon the waste problems but only displace the problem from one medium to another. As a result, such mismanaged practices have aggravated the pollution problem and total environment’s health because of inefficient facilities for clean-up and final disposal. There are some other problems as well in developing nations as given by Von Hauff and Wilderer (2000) that can become barrier for environmental protection and pollution prevention practices which are as follows: (1) Relatively low level of education and almost no environmental education which could provide awareness towards environmental protection, (2) Political structures which do not support environmental protection. In this respect, the following aspects can be mentioned: (i) highly bureaucratic structures, (ii) lack of transparency and accountability in decision making, (iii) strong influence of “political authorities” in technical decisions, (v) difficult and complicated methods of procurement; and/or, (vi) lack of transparency and accountability in decision making, (iii) low salary of bureaucrats which provides the ground for corruption.

Economic development has been the issue of top priority as a machine to enhance social prosperity for most of the developing countries. In this process, the environment protection/conservation part was left far behind just for the sake of development (World Bank, 2000). Since now industrial development has rapidly moved in developing countries, particularly Asian countries (and therefore so called ‘factory of the world’), and given the constraints as mentioned in the above section, it is a pressing need to accelerate the need for sustainable development with simultaneous protection of environmental resources.

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 refers to industrial symbiosis where the industries develop a symbiotic relationship among themselves (Frosh and Gallopoulos, 1989; Graedel and Allenby, 1995; Ayres and Ayres, 1996; Graedel, 2002). The sugar industry in India is going through a transition during recent years and therefore the industry is moving towards sustainability.
There is a strong force of Institutional pressure and top management commitment to build up economic, social and environmental sustainability. With the growth of the sugar factory it is essential to adopt better technologies in order to reduce pollution.

The current state of the sugar industry raises several research questions like what are the technology upgradation in the sugar factories? what can be the best measure for sustaining practices in sugar industry? what is the contribution of sugar factory in sustainability? What are the barriers of sugar industry ecosystem?

This research study was identified in terms of a need to conduct a study to identify the best measures of sustainable practices in sugar industrial ecosystem, to find out the technology trends and to analyze the barriers of technology adoption. The study was initiated with an extensive literature review which identifies the factors influencing sustainable practices of sugar industry. The study initiates with exploring sugar industry and their role in sustainability. Three sets of structured questionnaire were developed through literature. The first set constitutes of the basic information related to input output flow in the sugar industry, the second set of questionnaire was related to the barriers of technology adoption and the third set of questionnaire was developed using likert scale focusing on the model.

After the finalization of the questionnaire, the questionnaire was pretested by ten experts. After the successful approval and changes made in the questionnaire the three sets of the questionnaire were finalized. The content and criteria related validity of the instrument was checked. Pilot study was administered to gauge the reliability of the instrument. The final survey was conducted and data from 201 managers were conducted. The sample size was sufficient to conduct Multivariate Data Analysis. A non response bias test was conducted to ensure that the responses of the people, were not significantly different from the other using Wave Analysis as advocated by Armstrong and Overton, 1977.

**Technology Trends**

Sugar Industry has often been facing techno-economic constraints, which has led to unsustainability. Therefore, there has been changing trends in technology adoption in the sugar factories. In today’s scenario, technology has made its place in providing sustainability. The main purpose was to measure technologies used for providing sustainability in and around sugar industry. The trends of technologies used from the year 2000 to 2015 have been discussed in findings and the changing trends have forecasted a better condition. The study was conducted in the sugar factory belt of India that is Maharashtra and is based upon both
primary as well as secondary data. The primary data was collected from 200 sugar factories based on a structured questionnaire. Interviews of managers were conducted from several sugar factories. Quantitative data obtained was analysed through Statistical Product and Service Solutions (SPSS) software. The research findings include the changing trends of technologies used in several factories. As compared to the past, data shows that sugar factories has been a source of severe pollution since long which was reduced through application of suitable technologies. The study has interlinked technology with sustainable health care service.

**Barriers to technology adoption**

Exploratory Factor Analysis (EFA) was used to identify the forty six barriers to technology adoption. These barriers were then scaled down to build six major scales for barriers of technology adoption. These six barriers to technology adoption obtained were - Industrial Policy, Government Policy, Finance and Economy, Technical Skills and Knowledge. These scales were further linked as external and internal variable in the technology adoption model. The framework obtained reflects that technology can be adopted only by the consent and human capital variables like skills and work force planning of agro based industries. The technology and information in agro based industries requires a detail knowledge and training about technologies. The technology policy in the framework is to strengthen the adoption of new technologies in such a manner that they should not create any further environmental disturbances and reduce the effect of the old technologies (Vergragt and Jansen, 1993). The perception of workers is that the new technologies may lead to new environmental problems (Vergragt & Jansen, 1993). A new environmental oriented technology has been explored so that the objectives for a safe and protected environment can be maintained.

The scale developed for the barriers of technology gives further research direction. The model has to be further empirically tested to see the linkage of technology adoption in Industry with the Technology Acceptance Model.

**Model for Sustainable Practices in Sugar Industrial Ecosystem**

The model constitutes of Institutional Theory with Top Management Commitment, Technology Adoption and Sustainable Practices of Sugar Industrial ecosystem. The constructs have been explained in detail in the section of Theoretical Framework. According to Colwell and Joshi (2011), Institutional Theory proposed in recent literature has ignored the role of Top
Management. Therefore, the study has linked Institutional Theory with Top Management Commitment. The literature suggests that more empirical research is required for the application of institutional pressure towards sustainability (Ciulli, 2016; Dubey et al., 2016; Glover et al., 2014; Grob and Benn, 2014). The institutional pressure constitutes of Coercive Pressure, Mimetic Pressure and Normative Pressure. It has been studied through empirical research that 61% of variation in Top Management Commitment is explained by Coercive pressures. This supports the literature which indicates that Coercive Pressure have direct significant effect on Top Management Commitment (Liang et al., 2007). Mimetic pressure copies the extensive form with the uncertainty (Heras-Saizarbitoria et al., 2011; Lawrence et al., 2001). It has been studied through empirical research that 32% of variation in Top Management Commitment is explained by Mimetic pressure. The positive influence on top management participation is also justified in literature (Liang et al., 2007). There has been paucity of research on the exploration of the relationship between Mimetic Pressure and Top Management Commitment. Therefore, the empirical research study explains this relationship. Normative pressures usually permeate through the channels of professional affiliations (Liang et al., 2007), and hence the Normative Pressure has a strong impact on Sustainability (Tseng et al., 2013). It has been studied through empirical research that only 5% of variation in Top Management Commitment is explained by Normative pressures. The literature surrounding Sustainable Consumption and Production has not stressed much on the relationship between Normative Pressure and Top Management Commitment. The empirical research also supports the above statement. Bansal (2005) also found that the two forces of institutional pressure mimetic and coercive were the key drivers in fostering sustainable development.

The efficient application of technology and other technologies can be made only if the technology is adopted for sustainability or in other words it is maintaining a balance between the economic, social and environmental perspective. Technology largely influences the productivity and market growth (Labrecque et al., 2007). It has been studied through empirical research that 69% of variation in Sustainability is explained by Technology Adoption. According to Colwell and Joshi (2013) Top Management Commitment is defined in terms of commitment to reform and capacity for change. It has been studied through empirical research that 68% of variation in Sustainability is explained by Top Management Commitment. It was observed that 87% of variation in Technology Adoption is explained by Top Management Commitment and Technology Adoption acts as partial mediator in the relationship between Top Management Commitment and Sustainability.
This is the first empirical study, confirming predictive relationships between various factors leading to sugar industrial ecosystem model. The research can be considered as a contributor into the ocean of knowledge about Industrial Ecology. Since the research confirms the model and, predictive behaviour of the factors; the future research may be directed at applying the methodology to other concepts with a larger sample size and covering larger location. The study can also be applied to other industrial sectors which are highly polluting.