A Bibliometric Anaylysis Of Green Manufacturing Visualizing Network

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Abstract: Green technologies issues have been receiving more attention in contemporary era of globalization. Nowadays, green manufacturing (GM) has become popular among manufacturing industries, especially in developing countries as it can assist in achieving higher performance of production industry. Bibliometric analysis on GM has been performed to explore the evidence based statistical comparison of published research in this domain. The present research is focused on presenting a bibliometric analysis of 461 manuscripts which were downloaded from Scopus database using the keyword "Green manufacturing" in article title. The comparative analysis of GM publication of three top countries i.e. China, India and US is presented. The visualized keywords analysis is performed using VOSviewer analytical tool for global trends as well as for Indian research scenario. The present work investigates the quantum of work performed by Indian researchers on different research concepts of green manufacturing using NVivo software. The outcomes of network analysis explore and justify the research gap in the field of green manufacturing.

Keywords: Green Manufacturing, Bibliometric analysis, Scopus database, Visualize network analysis

1. INTRODUCTION:

Green is often linked with practices or products or both including processes which do not harm the environment. Manufacturing system that supports and experiences a renewable means of manufacturing products which do no damage to the environment is known as green manufacturing (Dixit et al., 2012). Green Manufacturing (GM) is a way for production that minimizes pollution, waste etc. and preserves natural resources. It is advised to industry to create products and processes which are benign or beneficial environmentally (Dubey and Ali, 2015; Toke and Kalpande, 2019). The "greening" of manufacturing - minimizing waste and pollution by reducing natural resource consumption, reusing and recycling waste matter, as well as reducing emissions (Govindan et al., 2015). GM, an emerging industrial pattern having an achievable, long term future for sustainability, handles the ecological challenges with a systemic level. GM is largely about changing business and manufacturing methods, and the mindset of stakeholders, to mitigate the manufacturing effect of climate change along with other environmental issues (Jaiswal et al., 2018). Organizations have to implement physical strategies to run sustainable practices both within production facilities, across the

supply chain, and also through the consumer base (Mittal et al., 2013; Singh et al., 2020). In order to decrease the destructive effect on the atmosphere, there is an immediate need to boost manufacturing procedures which can decrease the waste generated by industries. The federal government must create policies, wherein the public and private sector banks must motivate the industry to adopt GM (Jaiswal et al., 2018).

It is the sustainability of manufacturing methods which will allow less use of natural energy and therefore entailing decreased amounts of pollution. Additionally, implementation of GM helps in the development of the economic system (Rehman et al., 2014; Mittal et al., 2016).

The quick development in the manufacturing industry in the past ten years has produced numerous green issues. In today's situation, the movement towards environmentally friendly products as well as businesses has strained the industries to search for alternate production processes to balance the manufacturing goals (Garza Reyes et al., 2014; Digawar et al., 2013).

It is apparent the GM implantation is necessary for developing nations as India, where SMEs are definitely the backbone of the nation. Government of started management advancement program (MDP) as among the sections of the national production competitiveness application (NMCP) in order to enhance the decision making power of supervisors of SMEs also to improve profitability/productivity (Gandhi et L., 2018). Manufacturing industry is essential for any developing as well as emerging economies to enhance the quality of living of the citizens of theirs (Lyer et al., 2014). The governments are under huge pressure to experience manufacturing growth especially in emerging as well as developing economies to enhance quality of life of the citizen of theirs.

The government must offer incentives on the market to motivate them for investment in environmentally friendly solutions in terminology of tax rebates, green performance awards, etc. The federal government must create policies, whereby the public and private sector banks must motivate the GM owner's subsisted loans to MSMEs for investments in environmentally friendly methods and environmentally friendly solutions (Rehman et al., 2015). Liu et al. (2005b) suggested that sustainable development has turned out to be the primary key policy by which green sources as well as management consumption could be done, despite constant advancement.

In this research work, a bibliometric analysis of the field of GM is discussed. An attempt has been made to visualize the bibliometric networks and present the associations among the dominated research concepts in green manufacturing. The bibliometric analysis based on the existing publication 2010 onwards. The literature showed only two bibliometric studies in the field of green manufacturing has been performed. Sangwan and Mittal (2015) performed the bibliometric analysis in this field using google scholar database and visualization the network was not presented in that research work. Setyaningsih et al. (2018) also performed the bibliometric analysis in this field which covers the time span from 1998 to 2017. The analysis part was restricted to Q1 and Q2 category journals only. In present work, a detailed bibliometric analysis is presented using network analysis to highlight and support the research gaps and suggestions are made for future research works in green manufacturing in Indian context. The next section provides the detailed bibliometric analysis of green manufacturing throughout the globe. Section 3 provided the bibliography analysis of green

manufacturing in Indian context. Section 4 discussed the existing research in different themes of GM. The last section presents the conclusion.

2. BIBLIOMETRIC ANALYSIS

The detailed bibliometric analysis of GM is performed using Scopus database. The methodology adopted in this research work is presented in figure 1.
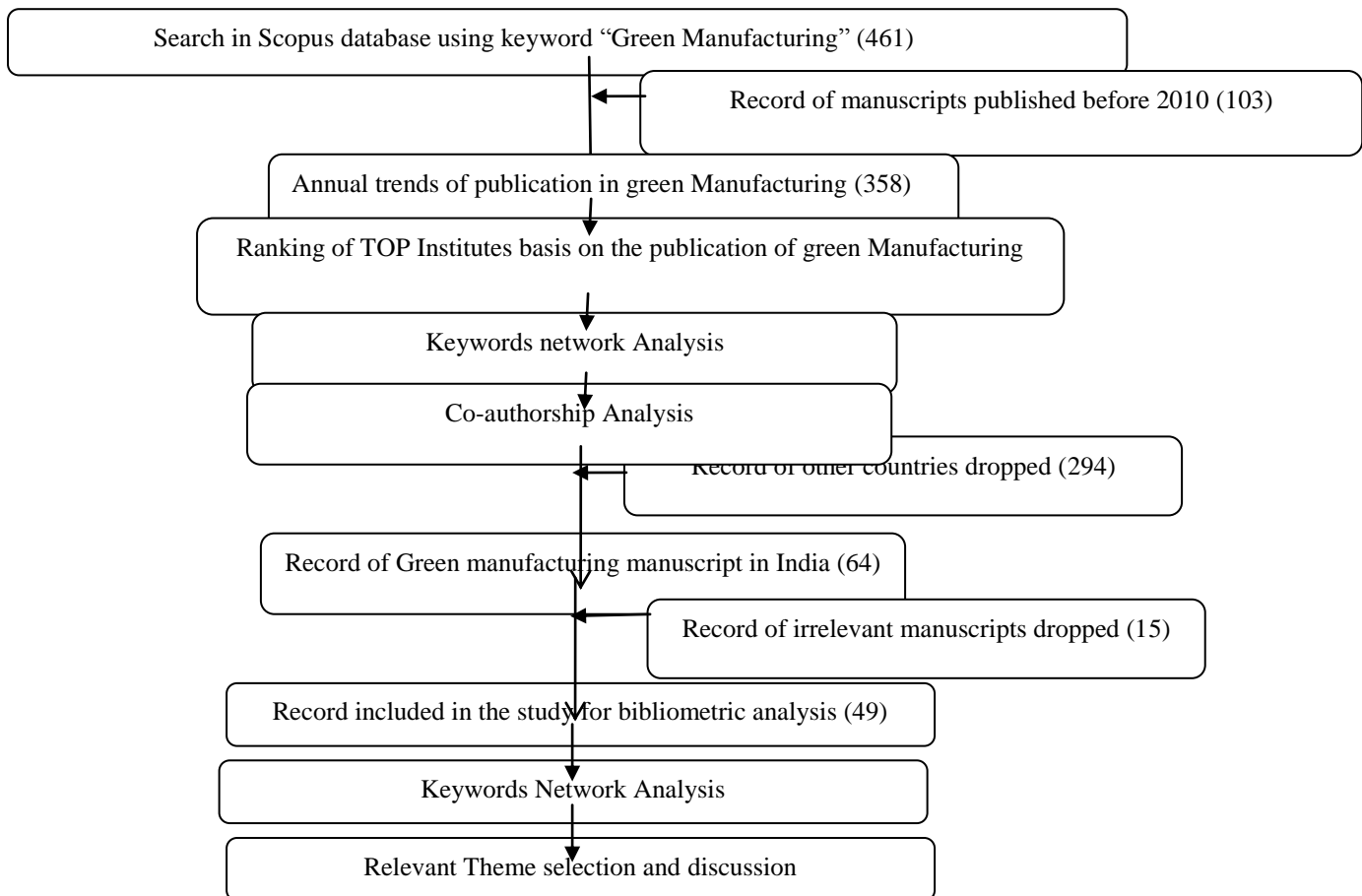

Figure 1 Flow chart of Present work

3. ANNUAL TRENDS OF GREEN MANUFACTURING PUBLICATION

The first manuscript was published in 1997 and it received low attention from researchers till 2004. In the time span of 2005 to 2009, 17 papers were published in 2009 and 11 manuscripts were published in 2006. The year-wise publication trends, 2010 onwards in this field is present in figure 2. China has published the highest articles and followed by India. India has published more articles than China in three year i.e. 2015, 2018 & 2019. United States has published more articles than India from 2010 to 2013. It seems that US researchers showed interest in GM till 2013 and after 2013, US researchers have not published many articles in this domain. In India, there were notable falls in the frequency of publication in 2019, however, in the current year, researches have again shown their interest and published the article in GM. China has also faced the same kind of situation in 2015, however, published more articles in the next year and still stand at first position throughout the Globe. China has published more than two times articles as published by India and more than three times

articles as published by US. It is clearly noticed that the total publication of India and US is less than publications made by China alone. This is a clear indication for all countries to accelerate the publication in GM to maintain their research value throughout the globe. Infact, countries should explore the research concepts to be aware as well as attract the researchers of their respective boundaries in GM.
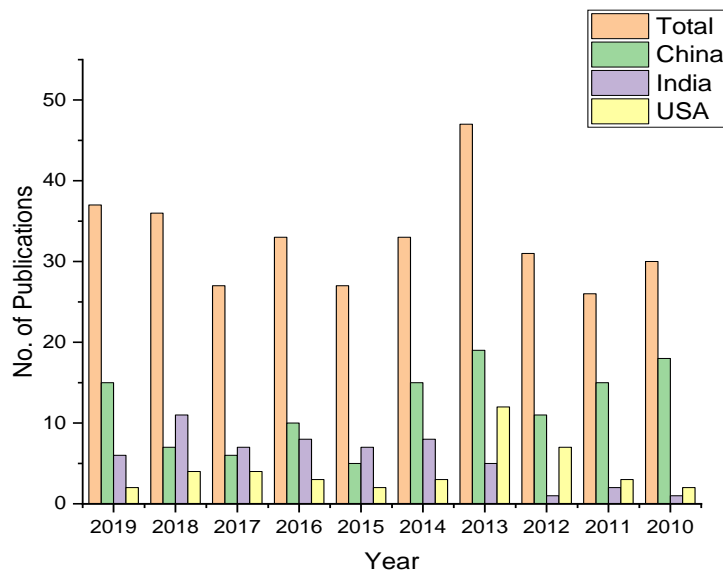

Figure 2. Annual trends of green Manufacturing

4. AFFILIATION DISTRIBUTION ON GREEN MANUFACTURING

The highest number of articles is published by Wuhan University of Science and Technology & Chongqing University and both universities belong to China. Birla Institute of Technology and Science, Pilani and Yeshwantrao Chavan College of Engineering are placed at rank 2 and rank 3 based on the number of articles published. Ministry of Education China and St.Vincent Pallotti College of Engineering and Technology have published 6 articles placed at rank 4. The five different institutes (one from US, Malaysia, India and 2 from China) have published the same number of manuscripts, therefore placed at rank 5. The top 11 institutes have published only 82 articles which imply that there is a large scope of research in GM as shown in Table 1.

Table 1 Affiliation Distribution on Green Manufacturing

Country	Institute	Number of articles	Rank
China	Wuhan University of Science and Technology	14	1
China	Chongqing University	14	1
India	Birla Institute of Technology and Science, Pilani	10	2
India	Yeshwantrao Chavan College of Engineering	7	3
China	Ministry of Education China	6	4
India	St.Vincent Pallotti College of Engineering and Technology	6	4
US	University of California, Berkeley	5	5
China	Tsinghua University	5	5

China	Northeastern University, China	5	5
India	Amity University, Noida	5	5
Malaysia	University Malaysia Pahang	5	5

5. TOP CITED ARTICLES AND CITATIONS

The top journals are shortlisted on the basis of documents published in GM. In present work, 9 journals are selected that have published at least 5 documents as shown in Table 2. It has been observed that Journal of Cleaner Production record for highest citation and h-index. Applied Mechanics and Materials has published the highest number of papers, however citations and h-index are significantly low. Both Sustainability and Key Engineering Materials have published 6 documents and have citations 54 and 10 respectively. International Journal of Production Research and International Journal of Precision Engineering and Manufacturing - Green Technology have published significant low documents, however records a high number of citations.

Table 2 Top cited articles and citations

Source	Documents	Citations	Category	Journal h-index	SJR 2019
Journal of Cleaner Production	19	609	Q1	173	1.89
International Journal of Production Research	5	129	Q1	125	1.78
International Journal of Precision Engineering and Manufacturing - Green Technology	6	123	Q1	27	1.41
Sustainability (Switzerland)	6	54	Q2	68	0.58
Applied Mechanics and Materials	29	21	NA	29	0
Advanced Materials Research	23	19	NA	33	0
Zhongguo Jixie Gongcheng/China Mechanical Engineering	5	13	Q3	22	0.22
Key Engineering Materials	6	10	Q3	50	0.18
IOP Conference Series: Materials Science and Engineering	11	7	NA	31	0.2

6. CO-OCCURRENCE NETWORK OF THE MOST FREQUENTLY USED AUTHOR KEYWORDS

Vosviewer software is used to present the co-occurrence of keywords with a minimum 6 occurrences of keyword. VOSviewer software was developed by Van and Waltman to visualize the bibliometric networks. In network, a term is represented by each circle, and the dimensions of the circle and font symbolize the activity of the term. The size of the circle is directly related to the activeness of the term in specific fields. The distances among terms the association between items and long distance indicate that there are weak associations and vice versa. Out of 2450 keywords, only 74 meet this threshold limit. The top 15 keywords are present in Table 3. The link strength shows the frequency of occurrence of a keyword. The term Total link strength shows the total strength of the co-occurrence of a keyword with other

keywords. The sustainable development and GM has total link strength, respectively, 445 and 1065. The word environmental impact appeared 31 times with total link strength of 189. It is clearly seen that keyword occurrence is directly proportional with total link strength.

Table 3 Occurrence of Keywords

Keyword	Occurrences	Total link strength
green manufacturing	246	1065
manufacture	195	996
sustainable development	68	445
industrial research	52	307
manufacturing industries	34	236
environmental impact	31	189
decision making	28	153
life cycle	27	162
energy utilization	25	149
sustainable manufacturing	24	137
supply chains	22	127
planning	21	144
manufacturing	20	65

The distance between two keywords represents the relation between them. The shortest distance indicates that there is a strong relation between two items. Figure showed that GM and sustainable development are closely associated with each other. Manufacturing companies and environmental impact belong to the same cluster, however the distance between environment impact and GM is significantly low. The colors help in recognizing the different clusters of as shown in figure 3a. Total seven clusters are formed which include the all 74 keywords. Cluster 1 consists of highest keywords i.e. 23 and represented by red colour. A total of 17 keywords are included in cluster 2 and shown in green colour. The shortness distance is observed from GM to manufacturing industry and product design as shown in

figure 3b. Green manufacturing assists in enhancing the performance of the manufacturing industry and design efficiency of a product. It is also observed there is a strong relatedness of GM with industrial research and sustainable development. Both industrial research and sustainable development are paramount domains for progress of a country and both can be enhanced with the help of GM.
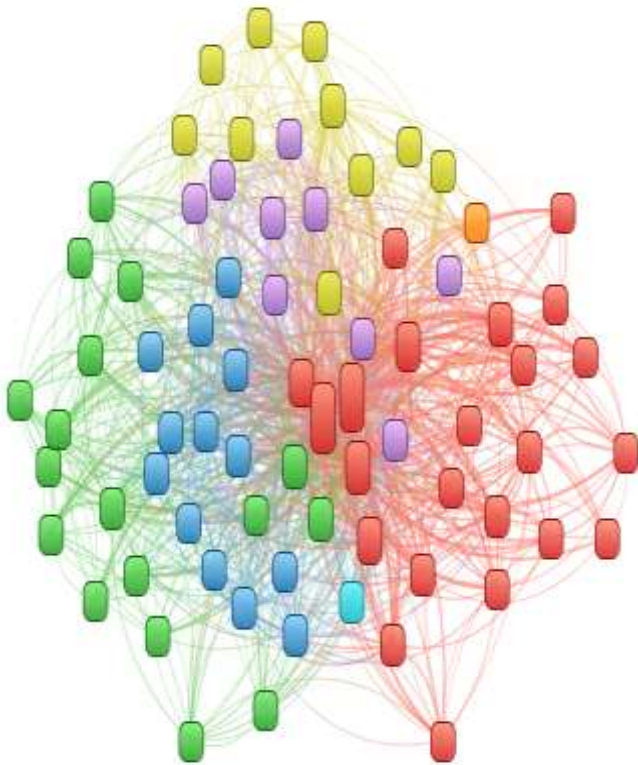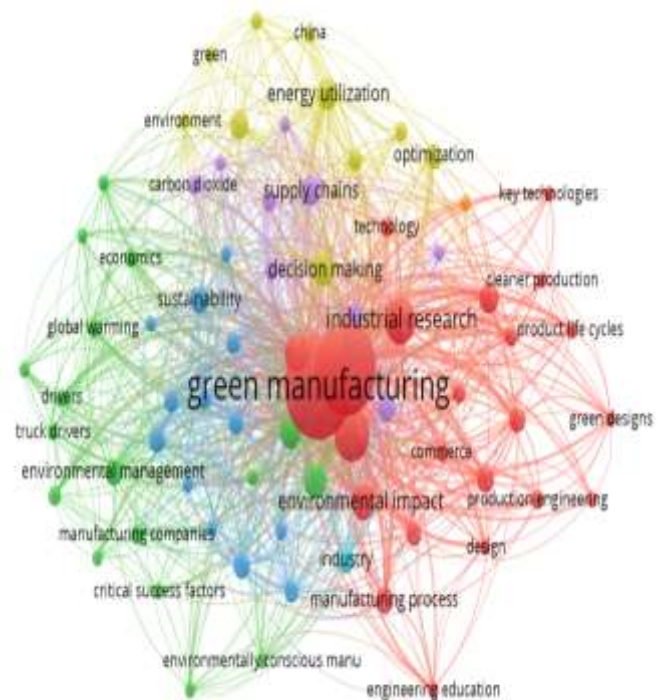

Figure 3a. Cluster of Keywords   Figure 3b. Keywords network analysis

7. CO-AUTHORSHIP NETWORK OF COUNTRIES:

It has been observed that a total 47countries have published in the domain of green manufacturing. In present work, only those counties have selected those who have published minimum 5manuscripts and also have minimum 5 citations. The below mentioned figure 4 showed the co-authorship analysis of 13 countries. It has been noticed that researchers in South Korea are doing collaborative research with the United States only. The United Kingdom is doing collaborative research with 8 countries. Researchers of India are doing collaborative research from only four countries viz. United Kingdom, United States, Australia and Germany. The notable finding is that there is no collaborative research between Chinese and Indian researchers in the domain of Green manufacturing. Researchers from Japan and France are doing collaborative research with 2 different countries.
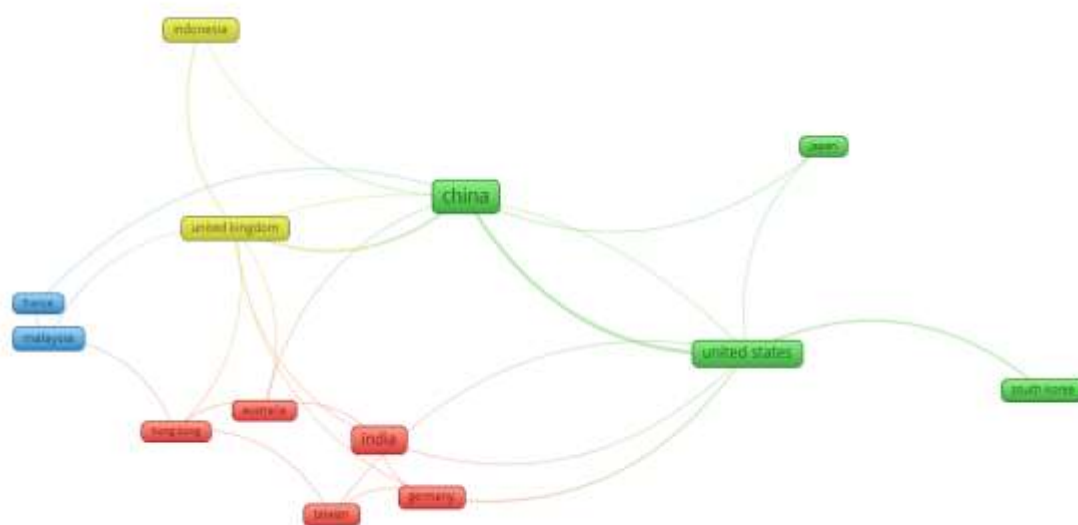
Figure 4 Co-authorship country wise analysis

Bibliometric analysis of green manufacturing in Indian context
Authors aim to provide the research gap and further directions in the field of green manufacturing. PRISMA focuses on ways where authors are able to make sure a complete and transparent reporting of this particular kind of investigation. The PRISMA guidelines are followed to make the analysis more effective. PRISMA is an evidence based minimum set of products targeted at helping authors to report a broad array of systematic reviews as well as meta analyses.

Initially, 64 research articles published 2010 onward in the scopus indexed journal were collected and further 49 research articles were shortlisted for further analysis.

Top states in India

An attempt has been made to present the analysis of the number of articles published by different states of India. Out of 49, 11 articles consist of affiliation of more than one state, in this case the affiliation of the first author is considered in this analysis. India consists of a total of 35 states. Highest articles are published by Maharashtra state and followed by Rajasthan as shown in figure 5. The notable finding is that none of papers is published by 24 states authors out of 35 states. Only 8 state authors have published two or more than two articles. It seems that authors of many states are unaware about the need of GM. This information will help researchers to analyze the existing research publication status in their respective state. The further analysis could be performed to reveal the facts for not doing research and publication in most of the states.
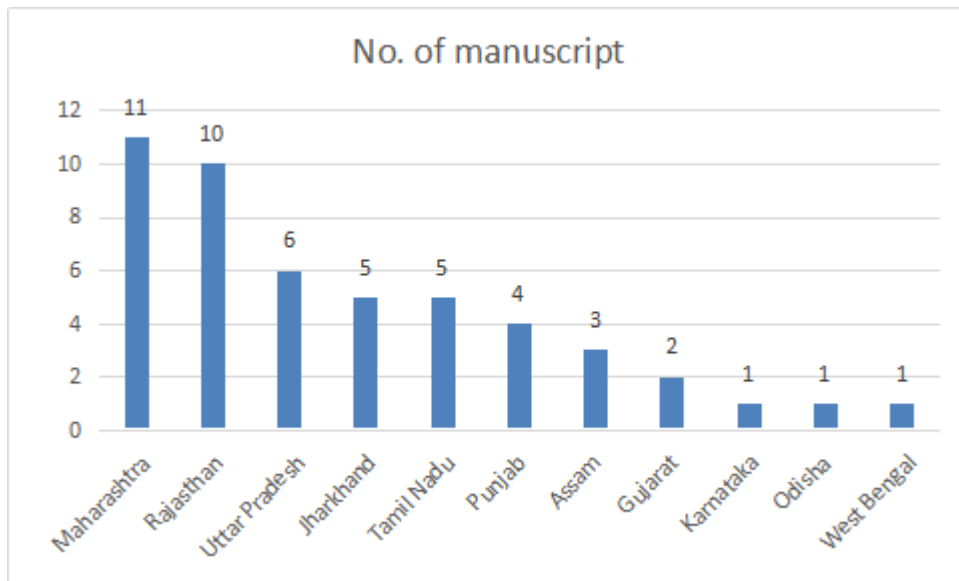
Figure 5 State-wise publication

Existing keywords Research on Green Manufacturing in India
Keywords network analysis is performed to present the existing research on GM in India. Initially, 9 keywords are shortlisted on the basis at least 5 occurrences. Three clusters are developed and each cluster contains three different items as shown in figure 6. Table 4 show the existing research covered on the basis of keyword. The first cluster contains green manufacturing (GM), environmental impact (EI) and energy utilization (EU) and the second cluster contains global warming (GW), greenhouse gases (GG) and life cycle (LC). The last cluster contains sustainable development (SD), manufacturing process (MP) and environmental protection (EP).
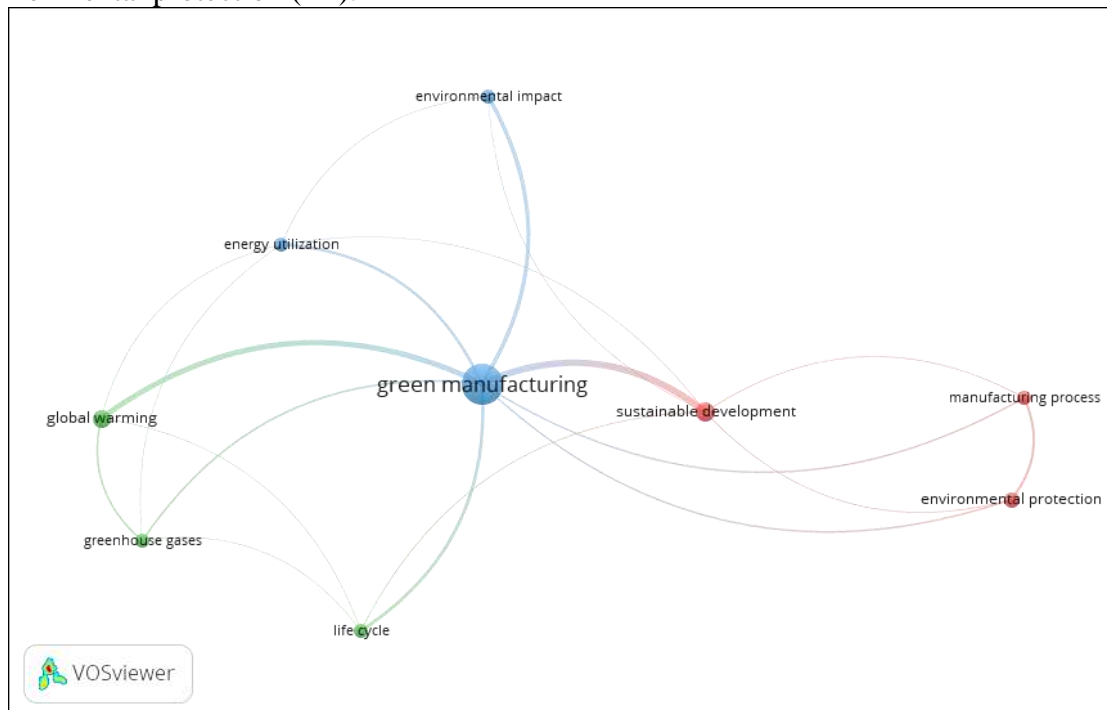

Figure 6 Visualization networks of keywords

Table 4

	EI	EU	GW	GG	LC	SD	MP	EP	Cluster	Weight
EI	-	√	×	×	×	√	×	×	3	5
EU	√	-	√	√	×	√	×	×	3	3
GW	×	√	-	√	√	×	×	×	2	4
GG	×	√	√	-	√	×	×	×	2	4
LC	×	×	√	√	-	√	×	×	2	4
SD	√	√	×	×	√	-	√	√	1	6
MP	×	×	×	×	×	√	-	√	1	3
EP	×	×	×	×	×	√	√	-	1	3

Exploring Research Gap in India context
Researchers have successfully explored the various dimensions of GM; however, few research contents are not studied till now as supported by network analysis.

Manufacturing process and Energy utilization:
There is large scope to perform the combined study of manufacturing process and energy utilization in relation with GM. The outcomes of network analysis showed the significance of both manufacturing process and energy utilization in the study of GM. In 9 keywords network, both manufacturing process and energy utilization have achieved the weight intensity of 3. The existing research is focused on either manufacturing process or energy utilization in the context of green manufacturing. Methodological parallels between manufacturing procedure optimization and operations exploration in the context of sustainable development were pointed out by a few writers (Rentz, 2003; (Mittal et al., 2013).
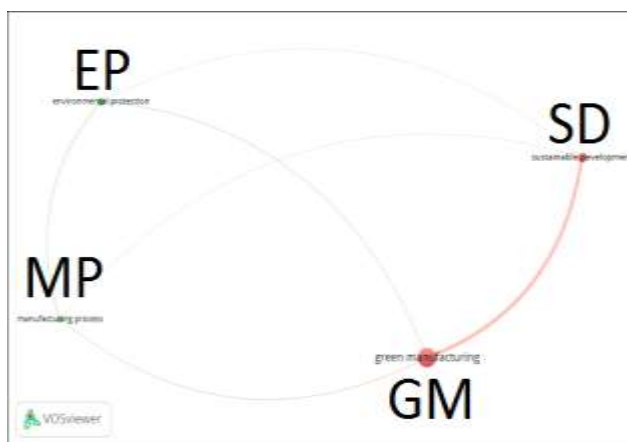

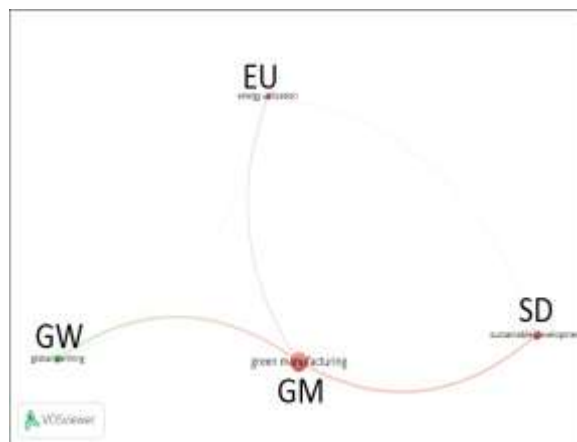Figure 7(a) Network of manufacturing process   Figure 7(b) Network of energy utilization

Figure 7(a) showed that the manufacturing process is studied with three research contents viz. environmental protection, sustainable development and GM only. Figure 7(b) showed that energy utilization was studied along with three themes i.e. SD, GW, GW. It is noticed that researchers have paid less attention to the study of manufacturing processes along with life cycle and environmental impact. It is advised to study the effect of life cycle and environmental impact, energy utilization along with manufacturing processes on GM in future research. Ball and smith (2012) proposed standards for modeling energy, material and

waste to see renewable manufacturing. Nevertheless, an additional driving element is the point that certain businesses are discovering recycling as well as remanufacturing being excellent companies which presents extra energy sources of revenue (Sangwan, 2011).

3.3.2 Environment Impact and Life cycle

Bibliometric analysis showed that both EI and LC research concepts are less studied along with MP in the domain of GM. There is more relatedness between EI and EU, however the distance is large between EI and GW. LC has more relatedness with GG as compared with SD. Both EI and LC both are the important theme of GM and it is recommended to study the combined effect of EI and LC on green manufacturing as shown in figure 8(a) and 8(b). Narayanan and Das (2014) provide a way for assessing as well as evaluating the green, occupational wellness as well as resource consequences of a merchandise at all life cycle phases. The proposed framework suggested that company environmentally friendly approach and eco oriented initiatives as critical driving forces for the achieving benefits of the GM methods and presented the impact of GM on economic and environmental results (Seth et al., 2018). GM has the ability to mitigate undesirable environmental impacts as well as source usage through the entire product life cycle.
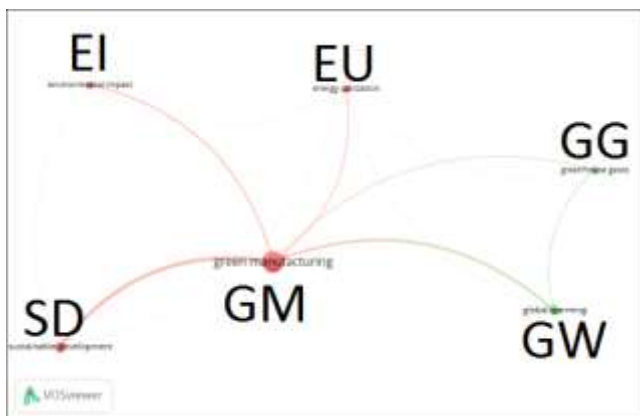

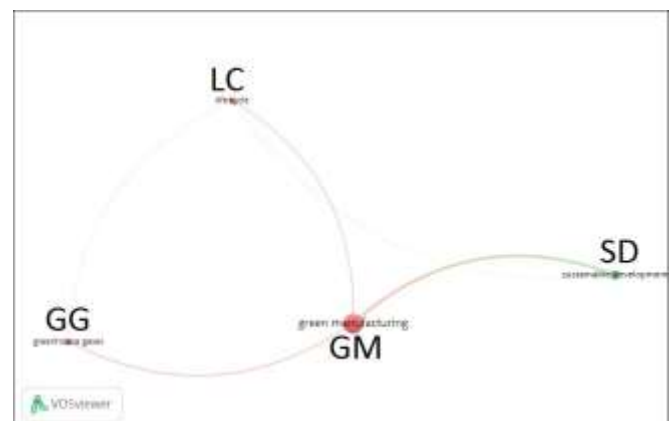Figure 8(a) Network of environment impact   Figure 8(b) Network of life cycle

Eco-friendly pollution plays a tremendous role in affecting both production and society development and in addition in manufacturing businesses (Dubey and Ali, 2015). Manufacturing is among the essential components of sustainable development as it makes items that are needed to focus on the requirements of the culture. There is a strong demand, especially in emerging as well as developing economies, to boost production effectiveness therefore there's much less manufacturing pollution, less material and power usage, less wastage, etc (Narayanan and Das, 2014). Education can be the important ingredients of good environmentally friendly and resource management, and therefore an important way of nudging the online business community towards an alternative development (Gutowski et al. 2005; Mittal and Sangwan, 2015).

GM provides possibilities to create global and local leadership. Soo and Quazi (2005) recommended specific performance measures by listing 7 elements identified as the primary key components of GM via reliability as well as validity analyses - major management commitment to green management, complete participation of workers, education eco-friendly product/process layout, supplier management, measurement as well as info management (Kalpande et al., 2013b). Noci and Azzone (1998) described many factors for deployment of GM techniques including change in production preparation, cleaner technologies, procurement policies, involvement of workers (Mittal et al., 2013). Zhou et al. (2008) described an environmentally friendly item using 6 characteristics specifically design and development, manufacture, packaging, transport and sale, use as well as recycling and maintenance as well as their variables/items (Toke and Kalpande, 2018). To green the organization results in advancement of environmentally friendly business image which improves market value in addition to function as a driving factor amongst organizations and this also may be achieved solely by management commitment (Mittal and Sangwan, 2014).

8. RESULTS AND DISCUSSION:

NVIVO software is used to collect the relevant themes from the published papers. Total 5 relevant themes viz. development, drivers, value, performance, process and energy are shortlisted which are more closely explored by Indian authors. The research carried out in each theme is discussed in details below:

Development:
El-Kassar and Singh (2019) discussed the role of GM methods in developing sustainable abilities. Data-driven processes involve collecting information based on measurable insights as well as datasets for producing much better advancement strategies and enhance information analysis accuracy (Belhadi et al., 2005). A conceptual design was created using literature review and established the linkage between enablers and barriers (Bhalaji et al., 2020). Because of the rapid development of natural manufacturing, lots of researchers focused the attention on specific themes such as drivers, energy etc. and conducted different studies with extensions, management should not overlook individual's advancement, product as well as procedure development for effective implementation of GM. Developed unit is going to be helpful to managers, decision makers, along with providers of GM in prioritizing the resources of theirs a bit more efficiently. For effective implementation of GM, management should concentrate on various factors of organizational functioning like good management determination, provider along with supplies management, products that are environmentally friendly as well as procedure layout, employee training as well as empowerment, etc. Furthermore, management must know structural connections between many different elements, which could assist in building techniques for effective implementation of GM (Sangwan, 2011).

Drivers:
It is essential to determine the vital driving factors which impact in adoption of GM. The drivers for integrated green and lean manufacturing are determined out of the combined assistance of current literature as well as experts' views in the appropriate area. It is suggested to focus on 5 most prominent drivers viz. technology, green brand image up-gradation, top management commitment, current legislation, and future legislation for effective implementation of LMGS in Indian manufacturing SMEs. A listing of 15 drivers accountable for successful implementation of integrated GM techniques is additional categorized in 4 categories depending on the implementation location of theirs in the organization: Market

drivers, Economy, and internal drivers, Policy owners, Society owners (Bisoyi et al., 2019). Choudhary et al., (2016) investigated the 12 typical drivers of natural production from the combined assistance of current expert opinion, industrial managers, and literature in the pertinent field. The two internal driver viz. enhance worker skill and machine utilization, standardize the operation process and eight external drivers viz. shorten manufacturing lead time, improve flexibility, reduce listing, improve quality, improve working atmosphere etc. were discussed for implementation of GM (Digawar et al., 2013; Singh et al., 2020). The findings also recommended increasing competitors would serve as the primary driver of GM practices. Whereas the primary key drivers are laws, client pressures, expected interpersonal responsibility as well as company advantages. In this category of drivers, the very first cluster is of independent drivers which have a sensitive driving energy as well as vulnerable dependence power. The other cluster is made up of drivers with weak driving strong dependence energy as well as energy. The 3rd cluster includes linkage owners which have a good dependence as well as driving power. The 4th group contains impartial motorists that have powerful driving energy along with a weak dependency power (Mittal and Sangwan, 2014). For Indian situation, different authors (Singh et al.,2014; Sharma et al., 2017) proposed that product design as well as product packaging are essential and drivers to be highlighted with far more stringent regulations from authorities to lessen impact on the environment (Sangwan and Mittal 2015).

Value:

The most effective benefit supply chains focuss on boosting crucial results and not just simply movement of the item from manufacturing device to customer ((Bhalaji et al., 2020). The goal of GM is achieving shortest likely cycle time by eliminating wastes from the whole benefit stream (Digawar et al., 2013). GM practices assist the organizations financially by assuring the better utilization of resources and also by obtaining worth using recycling (Shrivastava and Rehman, 2013). Employee empowerment, involvement as well as dedication, stimulate staff morale, staff development improve the factory procedure and value. The shift towards eco-friendly productivity, which looks ahead to socially right production as well as use aiming for worth development as well as resource conservation.GM is a vital element of using an alternative company which helps you to uncover secret worth for the company, while creating value for the atmosphere, the stakeholders, and the more community equally (Mittal and Sangwan, 2014). The standard methods for justification are based upon the use of the precious time value of money idea. Sangwan, (2006) created a functionality benefit analysis for the justification of GMS utilizing performance signs produced from literature review (Mittal et al, 2013). It is being experienced that in Indian context; using and developing more recent frameworks that attack on quality problems, wastes through as worth stream mapping (VSM) to provide value for the buyer (Rehman et al., 2016). Bonvoisin et al. (2017) comes with a structured framework defining 4 complementary aspects of renewable production, worldwide manufacturing,, value development networks, product development and viz. manufacturing technologies impacts.While increasing the revenue, companies must concentrate on unwavering quality, social responsibilities and customer value too numerous pressures on the businesses (Azhar and Jayanta, 2014; (Saxena and Khare 2015). At face value, living green may look like an impossible job for internet business excellence, but you will find an amazing amount of benefits (Seth et al., 2018). Noci as well as azzone (1998) described different elements deployment of GM techniques include alteration in manufacturing preparation, procurement policies, cleaner technologies. Benefit stream

mapping is an excellent application of lean manufacturing to minimize the wastage at virtually any approach by segregating great added and non value added pursuits.

Process:

The latest development in the techniques employed for process enhancement has additionally transformed the method of green performance (Cherra et al., 2016; Garza Reyes, 2015). Zhang et al. (2017) utilized a case study to show the power consumed throughout the manufacturing as well as maintenance operations in a product lifecycle. The goal of lowering processes mistakes as well as defects restricts the exhaustion of natural resources since more precision results in less source wastages (Chugani et al., 2017; Singh et al., 2018). Energy efficient technologies need to be applied consistent with the manufacturing process and also be updated constantly for industry efficiency (Belhadi et al., 2005). Eco-friendly manufacturing is described as elimination of wastages and also redefining present procedure to lessen the carbon emissions throughout every approach without increasing price and impacting manufacturing processes (Balan, 2008; Noci and Azzone, 1998; (Bhalaji et al., 2020). A pilot study done by Thakkar and Thanki (2014) suggests that Indian industries are doing badly in places as process and quality & system technology (Bisoyi et al., 2019). Smith and Melnyk (1996) define GM as a method which combines layout problems with problems of production process. GM consists of equipment as well as strategies to attain sustainable generation throughout the supply chain with green expenses in mind (Lyer et al., 2014).The insufficient regulatory framework is discussed to point the firms for producing green performance as well as efficiency. The participation of all levels of the workers is lacking to adopt new strategies and inefficient organizational framework hinders the flow of info to different levels of hierarchy. Florida (1996) analysis identified several typical greatest methods in between green and lean management systems (e.g. management determination, teams, brand new procedure engineering, innovative product design, and supply chain management) (Kushwaha and Talib, 2020).

There is a need to examine the manufacturers factors for the environmentally friendly impact in all phases of the production activity via source saving, elements along with recycling (Mittal and Sangwan, 2014). Eco-friendly processes have moved from being just end-of-the-pipe command to being an inherent consequence of system upgrades (Sawhney et al., 2007). An organization measurement system strongly impacts several manufacturing processes along with concerning peoples (Mittal and Sangwan, 2015). Smith and Melnyk (1996) defined eco-friendly manufacturing as a method which combines product or system layout problems with problems of manufacturing preparation. SP is described as the development of goods and services with processes and systems which are non polluting; conserving natural resources and electricity; economically viable; healthy and safe for employees, consumers and communities; and creatively and socially rewarding for those working people (Ellenbecker and Veleva, 2001). It highlights that for accomplishing general sustainability, a holistic perspective spanning the whole supply chain such as manufacturing program and processes involves enhanced product performance versions, predictive procedure designs (Narayanan and Das, 2014).

Performance:

Green consciousness of modern society is increasing day by day, reflecting manufacturing with several chances to enhance the green performance of manufacturing (Verma and Sharma,

2016). The GM methods have smart acceptance of businesses because they provide a systematic and practical more approach to attain sustainable functionality (Erdil et al., 2018; deFreitas, Ferraz and Costa, 2017). A framework is provided to implement green technology along with TQM and showed that there is a positive connection between GM methods as well as performance measures (Bhalaji et al., 2020). Noci and azzone (1998) defined eco-friendly manufacturing tactics as well as methods to apply them with regard to operations management to enhance the manufacturing performance. The clean and green supplier organizations are going to enable the parent group to adopt very similar green initiatives. Tseng et al. (2006) thinks that decreasing pollutants as well as waste materials at source is able to enhance the green, in addition to financial functionality of an organization.

Zhu and Sarkis (2006) think that eco-friendly design has immediate results on green performance, cost savings including lessening of cost for electricity use as well as costs for waste treatment and discharge. It is important for SMEs to create and make their green core competences to improve the green innovation efficiency. Zhan et al. (2016) proposed green methods and tools to enhance environmental and company performance. Sangwan, (2006) created a functionality benefit analysis for the performance measurement of GM using relevant literature and brainstorming. The factors such as functional strength, customer satisfaction, sales turnover, employee participation and emergency preparedness needs to adopt for linking the relation between implementation of and business performance ((Mittal et al., 2013)

GM is known as a mixture of techniques, initiatives, or actions which positively impact the environmental, economic or social performance plus assistance to mitigate the impacts of the firm's businesses (Alayon et al., 2017). It appears that businesses are under pressure from stakeholders to boost their environmentally friendly industry as well as overall performance image (Rehman et al., 2016). Soo and Quazi (2005) recommended primary key components such as major management commitment to green management, complete participation of workers, education eco-friendly product/process layout, supplier management for measuring the performance of GM. The top emphasis of a world management system (EMS) is preventing undesirable ecological consequences and enhances green performance by institutionalizing a variety of green methods including initiating atmosphere connected performance methods and building eco-friendly solutions, products (Gupta and procedures, 1995; Rehman et al., 2016).

Energy:

In the present era, with worldwide climate change as well as risks of source scarcity, the big energy dilemma will be here to remain. Among the new technologies which may be applied to contain the power situation to an excellent level is GM. GM helps in decreasing the energy use, gasoline or maybe sound emission, pollution, source wastage, along with any other harmful effects on the earth (Elfezazi and Touriki, 2018). Zhang et al. (2018) implemented an energy significant information acquisition in manufacturing assembly which reduced the power usage up to some extent. GM is a set of practices working to control green problems, including energy efficiency as well as decrease of misuse of healthy resources (Belhadi et al., 2005).

In general, re-manufacturing, reuse/recycle are just one primary technique of natural production, including tasks like decreasing dangerous waste volume, reducing coolant usage while machining, and calculating adequate power mixes to guarantee a renewable source of energy (Dornfeld et al., 2013; Choudhary et al., (2016). Rapid use of natural resources, developing energy expenditure, improving consumer understanding about eco aware goods

and also the necessity for consistency with ecological enactment with the development of environmentally friendly methods prompted the improvement of a GM strategy worldview (Gandhi et al., 2018). The limited natural resources & increasing energy need is slowing down the speed of improvement in advanced nations, meanwhile, the manufacturing industry of emerging nations is attracting worldwide interest due to untapped opportunity for development in terminology of human energy as well as natural energy (Jaiswal and Kumar, 2018). Karuppiah et al., (2020) the manufacturing sector use energy that is a lot of along with other energy and also emits a huge amount of natural house gases, which raises green issues including worldwide warming and climate change Customers are becoming increasingly educated about the environmentally friendly degradation, and they would like the product of theirs to be atmosphere friendly. Elimination of green waste as well as reduction of electricity usage by redefining the current production process/system is favorable for both industry and society as well.

The use of developing technologies in GM helps to change components into finished goods with reduction in electricity use, emission of greenhouse gases, use of toxic or non-renewable components. Pollution prevention methods on a single hand boost the manufacturing cost because of revolutionary technology demands and then again have the possibility to reduce the manufacturing cost as a result of decrease in resource and power usage, waste development and recycling (Narayanan and Das, 2014). Eco-friendly credit policy might additionally be utilized for funding tasks, like inexhaustible energy projects, environmentally friendly transportation, including energy efficiency improvement projects for energy intensive industries (Liu, et al., 2015). GM is a set of strategies concepts which minimizes energy usage, and also facilitates decrease in wastes, pollution and resources for the concerned business (Haleem et al., 2012). GM influences ecological and sustainability connected actions & consequently, ought to cover a lot more than air, clean water, land pollution, energy consumption effectiveness, waste development as well as recycling (Rehman et al., 2016). Industrial segment utilizes approximately 37 % of the global power generation and therefore, manufacturing should use much more efficient tactics as well as technologies to notice the renewable society dream. Waste to power is additionally an alternative for decreasing inexhaustible energy as well as energy costs source may be applied in consideration of vital options that come with GM (Islam et al., 2016). Sangwan and Mittal (2015) proposed a framework for implementation of GM in Indian SMEs in order to decrease emission, solid waste as well as a lesser amount of power usage.

9. CONCLUSIONS AND FUTURE SCOPE

The present research provides some notable findings by analysis and visualizes the bibliography networks on GM. There is little fluctuation in the annual trend of publication on GM. The number of GM publications in 2019 and 2010 is almost the same. It is observed that researchers have shown low interest in exploring the research concepts in GM. China has published the highest number of GM articles and top 2 institutes also belong to China. It is right to say that China is a forerunner in publications on GM. Keywords analysis revealed that green manufacturing is strongly associated with sustainable development; therefore, it is advised to perform more research on GM to assist the nation. The highest cited manuscript (215 times) on GM is authored by Rusinko, (2007), however she has not published any more articles on GM till now.

In India, authors of only two states i.e. Maharashtra and Rajasthan have published 10 or more articles on GM. The main four research concepts viz. sustainable development, life cycle, environmental impact and energy utilization of green manufacturing are explored in Indian context. The government must offer incentives on the market to motivate them for investment in environmentally friendly solutions in terminology of tax rebates, green performance awards.

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