

AN AWARENESS STUDY ON CIRCULAR ECONOMY IN INDIA

Chandrakant B. Kamble¹, R.Raju¹, R.Vishnu¹

¹Department of Industrial engineering

College of Engineering, Chennai-600 025, India.

cbkamble@yahoo.com, rraju@annauniv.edu, vishnu7raman@gmail.com

ABSTRACT

Waste management is a major challenge faced by many developing nations. This research deals with the awareness study of circular economy in India. The results from the responses to questionnaire survey collected from the individuals working in municipalities were evaluated on the basis of selected awareness and demographic variables and inferences were obtained. Awareness levels were seen as moderate. Recommendations were made based on the inferences after analyses to improve the overall awareness on circular economy that can be used by the people working in the municipalities.

1. INTRODUCTION:

Circular economy is a cyclic process which focuses on increasing the sustainability of a product through identification of reuse of used resources for a product during its various stages, thereby reducing the accumulation of waste dumped in landfills. The primal benefits of circular economy are resource benefits, environmental benefits, economic benefits, as well as social benefits [1]. Waste disposal and waste management till date follow a linear economy model, which inspires a one-time use of a product. As of the year 2019, India generates 62 million tons of municipal wastes each year, of which about 43 million tons are collected, 11.9 million tons are treated and 31 million tons are dumped in landfill sites. An increase of waste generation to 165 million tons is estimated in 2030 [2]. Circular economy focuses on zero wastes or near to zero waste. It became popular from the late 1990's. Since then it has been applied for business, academics and other potential fields [3].

Circular economy is adopted in municipalities and waste management industries of various nations successfully and has gained optimistic outcomes. Circular economy is adopted in waste management due to its features of zero waste, stimulating innovation, environment preservation and new employment opportunities. Successful implementation of circular economy requires the conduct of proper awareness study and identification of essential factors which require attention for circular economy's growth. No proper awareness study regarding circular economy has been conducted in India, till date.

A study identified the flaw in perceiving circular economy as a 3R model while it essentially necessitates a systematic shift [4]. A green supply chain developed in China for reduced E-waste generation had roots with circular economy and sustainability; its focus was on incorporating used E-waste component on a new product [5]. An empirical research on circular economy awareness in China found multitudes of factors like structural factors, cultural factors and contextual factors play a critical role in the creation of awareness of circular economy in manufacturing firms in China. This had eight sub factors which were identified in repetition, they were: employment terms, bottom to top hierarchical involvement in organization, incentives, flexibility and innovation, silos existence, risk aversion of managers and organization's commitment [6]. Another awareness study was done worldwide among the recycling industries and five sub factors seen were investment recovery, Eco-design, Green Purchasing, Customer Co-operation, and Internal Environmental Management [7]. An Awareness study was conducted for construction and a survey was conducted globally and the factors identified were design, manufacturing and supply, construction, in use and refurbishment and end of life [8]. An awareness study conducted in Egypt regarding environmental management systems saw the importance of adapting EMS in improving sustainability and reducing environmental degradation through awareness inferences obtained through an organization [9]. A research in South Africa suggests the sustainability involved in renewable energy based power production and its sustainability practices [10]. The research points out to how circular

economy concepts are seen in dimensions such as industry/service oriented, efficiency/zero waste target, or micro/macro scope [11].

2. RESEARCH OBJECTIVE:

A 400 gram waste is generated per capita per day in India. Till date, India uses the linear economy model of waste management which is a one way process, unlike circular economies. Literature indicates little or even absence of attention paid towards circular economy in India. Hence, there is a need to conduct a study on circular economy to identify the level of awareness among individuals and to stress the importance of waste management for developing nations like India.

3. RESEARCH METHODOLOGY:

The focus of this research is on the creation of awareness of circular economy in India. The study was conducted in a municipality in Tamil Nadu through a survey. The survey was conducted through the use of a questionnaire which comprised a set of questions provided to the hierarchy of the municipal employees. The research methodology followed in this study is as follows:

- Literature study
- Factor selection
- Questionnaire development
- Data collection
- Reliability & Validation
- Analysis & Results

3.1 Factor selection:

Factor selection was done through literature analysis. 12 awareness variables and 5 demographic variables were considered for this study. The demographic variables were age, gender, hierarchical levels, experience, and qualification. The twelve variables were 3R's (Reduce, Reuse, Recycle), knowledge about Circularity, Business approach, Regeneration of waste, Recycling of products, Product development using used materials, Of municipalities in handling environment sensitive materials and striking an ecological balance, segregation of waste, Verification of handling wastes before disposal, Audit done by municipalities, involvement of managements in implementing circular economy[6]. Thus, the variables for determining the awareness involved in circular economy were derived.

3.2 Questionnaire design:

In this research work, a questionnaire was developed for collection of data from the target population, that is, the municipality of Chennai. Adams and Osmani [8], in their work conducted an awareness study for different levels of people in the construction sector between the individuals, organizations and industrial wide approach as factors with a four point Likert scale. Liu and Bai [6], in their work, considered gender, educational level and age and grouped 10 variables in two categories which were awareness and behavior in their study with a five point Likert scale with ranges varying from the least important to the most important in their case. The questionnaire developed for this research work consists of two sections, namely demographics and questions based on circular economy awareness with a five point Likert scale ranging from "strongly agree" to "strongly disagree".

3.3 Data collection:

About 500 questionnaires were distributed to the target respondents. Personal visits were made and, after repeated reminders, the researchers were able to collect 385 filled in questionnaires. On scrutiny, 365 questionnaires were found useable and the remaining 20 were found to be defective due to incomplete information provided and therefore not considered for analysis. Responses were obtained through data collection with details of different genders, levels, educational qualification and work experience. The participants' efficiency in answering the questions was based on the level of awareness and partially educational qualifications, and experience sometimes. The Likert ratings were assessed on the basis of

marks for ranks for instance; strongly disagree was rated (1 mark), disagree (2 marks), neutral (3 marks), agree (4 marks), strongly agree (5 marks).

3.4 Reliability & validation:

The importance of reliability and validity of the questionnaire plays a crucial role as these are factors involved in the validation of the accuracy of the data collected; Nunnally [12] has suggested the same in his research work. For this research work the Cronbach's alpha was calculated for 12 variables and details are provided in table 1:

Table 1: Reliability statistics of the awareness variables

Cronbach's Alpha	0.819
N of items	12

Twelve variables of awareness on circular economy were considered for the extraction of a single factor using the principle component method of factor analysis. The results in single factor with loading ranged from 0.407 to 0.750. The construct validity for the research was established. Table 2 shows details of the factor loading for the twelve awareness variables.

Table 2: Principle component analysis for factor selection

Variables	Factor loading	Communalities
Knowledge about circular economy	0.566	0.321
3R's (Reuse, Reduce, Recycle)	0.407	0.165
Business approach	0.655	0.429
Regeneration of wastes	0.598	0.358
Recycling of products	0.671	0.450
Product development using waste materials	0.750	0.562
Environmental sensitive material handling	0.492	0.242
Segregation of wastes	0.574	0.329
Verification of handling wastes before disposal	0.560	0.314
Ecological balance	0.487	0.237
Audit	0.591	0.350
Management Involvement	0.619	0.383

3.5 Analysis and results:

The awareness survey was conducted in the chosen municipality in Chennai city and an overall 64% awareness obtained at the end of the study is considered moderate. The variables considered for the survey were ranked as shown in the table 3 which shows the mean values ranging from 2.93 to 3.51 in a five point Likert scale. Only the score of the "business approach" scored was above 3.50 (i.e. 70%) out of twelve variables nine variables scored above 3.0 (i.e. 60% awareness).

Table 3: Ranking of awareness variables

Variable	Mean(μ)	S.D(σ)	Rank
Business approach	3.51	1.13	1
Verification of handling waste before disposal	3.46	1.12	2
Recycling of products	3.25	1.04	3
Product Development using used materials	3.22	0.96	4
Management involvement	3.22	1.03	5
Auditing	3.22	1.06	6
Segregation of wastes	3.22	1.09	7
Knowledge about circular economy	3.15	1.02	8
3R's (Reduce, Reuse, Recycle)	3.12	1.06	9
Regeneration of wastes	3.08	1.07	10
Environmental sensitive material handling	2.96	1.28	11
Ecological balance	2.93	1.13	12
Overall Awareness	3.20	0.62	

Table 3, shows the overall awareness as moderate. Only the variable business approach has 70% awareness which is good. Variables like 3R's, knowledge about circular economy, Regeneration of waste, environment sensitive material handling and ecological balance which are quite important showed poor awareness. Compared to China, India has more awareness on considering circular economy as a business approach for waste management, but has low awareness on variables like 3R's which has , environmental sensitive raw materials, etc.,[6]. Knowledge of circular economy showed 90.2% awareness which is higher compared to that of India. The Chinese have shown more awareness on the 3R's where they could identify the function of each R's individually. 65.8% [6] of the population considered for the survey in China had willingness and awareness to regenerate waste compared to that of India. It is evident from the foregoing analysis that the awareness on circular economy has to be improved on a top priority basis.

4. DEVELOPMENT OF HYPOTHESIS:

In-order to improve the awareness level on circular economy, the demographic variables used in the study were grouped and the following hypotheses was developed.

H1: There is a significant difference in the variables of awareness on circular economy between male and female respondents. (Hypothesis based on gender awareness)

H2: There is a significant difference in the variables of awareness on circular economy among different age group of respondents. (Hypothesis based on age group)

H3: There is a significant difference in the variables of awareness on circular economy among various levels of respondents. (Hypothesis based on different hierarchial levels of employees in the municipalities)

H4: There is a significant difference in the variables of awareness on circular economy among various experience groups of respondents. (Hypothesis based on experience of employees in municipalities)

H5: There is a significant difference in the variables of awareness on circular economy among various qualified respondents. (Hypothesis based on qualification of employees in municipalities)

4.1 Testing of hypothesis:

The data collected from the respondents were fed and analysed using SPSS- version 21 software package.

4.1.1 Testing of gender based awareness

H1: There is a significant difference in the variables of awareness on circular economy between male and female respondents. T-test was used for this hypothesis. The results of the t-test are given in Table 4.

Table 4: t-test for testing gender awareness hypothesis

Variables	N=156 Males		N=209 Females		t	Sig.
	Mean	S.D	Mean	S.D		
Knowledge about circular economy	3.38	0.84	2.98	1.10	4.021	0.000
3R's (Reuse, Reduce, Recycle)	3.23	0.89	3.04	1.17	1.784	0.075
Business approach	3.69	0.91	3.38	1.26	2.766	0.006
Regeneration of wastes	3.31	0.91	2.92	1.06	3.758	0.000
Recycling of products	3.46	0.93	3.09	1.09	3.500	0.001
Product development using waste materials	3.38	0.93	3.10	0.98	2.860	0.004
Environmental sensitive material handling	2.92	1.21	2.99	1.34	-0.467	0.641
Segregation of wastes	3.31	1.07	3.16	1.10	1.305	0.193
Verification of handling wastes before disposal	3.46	1.01	3.46	1.20	0.019	0.985
Ecological balance	2.69	1.07	3.11	1.14	-3.517	0.000
Audit	3.15	1.23	3.27	0.90	-1.017	0.310
Management Involvement	3.23	0.89	3.22	1.12	0.147	0.884
Overall Awareness	3.27	0.48	3.14	0.71	2.056	0.040

Table 4, leads to the observation of the knowledge of variables about circular economy, business approach, regeneration of waste, recycling of products, product development using waste materials and ecological balance as significant. Compared to the male population (mean=3.27) the awareness was less among the female population (mean=3.14). A comparison between the two genders awareness among females was seen lower than among males, indicating the need to take appropriate steps for improving the overall awareness among.

4.1.2 Hypothesis testing of different age groups

H2: There is a significant difference in the variables of awareness on circular economy among respondents of different age groups. (Hypothesis based on age group awareness). F-test was used in this test.

Age was sub-divided into four categories starting from less than 30, starting from (18-29), 30-40 years, 40-50 years and more than 50 years. The frequency of high level of labor power was between 30-40 years which was identified during the time of data collection. The results are tabulated in table 5.

Table 5: Testing of hypothesis of the influence on age in circular economy awareness

Variables	N=86 (<30 years)		N=108 (30-40 years)		N=74 (40-50 Years)		N=97 (>50 years)		F	Sig.
	μ	σ	μ	σ	μ	σ	μ	σ		
Knowledge about circular economy	3.19	0.94	2.81	1.27	3.53	0.50	3.12	1.05	6.901	0.000
3R's (Reuse, Reduce, Recycle)	3.07	1.11	3.10	1.27	3.03	1.01	3.26	0.83	0.805	0.492
Business approach	3.07	1.11	3.37	1.62	3.84	0.68	3.88	0.60	12.237	0.000
Regeneration of wastes	3.00	0.95	2.84	1.25	3.59	0.99	3.01	0.71	8.863	0.000
Recycling of products	3.33	1.06	3.12	1.01	3.43	0.81	3.13	1.17	1.886	0.131
Product development using waste materials	2.89	0.88	3.55	1.20	3.12	0.72	3.37	0.86	9.159	0.000
Environmental sensitive material handling	2.72	1.29	2.41	1.06	2.91	1.51	3.75	0.83	22.302	0.000
Segregation of wastes	2.91	1.20	2.84	1.18	3.27	0.78	3.88	0.78	21.533	0.000
Verification of handling wastes before disposal	3.23	0.64	3.13	1.47	3.80	0.40	3.75	1.39	9.021	0.000
Ecological balance	2.74	0.91	2.99	1.32	2.55	1.15	3.37	0.99	9.403	0.000
Audit	2.91	0.87	3.26	1.05	2.95	1.01	3.75	1.09	14.486	0.000
Management Involvement	2.42	1.18	3.70	0.90	3.49	0.50	3.49	0.71	43.310	0.000
Overall Awareness	2.96	0.56	3.09	0.93	3.29	0.42	3.48	0.27	14.921	0.000

Table 5, reveals the significance of variables like knowledge relating to circular economy, business approach, regeneration of wastes, product development using waste products, environmental sensitive material handling, segregation of wastes, verification of waste before disposal, ecological balance, audit, management involvement. The overall awareness among the age group less than 30 years showed the need for more attention as the awareness was low. Further analysis of the individual variables for different age groups showed lower awareness in the age group of 30-40 years on certain variables like knowledge about circular economy, regeneration of waste, environment sensitive material handling, and verification of wastes before disposal. This proved the urgent need to create awareness among the people in the age group less than 30 years.

4.1.3 Testing of hypothesis of different level of respondents:

H3: There is a significant difference in the variables of awareness on circular economy among various hierarchial levels of respondents. (Hypothesis based on different level of employees in the municipalities)

The levels indicate the workers, supervisors and managers working at the municipalities where the data was collected. F-test was employed in the analysis of the collected responses. Inferences were obtained from 180 municipality workers, 130 supervisors and 55 managers. Details are shown in table 6.

Table 6: Testing of hypothesis of the influence different levels of employee hierarchy in circular economy awareness

Variables	N=180 Workers		N=130 Supervisors		N=55 Managers		F	Sig
	Mean	S.D	Mean	S.D	Mean	S.D		
Knowledge about circular economy	3.04	1.24	3.16	1.10	3.19	0.76	0.583	0.558
3R's (Reuse, Reduce, Recycle)	2.95	1.08	2.98	1.08	3.38	0.99	6.454	0.002
Business approach	3.36	1.27	3.48	1.17	3.62	1.02	1.071	0.344
Regeneration of wastes	2.98	1.10	3.06	1.07	3.16	0.90	0.700	0.493
Recycling of products	3.24	1.04	3.41	0.98	3.04	1.09	4.823	0.009
Product development using waste materials	3.07	0.94	3.26	1.01	3.23	0.91	0.771	0.463
Environmental sensitive material handling	2.65	1.21	2.93	1.28	3.13	1.30	2.798	0.062
Segregation of wastes	3.16	1.18	3.24	1.12	3.22	1.00	0.120	0.887
Verification of handling wastes before disposal	3.44	1.10	3.32	1.13	3.67	1.10	3.812	0.023
Ecological balance	2.78	1.18	2.63	1.08	3.40	1.01	19.894	0.000
Audit	3.09	1.08	2.99	1.10	3.59	0.88	13.419	0.000
Management Involvement	2.93	0.94	3.03	0.91	3.61	1.11	15.584	0.000
Overall Awareness	3.06	0.68	3.13	0.64	3.35	0.54	6.874	0.001

Table 6, shows that variables 3R's (reduce, reuse, recycle), regeneration of wastes, recycling of products, verification of wastes before disposal, ecological balance, audit and management involvement as significant. Overall awareness among the workers was low compared to workers and supervisors. Further, individual analysis of variables showed the need for larger focus on recycling of products,

creation of awareness variables like awareness of variables like verification of wastes before disposal, ecological balance and audit, in-order to increase overall awareness. Different levels of hierarchy have influence on awareness of the circular economy.

4.1.4 Testing of hypothesis of involvement of experience groups on circular economy awareness:

H4: There is a significant difference in the variables of awareness on circular economy among various experience groups of respondents. (Hypothesis based on experience of employees in municipalities). F test was used for the analysis of the collected data to obtain inferences relating whether job experience plays a crucial role in circular economy awareness. The experience categorization was divided into three groups, namely less than 10 years, 10-20 years and more than 20 years. The inferences obtained are shown in table 7.

It was noted that less than 10 years of experience were present in high numbers i.e., N=180 than compared to intermediate and more than 20 years respectively.

Table 7: Testing of hypothesis of the influence different levels of employee experience in circular economy awareness

Variables	N=180 <10 years		N=110 10-20 years		N=75 >20 years		F	Sig.
	Mean	S.D	Mean	S.D	Mean	S.D		
Knowledge about circular economy	3.12	0.99	3.16	1.06	3.16	0.97	0.045	0.956
3R's (Reuse, Reduce, Recycle)	3.21	1.11	3.06	1.07	3.16	1.02	0.712	0.491
Business approach	3.55	1.21	3.52	1.14	3.48	1.07	0.075	0.928
Regeneration of wastes	2.97	1.11	3.09	1.00	3.15	0.97	0.710	0.492
Recycling of products	3.23	1.02	3.21	1.11	3.28	0.93	0.448	0.639
Product development using waste materials	3.13	1.09	3.24	0.88	3.24	1.00	0.375	0.687
Environmental sensitive material handling	2.83	1.35	3.03	1.30	2.93	1.21	0.735	0.480
Segregation of wastes	3.19	1.19	3.25	1.10	3.20	0.98	0.122	0.886
Verification of handling wastes before disposal	3.11	1.37	3.53	0.91	3.58	1.21	4.869	0.008
Ecological balance	2.61	1.15	3.03	1.10	2.97	1.20	3.857	0.022
Audit	3.08	1.22	3.17	0.94	3.40	1.10	2.454	0.087
Management Involvement	3.13	1.12	3.26	0.91	3.23	1.15	0.325	0.688
Overall Awareness	3.10	0.70	3.21	0.55	3.24	0.68	1.242	0.290

After analysis for the values are shown in Table 7, verification of waste before disposal and ecological balance were determined as the two awareness variables found significant. The overall awareness of the people with less than 10 years of experience was low. Different levels of employee experience constitute a major factor for determining the awareness of a circular economy. Experience does not play an influential role in circular economy awareness. Hence experience is not a determining factor for the determination of the awareness of circular economy.

4.1.5 Testing of hypothesis to find the influence of qualified respondents for circular economy awareness:

H5: There is a significant difference in the variables of awareness on circular economy among various qualified respondents. (Hypothesis based on qualification of employees in municipalities).

Here the qualification of the respondents was categorized as HSC and below, Diploma, Undergraduate and Postgraduate respectively. For population size of overall 365 respondents, the following observations were made.(shown in the table 8).

Table 8: Testing of hypothesis of the influence qualifications of employees in circular economy awareness

Variables	N=160 HSC & below		N=40 Diploma		N=118 Undergrad.		N=47 Post grad.		F	Sig
	μ	σ	μ	σ	μ	σ	μ	σ		
Knowledge about circular economy	3.20	1.08	3.17	0.99	2.98	1.14	3.18	0.95	0.507	0.678
3R's (Reuse, Reduce, Recycle)	3.03	1.11	3.11	1.09	3.33	1.14	3.14	1.00	0.837	0.475
Business approach	3.43	1.31	3.53	1.30	3.45	1.32	3.58	0.86	0.437	0.727
Regeneration of wastes	2.92	1.18	2.83	1.15	2.98	1.07	3.31	0.77	4.803	0.003
Recycling of products	3.05	1.05	3.00	1.04	3.25	1.19	3.47	0.94	4.875	0.002
Product development using waste materials	2.99	0.98	3.04	1.04	3.30	1.09	3.42	0.85	5.276	0.001
Environmental sensitive material handling	2.69	1.25	2.79	1.23	2.80	1.29	3.25	1.27	5.184	0.002
Segregation of wastes	2.98	1.21	3.09	1.16	3.13	1.26	3.46	0.85	5.041	0.002
Verification of handling wastes before disposal	3.26	1.21	3.43	1.12	3.28	1.22	3.66	1.00	3.408	0.018
Ecological balance	2.70	1.27	2.77	1.34	2.98	1.25	3.13	0.86	3.727	0.012
Audit	3.14	1.18	3.13	1.13	3.35	1.17	3.28	0.90	0.749	0.524

Management Involvement	3.02	1.11	3.04	1.23	3.23	1.14	3.43	0.82	4.228	0.006
Overall Awareness	3.03	0.70	3.08	0.73	3.17	0.78	3.36	0.43	7.099	0.000

Table 8, shows the awareness variables regeneration of wastes, recycling of products, product development using wastes, environmental sensitive material handling, segregation of wastes, and verification of wastes before disposal, ecological balance and management involvement as significant factors. Qualification plays a significant role in circular economy awareness. The HSC & below population, the highest in number showed low awareness to circular economy. Out of twelve awareness variables, six were significant, pointing out to greater attention to these six variables without any indifference to others.

5. RESULTS AND DISCUSSION:

The analysis shows moderate awareness in circular economy in India. Business approach showed more awareness compared to more critical factors important for a circular economy. Further testing of the five demographic variables, showed four as significant on testing the hypothesis. The reliability of the questionnaire was found to be 81.9% which is good.

For the gender based hypothesis, female population showed less awareness compared to the male population. Further six out of twelve awareness variables showed a significant difference and, except for three awareness variables, females had less awareness for each awareness variable, implying a significant role by gender in determining awareness of circular economy.

On the subject of the influence of age in a circular economy, ten out of twelve awareness factors were found significant. The age group less than 30 years of age with a large percent of the population showed low awareness. But, on individual comparison of awareness variables except for factors like 3R's, business approach, product development using waste materials, ecological balance and management involvement the other variables for people aged 30-40 years showed low awareness. (The influence of age was found sig= 0.000). Hence the role played by age in circular economy awareness is significant.

A studying of the results obtained for the hypothesis based on different hierarchical levels of employees, showed the awareness of workers as lower compared to that of managers and supervisors. Six out of twelve awareness factors had significant difference. Workers should be updated and aware in terms of waste collected in their municipality. Thus level of employees play a significant role in circular economy awareness.

Out of twelve awareness factors, only two were significant in the hypothesis testing of different levels of employee experience. The overall awareness was found insignificant, hence role played by different levels of experience in the awareness of circular economy cannot be considered significant.

The significance of six out of twelve factors in the awareness of circular economy was seen. The overall awareness of the circular economy was found to be significant and hence qualification plays a major role in circular economy awareness. HSC & below population which were high in number had lower awareness of a circular economy, but awareness variables like knowledge about circular economy were seen lower in people with diploma level education. Hence more training is suggested for people with diploma level education for overall improvement.

6. CONCLUSION:

In this paper, the awareness of circular economy in India has been explored and analysis done for five demographical factors showed that it is moderate, and proves that the circular economy is still in its

growth from the infancy state. Circular economy is a new concept for a developing nation like India, with its rising population showing an exponential increase in generation of waste per individual. With the increasing tonnage of wastes per year, there is a pressing need to use an innovative cyclic model which implies the use and re-use of waste and to consider "waste as a resource".

So far this has study discussed the awareness related to a circular economy in municipalities of Chennai Metro city, India and various inferences have been obtained. Twelve variables were adapted to the identification of circular economy. These were Knowledge, 3R, Business approach, Regeneration, Recycling, Product development, Environmental sensitive material handling, Segregation, Verification, Ecological balance, Audit, Management Involvement with five demographic variables which were gender, age groups, levels, experience, qualification and their influence in the awareness study.

Further, for future studies, a state wide approach is suggested in handling waste and identifying a target consumer who can convert the waste dumped into landfills as a useful resource for new product development.

REFERENCES

- [1] Raichel, A., Schoenmakere, M De, 2016, *Circular economy in Europe developing the knowledge base, EEA report.*
- [2] Javadekar., 2016, *Solid Waste Management Rules Revised After 16 Years; Rules Now Extend to Urban and Industrial Areas. Press Information Bureau, Government of India.*
- [3] Andersen., M.S, 2006, *An introductory note on the environmental economics of the circular economy. Sustainability Science, Springer Verlag.*
- [4] Kirchherr, J., Reike, D., Hekkert, M, 2017, *Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation & Recycling, Elsevier, 127 221-232.*
- [5] Guo, J.-J., Tsai, S.-B, 2015, *Discussing and evaluating green supply chain suppliers: A case study of the printed circuit board industry in China. South African Journal of Industrial Engineering, Vol. 26, pp 56-67.*
- [6] Liu, Y., Bai, Y, 2014, *An exploration of firms' awareness and behavior of developing circular economy: An empirical research in China. Resources, Conservation and Recycling, Elsevier, 87, 145-152.*
- [7] Masi, D., Kumar, V., Garza-Reyes, J.A., Godsell, J, 2018, *Towards a more circular economy: exploring the awareness, practices, and barriers from a focal firm perspective. Production Planning & Control, Vol.29, No.6, 539-550.*
- [8] Adams, K.T., Osmani, M , 2017, *Circular economy in construction: current awareness, challenges and enablers. Waste and Resource Management, Issue WR 1, pages 15-24.*
- [9] Sakr, D.A., Sherif, A., El-Haggag, S. M , 2010, *Environmental management systems' awareness: an investigation of top 50 contractors in Egypt. Journal of Cleaner Production, Elsevier, 18, 210-218.*
- [10] Pieters, I.J., Lotz, M., Brent, A.C, 2014, *Investigating the financial close of projects within the South African renewable energy independent power producer procurement programme. South African Journal of Industrial Engineering.*
- [11] Geisendorf, S., Pietrulla, F, 2017, *The circular economy and circular economic concepts- a literature analysis and redefinition. Thunderbird International Business Review, 60: 771-782, Wiley.*
- [12] Nunnally, J.C, 1978, *Psychometric theory. 2nd edition, New York: McGraw-Hill.*