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# Mining the social discussions surrounding Circular Economy: Insights from the collective intelligence shared in Twitter

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**Abstract.** Organisations like UNDP, UNEP, CES and many more along with Fortune 500 companies have been sharing support towards the circular economy in order to bring focus towards long term sustainability. The purpose of this study is to explore the collective intelligence towards circular economy which may help in obtaining greater support from different stakeholders. For this objective, three research questions had been explored by analysing Twitter discussions on circular economy through content and network analysis. The insights reveal that users are discussing about all the three elements of circular economy, i.e., economic benefits, environment impacts and resource scarcity. The polarity of sentiments surrounding these elements of circular economy is also established and explained. Insights also indicate that artificial intelligence is strongly being perceived as a solution for resource optimisation, remanufacturing, re-generation of by-products and many more towards achieving circular economy objectives.

**Keywords:** Circular economy; Collective intelligence; Social media; Twitter analytics; Social media analytics.

## 1 INTRODUCTION

Circular economy is an economic model aimed at zero production waste. Circular economy aims to shift resources usage towards regenerative manner [3][22]. By doing so, it attempts to address social and environmental needs without compromising significantly on the economic profitability for the firm. Successful implementation of circular economy lies on the following principles, whereby waste becomes a resource, focus on reuse, repair, valorization, eco-design, industrial and territorial ecology. Objectives adfa, p. 1, 2011.

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towards achieving circular economy have been highly supported by organizations like European Union and different national governments [19] Korhonen et al., 2018). Several organizations around the world are also supporting and implementing circular economy concepts in industrial processes. In line with such national and international priorities, academicians are also suggesting frameworks for moving towards a sustainable society by meeting circular economy objectives [5]. One of the popular ways of diffusing circular economy in industrial processes is by integrating activities of reverse supply chain into forward supply chain. Lieder and Rashid (2016) had indicated circular economy is the solution for resource scarcity, waste generation and sustaining economic benefit. Kirchherr, Piscicelli, Bour, Kostense-Smit, Muller, Huibrechtse-Truijens and Hekkert (2018) had highlighted that the biggest barrier in the adoption of circular economy is the lack of awareness on circular economy. Circular economy activities requires specific education and training programs among practitioners [8]. However such initiatives are likely to become successful if they get ample support from both the internal and external stakeholders of the firm. In this context, with so much of focused efforts surrounding enhancement of its awareness, there is a need to assess the discussions surrounding circular economy among stakeholders to comprehend the nature and drivers of such support among stakeholders.

As per global digital report 2019, the number of social media users worldwide stands at 3.5 billion [27]. The numbers indicates roughly 50% of world's population is active on social media. Nowadays, organisations are also engaging with users on social media to express their views and interact on different issues in order to spread awareness on their offerings as well as to understand their concerns. Attempts for increasing engagement and awareness among different stakeholders like suppliers and customers are driven by firms on social media to improve business growth [9]. The monthly active users on Twitter grew 9% from third quarter, 2018 to fourth quarter, 2018 and stand at 330 million. Such population are seen to share their perspectives on different areas of interest across themes, and we attempt to mine this collective intelligence for understanding the nature of discussions surrounding circular economy. In such a context, since Twitter being a widely used platform by people of diverse backgrounds and demography as well as organisations, it makes Twitter an useful source of analysing views and opinions surrounding circular economy based on user generated content. Assessing progress towards environmental sustainability a systematic and robust knowledge base and buy in from key stake-holders are required. On the basis of this evidence, this study is using social media analytics to understand the major themes of discussion on twitter of the people towards circular economy. Circular economy is about many actors working together to create effective flows of materials and information, in order to move away from linear economy, take make consume throw away approach of resources [10] to recycle, repair and reuse of resources. Therefore to quantify human perspective on circular economy diverse views of users on Twitter had been analysed. Literature indicates diverse perspectives help in making accurate predictions [21]. This study focuses on three interrelated research questions (RQ) surrounding how stakeholders discuss about themes related to circular economy:

**RQ1: How do the social media users prioritize among the outcomes of circular economy with respect to economic benefits, environmental impact and resource scarcity?**

**RQ2: How do the sentiments differ among the social media users regarding these outcome factors, namely, economic benefits, environmental impacts and resource scarcity?**

**RQ3: How do these factors affecting these outcomes of the circular economy, namely, economic benefits, environmental impact and resource scarcity, associate among each other in social discussions?**

Empirical methods had not been used for examining the human perspective on circular economy because circular economy practices involves working of many actors in collaboration. To the best of our knowledge, a single questionnaire cannot capture the perspectives of the different actors. Further geographically dispersed stakeholders cannot share their perspectives through such an approach. Hence to acquire collective intelligence, we attempted to address these questions by analyzing tweets by different actors who were sharing their perspectives on the circular economy surrounding environment impact, resource scarcity and economic benefits (Lieder and Rashid, 2016). The remaining sections have been organized as follows. Section 2 is dedicated to background literature. Section 3 illustrates research question and hypothesis explored in the study. Section 4 presents the research methodology adopted for the study. Section 5 illustrates insights from the social discussions on economic benefits, environmental impact and resource scarcity with context to circular economy. This is followed by the discussion section whereby we share the contributions to literature and the implications of our study for practice. The final section concludes the paper and presents the limitations of the study along with future research directions.

## 2 BACKGROUND LITERATURE

Circular economy as a dynamic, multidimensional, integrative approach for promoting transformed socio-technical template for economic development [11]. Korhonen, Honkasalo and Seppälä (2018) had pointed out circular economy is the economy constructed by using cyclical materials flows [34] and cascading energy flows within the societal production consumption systems. Table 1 presents the circular economy activities such as reduce, reuse and recycle for different items and categories.

Table 1. Circular Economy - reduce, reuse and recycle activities for different items and categories

Items & Categories	Task - Reduce, Reuse and Recycle	Literature Evidence
Rare-earth elements	Recycle material mitigates the supply risk and led to circular economy.	[37]
	Recycling Yttrium is profitable rather than extracting.	[15]

End-of-life products	Reuse and recycle end-of-life products reduces greenhouse gas emissions while manufacturing and leads to circular economy.	[20]
Food waste	Recycling bin for transforming the food waste into usable end product such energy.	[38]
Cloth	Textile recycling technologies	[35]

The supply of these resources faces high uncertainty, application of circular economy concept may mitigate the risk of supply of these resources [37]. Reuse and recycling can led to reduction in unused raw material [20]. Circular economy can also improve the sustainable use of critical raw materials such as yttrium [15]. Industrial symbiosis as an effective practice for circular economy [17]. Industrial symbiosis engages different industries in exchange of materials, services and energy. Literature indicates circular economy discussions are at the niche stages [28] and driven because of economic consideration (Masi et al., 2018), therefore there is a need to put in significant efforts for motivating the people towards circular economy practices [28]. Technical and economic factors are hard drivers and barriers in transition towards circular economy whereas institutional and social factors as soft drivers and soft barriers in transition towards circular economy [11]. Institutional factors act as soft drivers when it comes to building environmental legislation, environmental standards and waste management directives. Six challenges of circular economy with respect to environment sustainability [29] these were, (a) thermodynamic limits; (b) spatial and temporal system boundary limitations; (c) limits posed by physical economic growth such as rebound effect, Jevon's paradox and the boomerang effect; (d) limits posed by path dependencies and lock-in; (e) intra-organizational versus inter-organizational strategies and management; and (f) definition of physical flows which varies within social and cultural context.

In this era of digital economy, social media allows people to generate, exchange and share in virtual communities. Online knowledge communities present on Twitter specializes in knowledge seeking and sharing purposes. Such mass media channels are effective for creating awareness on practices. Interaction on Twitter triggers effectual cognitions and more communication on a topic can lead to effectual churn as well [16].

### 3 RESEARCH QUESTION AND HYPOTHESIS DEVELOPMENT

This study focus on three interrelated questions RQ1, RQ2 and RQ3 on circular economy perspectives. Circular economy revolutionize the existing industrial processes by transforming existing business models by using 3R's, reduce, recycle and reuse, such that resources, materials or goods re-used and continue to remain a part of the cycle and not go out of it. Business models are designed in such a way that products are leased, shared or rented wherever possible. Companies like AirBnb and Zoomcar are prime examples of this concept. In case the goods cannot be rented and have to be sold, incentives are given to ensure that instead of the goods being disposed off at the end of their life, they are returned, which allows reuse of the product or their components [13].

Circular economy brings down production prices, which leads to reduction in selling price, thereby helping the consumer economically as well as socially and environmentally. A comprehensive framework on circular economy which includes three perspectives such as economic benefit, environmental impact and resource scarcity with context to circular economy [31]. Firms and organizations moves towards the circular economy for gaining economic benefits over the competitors. This may require redesigning and restructuring some of the activities related to businesses such as product design, supply chain design, material choices and many more. The three perspectives of circular economy, economic benefits, environmental impact and resource scarcity covers the short-term and long-term objectives of circular economy and are seamlessly linked to each other. Therefore, the comprehensive nature of this framework will enable us to analyze the discussions on circular economy on twitter in a more complete manner. Hypothesis H1 proposes that there is no statistically significant difference among the discussions on three perspectives of circular economy, economic benefits, environmental impact and resource scarcity on Twitter.

*H1: All three perspectives of circular economy, economic benefits, environmental impact and resource scarcity had been discussed equally on Twitter.*

Resource scarcity takes into account the way scarce critical resources and materials, such as rare-earth elements, use can be reduce, reuse and recycled. Resource depletion speed is reduced in circular economy as compared to linear economy. Literature indicates environment impacts should be avoided and minimized as much as possible. This may include reducing solid waste, landfill and emissions. The solid waste may include food waste, e-waste, waste management and municipal solid waste. Due to competitive pressure on the firms, firms do not consider environment impact over economic benefit. Literature indicates that positive sentiments on themes indicate higher levels of support and user engagement and this becomes critical for the success of the objectives [2]. Thus RQ2 tries to find the sentiments of the people on circular economy with respect to different aspects such as economic benefits, environmental impact and resource scarcity.

*RQ2: How do the sentiments differ among the social media users regarding these outcome factors, namely, economic benefits, environmental impacts and resource scarcity?*

Economic benefits gained by the firms highly depend on the availability of resources and pricing policies of the resources. Pre-processing of raw materials into products and services directly impacts the environments of the producers and consumers (Lieder and Rashid, 2016). The nation's legislation regulates the impacts of the firms and organizations on environment for economic benefits. Speed of waste generation and speed of resource depletion influences environment.

*RQ3: How do these factors affecting these outcomes of the circular economy, namely, economic benefits, environmental impact and resource scarcity, associate among each other in social discussions?*

Analyzing these discussions on twitter gives us an idea of the penetration and awareness of circular economy among the people across the world. It also gives us the main themes of discussions and polarity. Compared to offline surveys and interviews, twitter served to be a better source of data as surveys are firstly time-consuming, with different

biases coming into the picture and not only this, for issues like circular economy, a concept which is well-spread in India so far, it becomes very difficult to come across people who could share unbiased and useful views on the issue.

## **4 Research methodology**

To derive insights from Twitter on three perspective of circular economy, economic benefits, environmental impact and resource scarcity of people social media analytics methodology, the CUP framework (Fan and Gordon, 2014) has been applied to the tweets. The CUP framework is a three stage framework. The first stage captures the people generated data from Twitter on circular economy. The second stage tries to understand the data extracted by applying descriptive, content, diagnostic and prescriptive analysis. The third stage presents the insights derived from these analysis. To extract the tweets, a list of synonymous of circular economy had been made by searching through internet and research articles. The list includes the following keywords, “circular economy”, “recycling”, “reusing”, “smart design”, “industrial ecology”, “war on waste”, “zero waste”, “adaptive reuse”, “upcycle” and “sustainability”. These keywords were identified based on the literature which was elaborated earlier in the second section of this article. The extraction of tweets was done using ‘Tweepy’ library in Python. The extraction of tweets was done for a period of four months from December 2018 to March 2019 and a total of 90,113 tweets were collected.

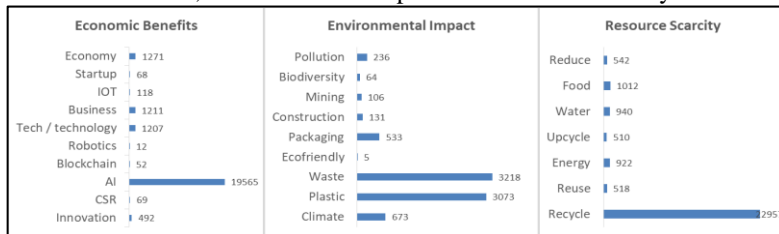
In stage two, top 100 hashtags had been found in the data. These hashtags through manual coding had been assigned to three perspectives of circular economy, economic benefits, environmental impact and resource scarcity. To better understand the perspective of the users on these sentiment analysis was applied. Sentiment analysis is a part of content analysis and is a technique which analyses underlying sentiment of a tweet. Based on the sentiment, each tweet is categorized as positive, negative or neutral [23][32]. To find the linkages between economic, environment and resources, the tweets containing top hashtags related to economic, environment and resources hashtags, any two at time were analyzed with the help of the network analysis. The edges in the network diagram represents the linkages among economic, environment and resources. The links between economic benefits and environment impacts may represent value perception or legislation. The links between economic benefits and resource scarcity may represent resource dependency or price volatility. The links between environment impacts and resource scarcity may represent depletion or waste generation. Once the network is formed the community detection algorithm based on greedy optimization of modularity had been applied. To explore the linkages among different economic benefits, environment impacts and resources. The last and third stage of CUP framework the insights of the analysis were discussed in the light of circular economy framework suggested by Lieder and Rashid (2016).

## 5 FINDINGS

Circular Economy is a concept which is about to become an integral part of our lives, sooner rather than later. In fact, the sharing business models of Zoomcar and AirBnB are prime examples of circular economy in India. The organizations like UNDP, UNEP, TERI, FICCI - Circular Economy Symposium, etc. posting their views on circular economy on twitter and engaging with the users. Various companies were also taking part in discussions related to circular economy on Twitter and had extensively posted their views and vision on circular economy. Figure 1, indicates artificial intelligence (AI) is dominant among economic benefits followed by business and technology hashtags. In environment impact dominant hashtag is on waste and plastic. Within resource scarcity, recycle is the dominant hashtag.

**H1: All three perspectives of circular economy, economic benefits, environmental impact and resource scarcity had been discussed equally on Twitter.**

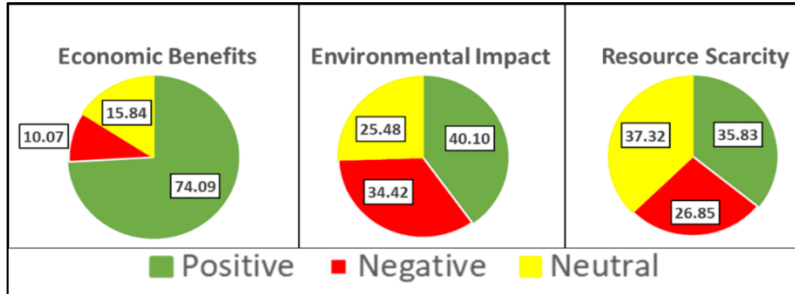
Let  $\alpha=0.05$  (assumption), the degree of freedom is (k-1, n-k), where k is the number of samples (k=3; economic benefit, environment impact and resource scarcity) and n is the total number of observation (n=26; say characteristics identified from literature). The degree of freedom for this equal to (2, 25). The decision rule states, if the calculated value of F is greater than table value of F, reject H1. The table value of F at 5% level of significance for degrees of freedom (2, 25) is 3.39. The calculated value of F- statistic on circular economy discussions surrounding economic benefits, environmental impact and resource scarcity is 0.548 which is lesser than the threshold value of 3.39. Therefore, H1 is not rejected. Hence there is no significant difference between means of discussions of economic benefits, environment impact and resource scarcity in context to circular economy. This indicates Twitter had been used equally for discussions related to economic benefits, environmental impact and resource scarcity.



**Fig. 1.** Occurrence of the hashtags captured related to economic benefits, environmental impact and resource scarcity

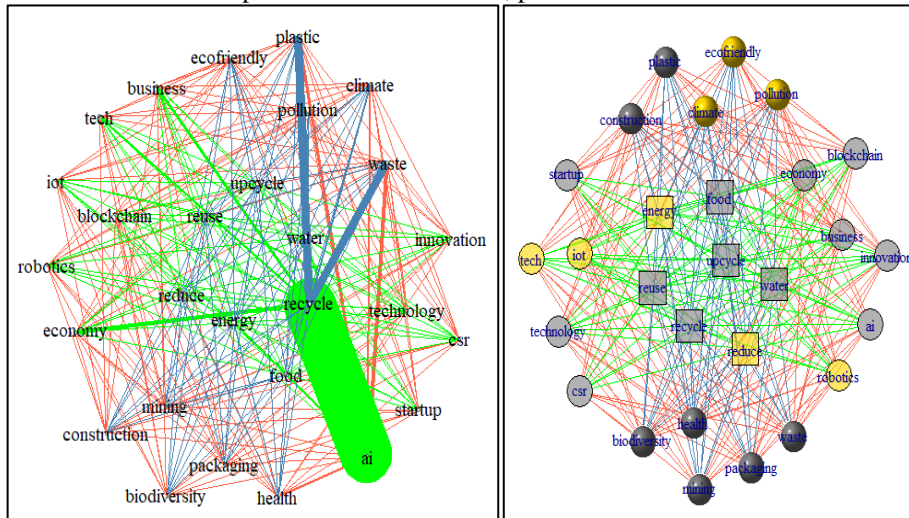
Circular economy is a concept that largely draws positive sentiment of the people as presented in Figure 2. It is see that most of the discussions surrounding economic benefits are having positive sentiments as compared to discussions on environmental impact and resource scarcity. Discussions related to environmental impact being most negative when compared to economic benefits and resource scarcity.





**Fig. 2.** Sentiment analysis of the three elements of circular economy, economic benefits, environment analysis and resource scarcity

It appears that most of the discussions surrounding circular economy is driven by positive sentiments when it comes to economic benefits. However when such discussions try to address environmental impact and resource scarcity, such discussions invariably become negatively polarized. Figure 3 presents the linkage among three elements of circular economy economic benefits, environmental impact and resource scarcity. The links between economic benefits and environment impacts may represent value perception or legislation, represented with red edges, in Figure 3. In red edges most of the discussion was on artificial intelligence (AI) from economic benefits to environment impacts in terms of climate, plastic and health.



**Fig. 3.** (a) Linkage among three elements of circular economy economic benefits, environmental impact and resource scarcity; (b) Linkages between three elements of circular economy economic benefits, environmental impact and resource scarcity

The links between economic benefits and resource scarcity may represent resource dependency or price volatility, represented using green edges, in Figure 3. In green edges most of the discussion was on artificial intelligence (AI) from economic benefits to resource scarcity in resolving measures such as recycle and things such as food, water and energy. Other than these business and technology had been extensively discussed

with recycling. The links between environment impacts and resource scarcity may represent depletion or waste generation, represented using blue edges, in Figure 3. In blue edges most of the discussion was on recycling waste and plastic. Followed by recycling packaging, climate and health. To find grouping among the linkages among three elements of circular economy economic benefits, environmental impact and resource scarcity, the community detection algorithm based on greedy optimization of modularity had been applied. The algorithm resulted in two groups, presented in figure 3(b), one demonstrated in grey colour and second group is demonstrated in yellow colour. In each group economic benefits presented using circle, environment impacts presented using sphere and resource scarcity in squares. Group 1 in grey colour, consists of following economic benefits, innovation, CSR, AI, blockchain, technology, business, startup and economy; along with following environment impacts hashtags, waste, packaging, plastic, construction, mining, health and biodiversity; and along with following resource scarcity hashtags, recycle, reuse, upcycle, water and food. Group 2 in yellow colour, consists of following economic benefits, robotics, iot and tech; along with following environment impacts, climate, eco-friendly and pollution; and along with following resource scarcity hashtags, reduce and energy .

## **6 DISCUSSION**

The data extracted for the study indicates circular economy had been extensively discussed by world organizations like UNDP, UNEP, CES, etc. along with Fortune 500 companies, This study had analyzed the circular economy tweets using social media analytics. Linear model has dominated industrial processes as compared to circular economy [29]. The development supported by linear economy had seriously had harm the environment. Social awareness is crucial for a successful transition from a linear economy to circular economy [31]. Figure 1 indicates artificial intelligence (AI) is dominant among economic benefits. Technology is hard driver, when technology facilitates resource optimization, remanufacturing and re-generation of by-products and development of sharing solutions. Technology is hard barrier when inappropriate technology been used in different context. Through this evidence, the authors of the study can suggest if used appropriately artificial intelligence (AI) can be used for resource optimization, remanufacturing, re-generation of by-products and many more. People on Twitter were discussing about waste management and use of the plastic impacting environment. Recycle hashtag had been found as the dominant hashtags. The discussions related economic benefits and resource scarcity have a stronger impact on polarity of discussions as compared to environmental impact.

### **6.1 Contribution to theory**

The current study contributes to the interface of literature surrounding public opinion, crowd intelligence for achieving multi-stakeholder support towards attaining circular economy objectives. Through hypothesis H1, the study establishes that all the three elements of circular economy, economic benefits, environment impacts and resource

scarcity had been equally discussed on Twitter. This is somewhat counterintuitive to existing literature where there are indications that organizations are implementing circular economy practices for economic benefits and in this process environment impact is given less importance [33]. The results of hypothesis H1 contrast this evidence, which indicates economic benefits, environment impacts and resource scarcity had been equally discussed on Twitter by the stakeholders. In similar lines, our findings towards RQ2 establish that people in general have positive sentiments while discussing about the economic benefits of circular economy. However, while discussing about the environment impacts and resource scarcity, often negative sentiments are driving these discussions significantly more. A closer look at the tweets manually reveal that while other stakeholders also support the other two elements of circular economy, the driver for such discussions are predominantly apprehension for the future needs.

RQ3 explores the linkages between the economic benefits, environment impacts and resource scarcity. Artificial intelligence had been strongly linked with climate, plastic and health for linkages between economic benefits and environment impacts. Artificial intelligence had been strongly linked with food, water and energy for linkages between economic benefits and resource scarcity. Recycling waste and recycling plastic had been found to be strongly linked among the links of environment impacts and resource scarcity elements of circular economy.

## **7 CONCLUSION AND FUTURE RESEARCH DIRECTIONS**

Analyzing these discussions on twitter gives us an idea of the penetration and awareness of circular economy among the people across the world. It also gives us the main themes of discussions and polarity. Economic benefits, environment impacts and resource scarcity had been discussed on Twitter equally. However while the discussions on economic benefits mostly have a positive sentiment, the discussions on environmental impact and resource scarcity are often driven by negative sentiments. Further, it is perceived in all such discussions surrounding circular economy, the role of AI is going to be very impactful. Future studies can also explore why these links, highlighted in results and outcomes of RQ3 had been found strong in the discussions on circular economy on Twitter. It would be also interesting to understand the diffusion of such discussions in social media, based on elements, in future research.

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