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RESEARCH

Evaluation of the effectiveness of green practices in manufacturing sector using CHAID analysis

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Abstract

Productivity, profitability and sustainability have become the essence of business survival; thus, modern industrial establishments are turning into frameworks consistent with environmental objectives by adopting cleaner technologies, green practices have ultimately resulting in generation of fewer pollutants. Urbanization and burgeoning technological advancement in different sector within India have brought the concept of green supply chain management, to highlight the importance of responsible consumption and production to maintain environmental quality, reduce wastage and bring out economic growth. This paper aims to segregate the sustainable and competitive performers from the average ones in the Indian manufacturing sector and to understand the degree of the impact of green practices of supply chain management based on their contribution towards sustainable environment. Using survey method, data are collected from 54 manufacturing organizations from Pune Nashik area, and a comprehensive framework of sustainability measurement is developed through successive applications of *Chi-square Automatic Interaction Detector analysis*, CHAID analysis. This paper is unique as it has applied the concept of CHAID analysis for first time to identify green logistics as main driver to achieve a reduction of ecological damage and improve business performance.

Keywords Indian manufacturing sector · Green procurement · Green logistics · Green process and product design · Regulatory framework · Business performance · Environmental performance · CHAID analysis

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Introduction

Global resource exhaustion and deteriorating environmental conditions have put global organizations to find routes to curtail global greenhouse gas emissions and to put the world on a path to sustainable industrial growth. Sustainable environment is just not an initiative undertaken by government but it is an inclusive approach which demands the society to go for environmentally responsible production and consumption. Increased pressure from public and social forums, new tighter environmental regulations, rising cost of fuel, growing emphasis on corporate social responsibility (CSR), all these factors are thrusting organizations to improve their environmental standards. Faced by these pressures, modern leadership or management is expected to devise strategies which are environment friendly, aim to conserve resources, and harbingers economic growth, thereby creating better working and health conditions and sustainable environment along with refined efficiency and minimized cost. So they are going green by integrating sustainability into their organization's core strategies. Organizations around the globe are taking corrective measures by adopting best ecofriendly practices to create benchmarks by integrating sustainable Green Supply chain management (GSCM) activities right from conceptual stages till the recycling of the product. Greening not only brings resilience and sustainability in the supply chain but also becomes a pull factor for a number of other benefits like rewarding business, contented society and stakeholders, enhanced productivity and satisfied customers [1, 2].

Indian industrial sector has consolidated its position as a fast growing economy with a growth rate of 7.3% along with the growth of manufacturing sector at 9.5%[1] due to a strong backing by government led initiatives such as 'Make in India'[1], 'Invest India'[2], and 'e-biz Mission Mode'[2] projects. With construction sector at a growth rate of 4.5%, public administration, defence and other services at 6.4%, financial, real estate and professional services sector at 9.1%, Mining and quarrying segment at 8.6% and electricity, gas, water supply and other utility at 9.3%[2] are advancing very fast. Growth means progress, prosperity and at the same time it means that the country has to find a solution to the problems associated with the growth. On one hand, growing infrastructure is sign of booming economy and at the same time increased mobility, vehicular concentrations, congested and narrowing geographical landscape, poor road infrastructure and increasing pollution pose as major problems. Out of all the problems the one which needs prior and serious approach is the environmental concerns. Data available untill 2013 has indicated India as third largest contributor of global CO_2 emissions after China and USA.[3] In 'Biennial Update Report' (BUR) presented to the United Nations on climate change by India, energy sector in India is the largest contributor (71%) of country's total greenhouse gas emissions (GHG's) followed by agricultural sector (18%), Industrial Processes and Products Use (IPPU) sector (8%), and waste sector (3%).[4] Growing population demands a massive industrial, commercial and residential infrastructural development which in turn creates intense energy demand. Energy intensive industries such as iron and steel, chemicals, petroleum refinery, cement, pulp and paper are major contributor

[1] http://www.ibef.org/economy/economic-survey-2015-16.
[2] http://economictimes.indiatimes.com/news/economy/indicators/indias-growth-at-7-6-in-2015-16-fastest-in-five-years/articleshow/52522153.cms.
[3] https://www.iea.org/media/news/2015/news/151104_webarticle_CO2_FINAL.pdf
[4] http://www.dnaindia.com/money/report-energy-sector-emits-70-of-country-s-greenhouse-gases-2169900

of CO_2 emissions. Trends indicate that manufacturing sector contributes 27% of global GHG emissions with Iron and steel industry at 25% and cement at 6.8% of global man-made CO_2 emissions.[5]

The adoption and implementation of CSR and green practices GSCM in Indian industries is of utmost importance, however there have been identified some barriers. Goyal and Kumar [3] identified, ranked and discussed about the 10 main barriers of the CSR implementation in Indian manufacturing companies, finding that lack of money and passive attitude of consumers are the major barriers. Regulatory pressures [4], Lack of clarity on design guidelines [5], and lack of coordination between the environmental expert and green chain designer [6] also contribute towards non-implementation of green practices.

Indian Government is aware of its responsibilities and is taking proactive steps to bring this level down with a huge investment in the form of clean environment fund (collected from tax on coal mined and imported) along with signing bilateral agreements with USA on clean energy and climate change.[6] Moreover India has pursues a GHG program[7] (Greenhouse Gas Program) initiated by World Resources Institute—India, The Energy and Resources Institute (TERI), and Confederation of Indian Industry (CII), to address the overall management and measurement of greenhouse gas and to devise mitigation strategies for emission reduction, and strengthening and widening of scope for environmental improvement. The GHG program is meant to guide the industrial organization in measuring their emissions, spot opportunities to reduce it by setting short- and long-term term reduction goals.

A brief overview of the Indian manufacturing sector is provided in the appendix, along with its position with other sectors, in order to o get a better understanding of the manufacturing scenario.

The present study intends to explore the possibility of improvement in supply chain in Indian manufacturing sector, after the inclusion of sustainable green practices on different chains stages. The research intends to find answers to the following questions:

i. How to identify crucial factors/constructs/variables responsible for greening the supply chain?
ii. What are the dynamics of relationship among the identified factors and how does this relationship impact the implementation green practices?
iii. How do we finally measure the successful implementation of Green practices in supply chain?
iv. How to find out the effectiveness of green practices on environmental sustainability?

The approach for this research includes a review of literature to identify the constructs/variables of various green dimensions associated with supply chain in the next section. Then the paper proceeds with the methodology (CHAID analysis) adopted to collect and analyze the data in the proceeding sections. Our paper advances with main findings and implications for all persons associated with greening the supply chain along with the limitations and conclusions provided in the final section.

[5] http://www.ndma.gov.in/images/cbt/presentations/Ayumi%20Fujino%2013.10.11.pdf
[6] http://climatescorecard.org/2016/11/06/india-energy-production-trends/
[7] http://indiaghgp.org/

Literature review

Responsible organizations are aware of their environmental footprint and continuously strive to meet sustainability goal by adopting a holistic and systematic approach which is inclusive of environmental concerns at all levels of management [7]. There is no uniform rule for the application of green practices, every region offers variety [8, 9]. Organizations across the globe are adapting to green practices [10] by adding green to their supply chain processes [11, 12]. This green component includes green operations, green manufacturing, green design, reverse logistics, waste management [13] and continuous efforts are made by organizations to add green in all phases of a product's life cycle right from its design conceptualization till it's end disposal [14]. The reason behind this drive could be social responsibility or better competitive edge or boosting organizational efficiency [15, 16]; stakeholder's pressure [17, 18]; external and internal pressures [19–21], environmental concerns along with long term association with suppliers [22] and design of supply chain including reuse of goods for environmental stability [23, 24]. Greening the supply chain however does not appear to be a easy task, but, it needs careful, strategic and consistent approach to remodel the supply chain at all levels [7] in such a manner that it becomes a remedy to address ever increasing environmental concerns and the increase of ecological footprint [25]. It requires a crucial and strategic approach on the related parts of organizations to find a balance between economic and environmental performances so that they gain a competitive advantage to maintain their businesses viability [26]. The survival and success of their business lies in their ability to deliver the right product at right time, cost, quality, quantity and right form to the right customer. Simultaneously, they have to stay focused at their goals of better profit margins through reduced inventory level, reduced lead time in production, increased flexibility, forecasting accuracy, cost saving and accurate resource planning [27], which leads to bigger market share and better brand image, customer satisfaction and finally environmental sustainability too [28]. For a supply chain to be completely and successfully green, the organizations need to identify green enablers [29, 30], barriers to be overcome [31]; and ecofriendly activities [32] to be adopted. Eco-friendly or green practices have been integrated by many organizations right from design, production and distribution phases to the use of products by the end users and its disposal at the end of product's life cycle [14, 33]. Green design is the most suitable way for organizations to innovate, improve their brand positioning and enhance their business performance and communication [34]. Integrating green practices benefit the organization in multiple ways, reduction in energy consumption [35], reduction in emission [36], harvest of disposable products [37], and increased reuse of old material. Bhardwaj [38], developed a sustainable model based on resource-based theory and value chain analysis, including the drivers of sustainability. The researchers found a high importance to train human resources for adopting sustainable practices as one of the main drivers of GSCM.

An extensive study of literature provides us with the fact that many attempts have been made by researchers to understand the effect of integrating green practices at different stages of supply chain as we have read in the discussion above. However, the details at individual stages have been discussed in the succeeding discussions.

Green Practices are mainly integrated in procurement, product and process design, manufacturing, transportation/logistics and final disposal of product and its parts as discussed below:

- **Green Procurement** [20, 21, 39–43]

Since GSCM is seen as a strategic link binding two partners, promoting synergy and efficiency [44] by facilitating environmental performance, minimizing waste and saving cost [45]. The process must begin with a green purchasing or procurement for which, supplier selection is crucial as the supplier's environmental performances must align with organization's green goals [46]. Thus it is imperative for organization to encourage their suppliers to develop new source reduction strategies, devise ways of cleaner production and for which they need to collaborate with suppliers in designing green products, educate them through regular meeting, using different communication channels, create awareness through regular workshops and seminars and help in developing environmental programs for suppliers [47]. Fujitsu Group, a Japanese company has started a campaign to purchase environmentally friendly parts, materials, and products with the support of business partners as a part of their only green procurement policy.[8]

- **Green Process and Product design** [10, 11, 43, 48–50]

The scope of Green design, which has been limited to green product and green processes, needs to expand to sustainable ecology design [51]. The design of any product should be contrived in a manner where it causes minimum environmental hazards [52–54]. Design should take into consideration environment-friendly raw materials, parts and components to reduce energy consumption, emissions, and generation of solid and liquid wastes during production, transportation, storage and usage [50]. Product should be planned with biodegradable and recyclable materials [45, 50, 55–58] for easy disposal or recycle after use. Product's design should also have quick disassembly of products for reuse and recycling in its' framework [1, 59, 60]. Focus on green design should move from general/common process perspective to product based environment management system which also takes into account impact from supplier's and other stakeholders' operations [61]. Minimization of energy and resource consumption, air emissions and liquid and solid waste should also be agenda during designing the manufacturing process [62, 63]. Operational inefficiencies caused due to uncertainty and variability of material flows and production conditions can be improved by incorporating different production policies and selecting optimal policies related to specific business settings and further by evaluating logistic performance [64]. The main idea behind green manufacturing [18, 65, 66] is improvement in process and product developments and organizational capabilities through advanced technologies to manage the flow of environmental waste with the goal of reducing and ultimately minimizing environmental impact while also trying to maximize resource efficiency. Manufacturing strategies should/must promote economic use of energy and water [50] and material [45], preference for nontoxic or renewable material [10, 43], reduction in unwanted outputs, noise and air emissions and conversion of outputs into inputs-recycling [67]. Production planning can be improved by using an optimal production model [68] or by incorporating a framework for the use of RFID (Radio-Frequency Identification) technology to find a real time location of components [69].

DENSO, the leading Japanese global supplier of advanced automotive technology, is known for its eco-friendly, sustainable green design and manufacturing/assembly solutions, often referred to as the "monozukuri-reduction" of CO_2, focus.[9] With help of ISEE which

[8] http://www.fujitsu.com/global/about/procurement/green/
[9] https://www.denso.com/global/en/csr/environment report/management/ecovision/pdf/eco_vision_2025.pdf

means Intelligent Sustainable Enterprise Engineering, they fit eco-friendly, sustainable green design into their product design for assembly, assembly line design and factory management principles.

- **Green Logistics** [70, 71]

Green logistics includes green packaging which has green packaging material, size of the package, strategy for the return and reuse of packaging material in its distribution scheme [55, 72, 73], take-back and recycling [74], end-of-life product recovery [10, 45, 59], returns collection and recycling [58, 60], and customer cooperation for product take-back [58]. Dell's Global Fulfillment and Logistics (GFL) team has been making tremendous efforts to refine their global transportation and logistics network to achieve maximum efficiency with a minimal environmental footprint.[10] In another case, DHL has integrated a range of measures in logistics system to increase fuel efficiency and cut carbon emissions by modernizing their air and ground fleets, optimizing their transportation networks and employing through purchase of electric vehicles.[11] Green warehousing and distribution is aims at inventory reduction, usage of reusable containers and storage equipment, energy saving through alternate sources like solar energy or green roofing, optimized location of their distribution hubs [1, 60, 74]. It also comprises of an arrangement where transportation cost, energy, fuel consumption is minimized through the use of alternate fuel vehicles, economic size of the batches to be delivered and proper planning of routes [45, 56, 59, 75–77]. The Japanese researchers have promoted the concept of designing products for remanufacturing, encouraging reverse logistics by establishing a new collection channel, strengthening remanufacturing process by acquiring knowledge about better methods and also stimulating the demand for remanufactured product by controlling the product quality [78]. Saman and Amin [79], studied the Canadian secondary cellphone market with specific focus on chemical, physical, and recoverable parts of cellphones as well as the recovery choices.

- **Regulatory Framework** [29, 80]

The government regulations and legislations are major push factors in the adoption and implementation of green practices in supply chain management [81]. Environmental regulations help organizations to think strategically to pool their resources for improved cost, quality and organizational capability [82]. The organizations can perform and sustain better if they prepare themselves for regulations rather than reacting towards these [67]. Acquaye et al. [83] emphasized that industry-level benchmarking approach helps individual firms to compare their carbon emissions with other similar firms and enables the firms to tap their high target carbon emission hot spots for regulating their environmental performance. Elhedhli and Merrick [84] stated that carbon cost should be taken into account along with emission cost during the design phase of supply chain. Čuček et al. [85] suggested use of ecological footprints-based, graph-based, and mathematical programming tools for carbon footprint evaluations to monitor its impact on air pollution, noise pollution, and water pollution controlling regulations.

Various dimensions of sustainable supply chain process like Green procurement, Green Process and Product Design, Green Logistics, along with Regulatory Frameworks (IF) have

[10] http://www.dell.com/learn/us/en/uscorp1/corp-comm/earth-transportation-logistics
[11] http://www.environmentalleader.com/2016/04/how-ups-dhl-drive-emissions-cuts-efficiency-improvements-in-transportation-and-logistics/

been taken into consideration to understand their eco-friendly nature. These dimensions have been subdivided in 22 constructs based on expert opinion and extensive literature review and shown in Table 1. Eventually, environmental performances of the organizations have been measured on the basis of 8 parameters, which has been identified with the help of similar studies and tabulated in Table 1.

- Overview of research conducted in Indian manufacturing sector and methodologies adopted:

Numerous research studies about Indian manufacturing industries indicates that researchers have taken a strong interest in exploring the impact of green practices adopted by Indian industries, using a number of analysis and techniques to get accurate information on the success rate of green implementations. Delphi method for environmentally conscious purchasing decision based on AHP [40, 41], ANP to develop a six-dimension strategic decision

Table 1 Enablers of green supply chain and business performance

Performance:			
P1: Reduction of air emission			
P2: Reduction of solid wastes			
P3: Decrease of consumption for hazardous/harmful/toxic materials			
P4: Decrease of frequency for environmental accidents			
P5: Decrease of cost for energy consumption			
P6: Increase scrap rate			
P7: Sales			
P8: Market share			
Green Procurement-GP:	Green Logistics-GL:	SRM:- Green Process and Product Design	IF: Regulatory Framework
GP1: Providing design specification to suppliers that include environmental requirements for purchased Items	GL1: Recovery of the company's end of life products	SRM1: Designing products for quick disassembly	IF1: Central governmental environmental regulations
GP2: Cooperation with suppliers for environmental objectives	GL2: Environmental Improvement for Packing	SRM2: Designing products with bio-degradable materials	IF2: Regional environmental regulations
GP3: Environmental audit for suppliers' inner management	GL3: Taking back of packing material	SRM3: Informing suppliers about benefits of cleaner production and Technologies	IF3: Export countries' environmental regulations
GP4: Substitution of environmental questionable materials	GL4: Eco product life-cycle approach for distribution	SRM4: Urging/pressuring suppliers to take environmental actions	IF4: Establishing company's green image
GP5: Choice of transport by environmental criteria	GL5: Strategic factors to consider in reverse logistics include cost, overall quality, customer service, environmental concerns and legislative concern	SRM5: Sending in house company's auditor to appraise environmental performance of the suppliers	IFS: Sustainability business practices for suppliers
GP6: Taking environmental criteria into considerations			IF6: Use of cleaner technology processes to make saving (energy, water, wastage

framework for GSCM [86], Delphi and fuzzy extended AHP for ranking more most cooperative green supplier [87], ANP for supplier selection for hazardous substance management [11], fuzzy multi criteria approach for evaluating the environmental performance of suppliers [88, 89]; MCDM approach based on fuzzy DEMATEL, fuzzy ANP & fuzzy TOPSIS for evaluation of practices of suppliers [90]; fuzzy multi criteria approach foe categorizing pollution production, resource consumption, eco-design and environmental management system as environmental criteria [91], Interpretive Structural Modeling (ISM), [92] to understand the influence of one barrier on another.

Majority of the recent studies have been taken into account in order to get the latest updates on GSCM scenario in India. Variables of GSCM practices, performances, pressures, and barriers are major themes of these studies. ISM and AHP have been mainly used by researchers to initially analyze the survey data and find out conclusive results. A review of literature of Green supply chain management indicates that CHAID analysis has not been used in this context. Present study has taken CHAID (Chi-square Automatic Interaction Detector analysis) [93, 94] as the main tool for impact and effect of sustainable green practices adopted by Indian manufacturing sector.

CHAID analysis [93] is a technique or toolbox employed to discover relationships between a categorical response variable and other categorical predictor variables, where a statistically significant result identifies their mutual dependence and the relationship between them. CHAID analysis tries to look for patterns in datasets with multiple categorical variables and builds a model in form of a decision tree by splitting the sample or the target dependent variable. CHAID analysis is best for data with large sample size, as the predictor variables are repeatedly split to get categories with equal number of observations to get a final outcome or till CHAID analysis does not find any significantly discriminating in order to receive predictor any more. Since CHAID is best applicable in scenario for categorized value instead of continuous and clearly shows how variables best combine to explain the outcome in a given dependent variable, to outperform better than other statistical tools, such as basic kinds of regression.

CHAID is convenient to use in the case of multiple variables as it offers segmentation of one variable based on the effect of combination of a range of independent variables [95–97]. CHAID analysis has been used in number of research studies ranging from general consumer research (e.g. [98–101]) to predict stock price fluctuation for the stock market analysts [102], to predict bankruptcy and problems related to the mortgage and its classification [103], to analyze customer churning classification in credit card market [104], to categorize text document automatically and verify its usefulness by far in solving practical problems [105], to predict fraud in online business transaction under e-business environment and prove its prediction accuracy [106]

The present research is focused on predicting effectiveness of green practices (categorized into four green supply chain constructs/enablers and one organization environmental performance construct, each having multiple variables) adopted by Indian supply chain sector. CHAID analysis offers more flexibility to researchers to find out how environmental performance of the organization gets affected by the variables in 4 practices of Green Supply Chain Management such as Green Procurement (GP), Green Logistics (GL), Green Process and Product Design (SRM) and Regulatory Framework (IF) and one enabler of Business Performance (P).

The next section describes the methodology adopted to carry out the research.

Research framework

After the identification of the enablers/practices of green supply chain management through literature review, the focus is on to how on the collection of collect data. A survey of 175 manufacturing organizations from Pune-Nashik area is planned to gather data with the help of questionnaire. Data collected from 54 organizations is further analyzed with the help of CHAID analysis to understand the effect and impact of green practices in supply chain management. (Fig. 1):

Instrument: The instrument prepared for survey was given in the form a questionnaire [11, 107, 108] and was thoroughly vetted and evaluated by industry and academic professionals and it had the entire range of questions related to the theme along with some queries about the demographic details of the respondents. The information of responding organizations was related to (a) the company (size, sector, and business unit size) and the product (revenue from the product, life cycle, and innovation); (b) the sustainable green initiative in the area of logistics, procurement, process and product design and environmental regulations for improving environmental performance of the organizations.

Survey: A cross-sectional survey was conducted to gather data from a sample of Indian manufacturing plants in industries of Pune Nashik belt.

Research Area: The area chosen for research was Pune Nashik belt comprising of three industrial cities of Pune, Mumbai and Nashik. This area being the industrial hub of western India has a heavy concentration of manufacturing firms (as shown in Fig. 2 below) from above aforementioned said sectors and it is supported by appropriate Infrastructure facilities, water and power resources, competent manpower and an environmentally aware working and industrial class.[12]

Data Collection: A target of 175 companies was set but only 54 organizations contributing towards data collection. The teams sent for the collection were well-trained and had prior experiences of similar kinds and were able to identify lack of awareness as the main reason behind this response. The questionnaire was addressed to the plant manager, operations manager, or equivalent decision maker like General Manager and the Vice President [109, 110]; however, the top management was not further involved. Respondents varied from work experience in the ranges of 10–15, 15–20, 20–25 years and more than 25 years, with engineering as main educational background, though a few had MBA as additional degree. The questions asked to the respondents were based on their awareness about GSCM and corporate social responsibility (CSR) and ISO certifications.

Data Analysis: For analyzing the data the research adopted a two-fold approach:

a) The data collected is divided based on the adoption of CSR by the responding organizations. Then the variations and averages for the green supply chain management constructs are calculated for the green practices.

[12] http://planningcommission.nic.in/plans/stateplan/sdr_maha/ch-5-14-02-05.pdf

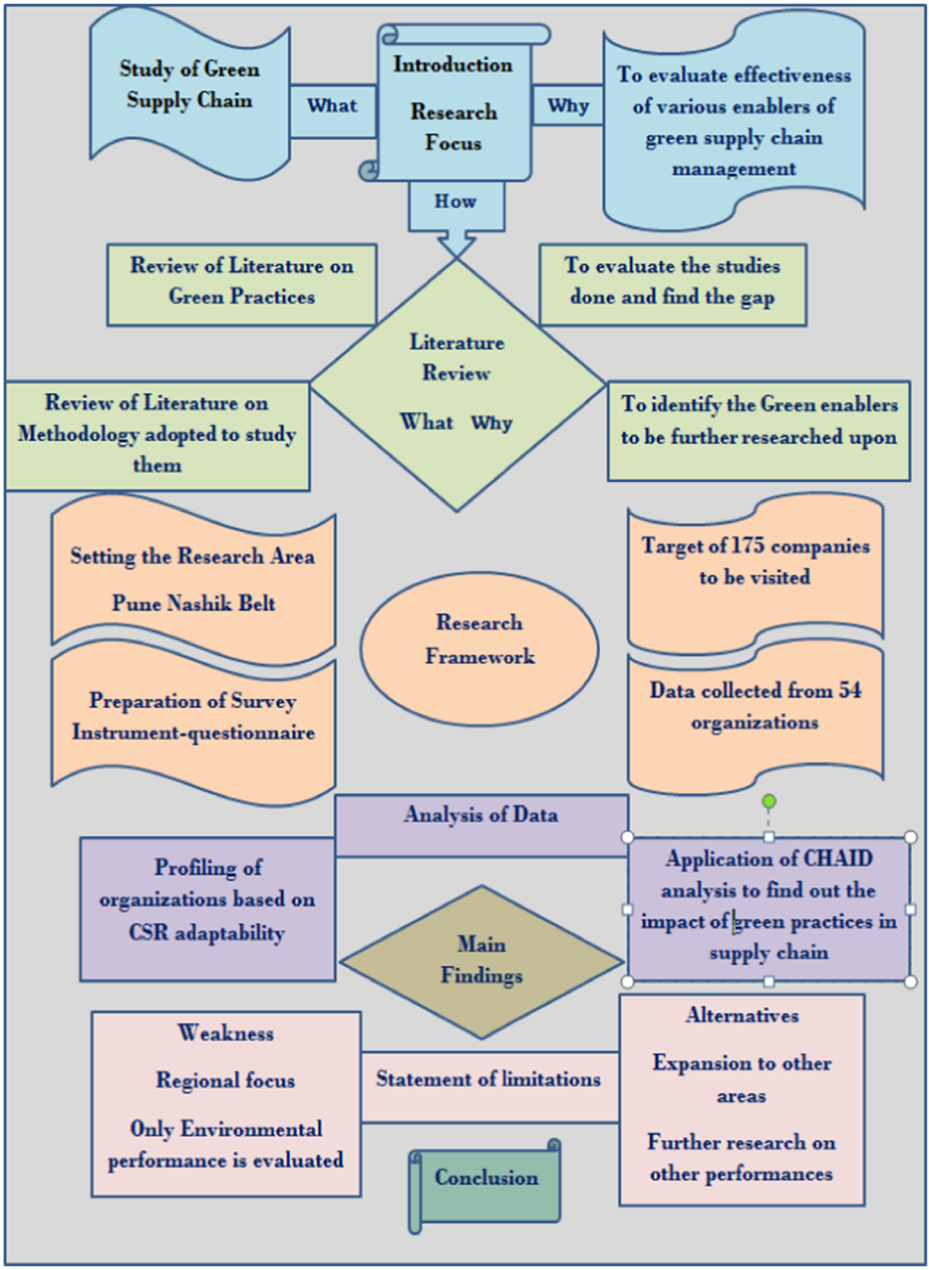

Fig. 1 Overview of the research process

b) The data is further analyzed with the help of CHAID to identify which activity out of four selected practice- Green Procurement, Green Logistics, Green Product and Process Design,, Regulatory Frameworks in the entire supply chain process has the best effect on the environmental performance of the organization.

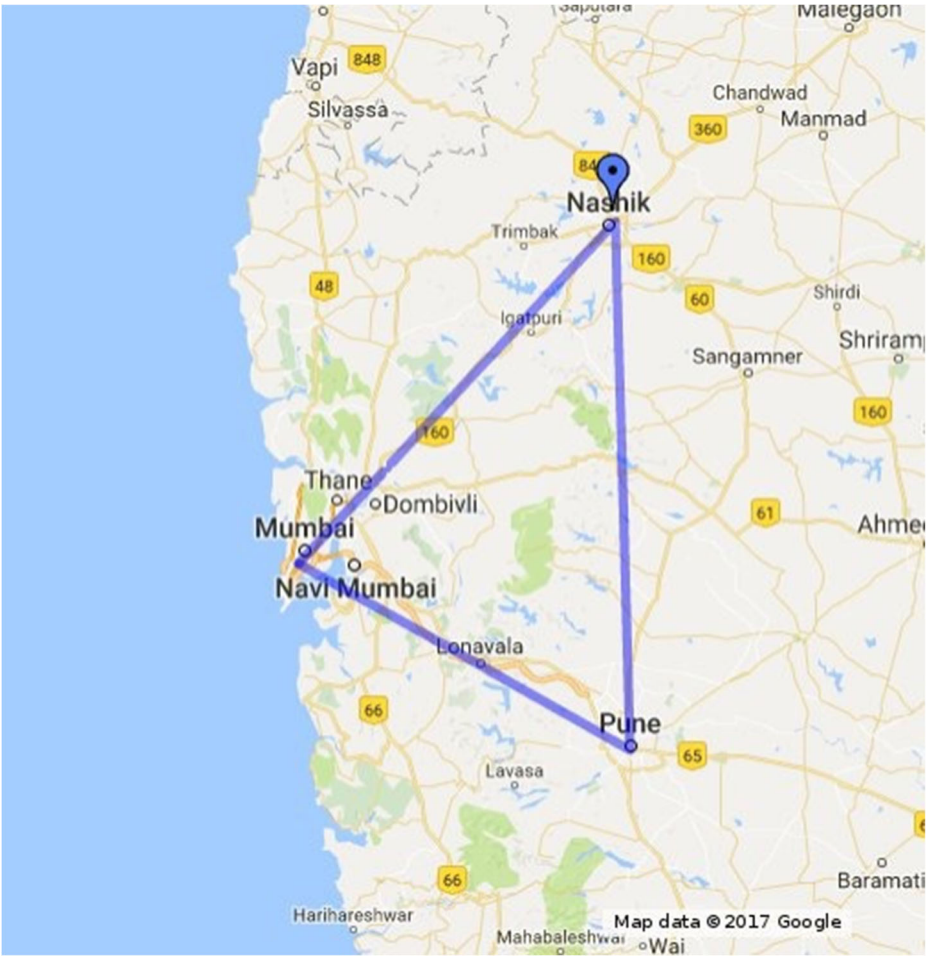

Fig. 2 Map of Golden triangle: three industrial areas of Mumbai, Pune and Nashik (http://www.dell.com/learn/us/en/uscorp1/corp-comm/earth-transportation-logistics)

The percentage of the various categories of manufacturing sector is reflected in Appendix Table 2, where automotive section placed at 14 (25.9) of total responding organizations share is the in the lead. This is followed by machinery with 6 (11.1), electrical goods manufacturing 5 (9.3), pharma 4(7.4), wood and wood products 4 (7.4), food products 3 (5.6), plastic products 3 (5.6), rubber 3 (5.6), cement 2(3.7), electronic industry 2(3.7), steel unit 2(3.7), Textile product 1(1.9), optical instrument 1 (1.9), lubricants 1 (1.9), graphite electrodes 1 (1.9), basic metals and fabricated metals 1 (1.9).

Out of 54 organizations, 45 organizations have a working CSR department where as other 9 organizations though have sustainability as a part of their corporate vision but have no CSR departments (cf. Appendix Table 3). Most of the organizations in the manufacturing sector are required to get certifications for environmental benefits so ISO 14001; ISO 9001[13] are suitable

[13] http://www.isoindia.org/iso_ISO_140012004_Certification_in_India.php

though not compulsory certifications for Indian organizations. ISO 14001 is an integral part of the European Union's Eco-Management and Audit Scheme (EMAS).[14] ISO 9000 and ISO 14001 quality management systems are applicable to all types of industry and operations and evaluate the organizations based on the size and nature of their business. Organizations from cement, automotive, infrastructure food and beverages, food products rubber and machinery, electronics industry, pharma, plastic products, electrical goods manufacturing have ISO 14001 certification and majority of our respondents are ISO 9000 certified (cf. Appendix Table 3).

Table 3 (in Appendix) reflects the result of CSR integration amongst industries as per various constructs, out of 45 organizations who have CSR department the mean and standard deviation for Green procurement (GP) is 2.95 and .66 respectively; mean and standard deviation for green logistics (GL) is 3.29 and.84; and for regulatory framework (IF) is 2.81 and.76 and for green process and product design (SRM) is 3.25 and 0.68.

Figure 3 gives clarity about the results. Here the relationship between the effects of the implementation of sustainability concepts gets reflected. The organizations with CSR departments and without them have 'Y' and 'N' as starting points, respectively. The spider web diagrams shown in Fig. 3 indicates that the organizations from machinery and lubricants categories reflect a maximum effect of sustainable green enablers as number of companies covered are higher in this categories, indicating maximum CSR initiatives by these organizations. They are followed by organizations from rubber and plastic categories which further are followed by automotive and steel unit categories. The organizations with least numbers are from electrical goods manufacturing category. Though these organizations have CSR departments, but the number of responding organizations from these categories are relatively lower. The organizations which do not have CSR departments have also been taken into account. In this section, the organizations from basic metal and fabricated metal category have the minimum number of organizations from optical instrument category. It is to be noticed here that few organizations from automotive, cement, wood and wood products, electronics industry and pharma categories have no CSR departments. The result of our study collaborates with the findings that rubber and petrochemicals, chemicals, food products electrical machinery from manufacturing sector are top contributors with 66.0% of total revenue[15] in manufacturing coming from them.

The data collected is further subjected to CHAID Analysis to understand the impact of various green practices on the environmental performance of the organizations.

- CHAID Analysis.

CHAID algorithm is applied by us to disclose the effectiveness of various enablers of GSCM on each other for green supply chain data. It is ideal to choose one classifier which helps in finding the mutual impact of effectors or variables on each other. CHAID or decision trees are excellent tools for data classification and forecasting as they provide an effective structure where one gets an opportunity to display one's options in the form of a tree where one has dependent variables which is related to independent or predictor variables via the branches of a tree, and all the possible options are displayed in the form of a complete tree, approximating all the relationships.

The process begins with setting of a depending variable as the root node and the independent variables as parent nodes which are further split into branches. During the splitting

[14] https://en.wikipedia.org/wiki/ISO_14000
[15] http://www.makeinindia.com/article/-/v/direct-foreign-investment-towards-india-s-growth

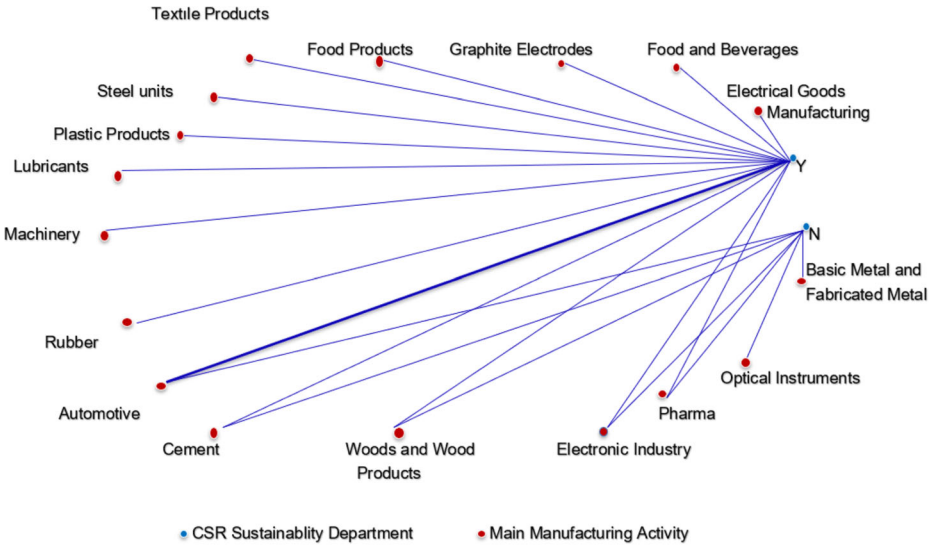

Fig. 3 CSR integration in various industries of the manufacturing sector

process the unnecessary or irrelevant data gets pruned thereby stopping the enlargement of the tree.

As the theory of decision tree has following main parts: a root node or starting point; followed by branches or child nodes representing flow of questions to answers. CHAID Procedure is as follows:

Step I: Selection of a root node or dependent variable to calculate its optimal value

Step II: Selection of predictors or parent nodes and their combinations.

Step III: Building the classification tree by further splitting the parent nodes into child nodes or independent variable categories. With the help of chi square and F test, p values of the predictor variables are calculated to find significant discrimination. If the p values are significant, then a split is made which leads to formation of a tree structure (considering a p-value of less than 0.05 to be statistically significant).

Step IV: Once the initial split is made with two or more nodes (depending upon the values of an independent or predictor variable), the process is continued with splitting at each node. Each node is treated like a new subpopulation which further gets bifurcated untill final node also called leaf is obtained. Final decision is made based on the observations of each leaf, which is subject to the context of our study. Eventually, we receive the terminal or the final category of significantly different predictor variables having maximum influence on the root node or dependent variable.

The process begins with choice of a data-mining algorithm to classify the data and to identify in appropriate clusters; then, a further analysis is made so that the much needed knowledge required to make decisions is obtained. This study has used IBM SPSS Statistics program for preprocessing the modeling study, data cleansing, and merging and conversion process. Decision Tree algorithm was applied to find results of CHAID algorithms on IBM SPSS Modeler 11.1. IBM SPSS Decision Trees enable the exploration of results, and the visual

determination of how the model flows. This helps to find specific subgroups and relationships, in fact, are that are impossible to obtain with more traditional statistics.

The data received through that process are further subjected to CHAID algorithm to explore the result through the visual flow of the data in the form of a tree. This serves to help in clearly showing the specific subgroups and relationships which are otherwise difficult to predict by traditional statistics.

Since this study aims to find out how organization's environmental performance gets affected by the green practices adopted by an organization; herewith, its organizational performance is the response variable or the classifier. The predictors or dependent variables are Green Procurement-GP, Green Logistics-GL, Green Process and Product Design-SRM, and Regulatory Framework-IF.

- CHAID Algorithm.

The target or root node in present case is organizational performance and the attributes are Green Procurement, in short: GP, Green Logistics-GL, Regulatory Framework-IF, Green Process and Product Design, in short: SRM. The aim of our study is find out which attributes of parent nodes have highest influence on root node '0', i.e., to verify which respective dimensions out of all four, GL, GP, IF and SRM, has a highest effect on the environmental performance (recorded by CSR Sustainability department) of the organization. A total of 54 organizations have been surveyed to collect data who have integrated green elements into various activities undertaken by them. The results of CHAID analysis are shown in Figure no. 4 below. Here, main manufacturing activity refers to the activities which were made in manufacturing sector like Automotive, Basic Metals and Fabricated Metal, Cement, Electrical goods manufacturing, Electronics Industry, Food & Beverages, Food Products, Graphite Electrodes, Lubricants, Machinery, Optical Instruments, Pharma, Plastic Products, Rubber, Steel Unit, Textile Products, Wood and Wood Products. The four dimensions of GL, GP, IF, SRM are dependent variables which impact the manufacturing activities which eventually impacts the independent variable -the organizational performance.

The data collected is run through IBM SPSS Statistics program for preprocessing the modeling study, data cleansing, and merging and conversion process and finally subjected to CHAID Algorithm. The result obtained after subjecting it to CHAID is shown in the calculation in Fig. 4 above.

However, for better clarity and understanding, these calculations have been shown the form of tree diagram in Fig. 4a below along with the resultant values (Authors are having original software file of above Fig. 4a).

Figure 4b: CHAID's Tree showing effect and impact of green sustainable practices based on Fig. 4a

n = number of records in a node
%- distribution frequency at each node

Predicted: expected penetration of positive influence on the adoption of green practices i.e. improvement in green performance of organization as a result of integration of green sustainable practices such as

1. Starting from node 0 or root node which is organization's environmental performance n = 54 which is the total number of organizations under consideration. Integration of green

a

Fig. 4 CHAID Algorithm. **a** CHAID's Analysis showing effect and impact of green sustainable practices. **b** CHAID's Analysis showing effect and impact of green sustainable practices

practices in logistics activity results in a mean, which is giving a mean ranging from 2.600 to 3.800 at four different nodes.

2. Node one has 12 organizations with a mean of 2.600 who have adopted green logistics-(GL). Now these organizations are further split into categories working within the confines of regulatory frameworks (IF). 4 out of 12 (Node 2) organizations have not given regulatory frameworks (IF), whereas 8 (node 3) have followed. It is to be noted here that variance in predicted category is higher at Node 2 (4.125/3.188 = 1.29) when compared with result at Node 3 (2.719/3.188 = 0.85).
3. These are further splits into categories, which have an integrated green process and product design (SRM).

The standard deviations, SD, are as follows: For Node 4 is 0.87, Node 5: 0.91, Node 6: 1.14, Node 7:1.01, and for Node 8:0.96. This clearly indicates that organization at node 4 have a high intensity of green process and product design (SRM) in their system, followed by 2 at node 5, 1 at node 8, 2 at node 7 and 2 at node 6, with less intensity of green in their design process.

4. At node 9 we have 5 organizations in range of 2.600 to 3.000 who have integrated green logistics (GL) into their system. These organizations are further split based on their green manufacturing activities. It can be seen that 1 organization from steel unit category and 1 from plastic products category have the smallest variance, namely, the nodes 12, 13 (2.250–2.220 = 0.030). These sectors have evolved their manufacturing process with the aim to reduce waste, noise, water and energy wastage. Automotive sector (node 10) comes

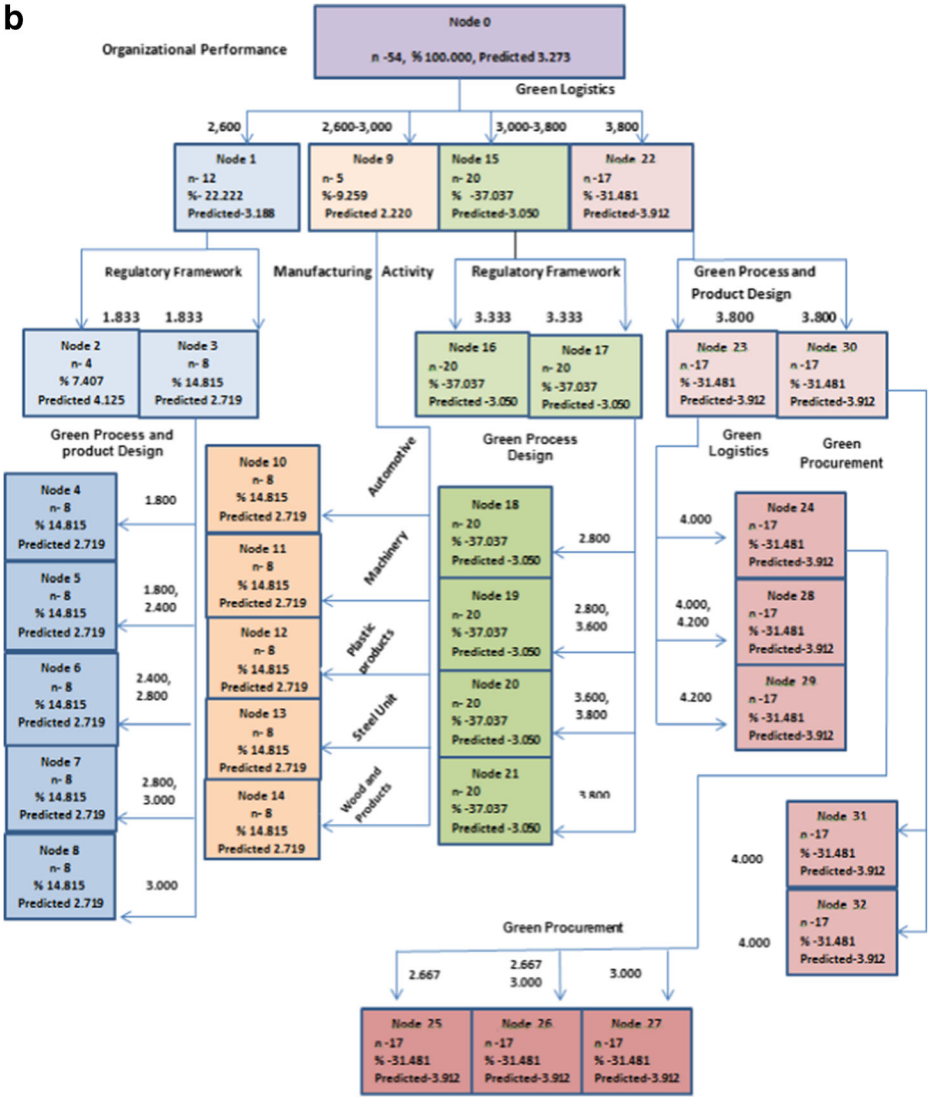

Fig. 4 (continued)

close to second with a variance of (2.220–2.125 = 0.95), whereas machinery (node 11) and wood products (node 14) sectors show variance of 0.405, and 0.47, respectively indicating the gap in the implementation of green practices.

5. At node 15, there are 20 organizations with a mean in the range of 3.000 to 3.800 with green logistics (GL) implementations. Out of these 20 organizations 14 have not followed regulatory frameworks (IF) whereas 6 are working in accordance with regulatory Framework (IF). These organizations cited pressure from government, customers, society and long term profit as main drive for following the regulations. Out of these 6 organization, 2 organizations (node 19) had variation of (3.375/3.521 = 0.9585) which is least of the rest, at node21(3.250/3521 = 0.92), node20(03.135/3.521 = 0.8875) and node 18 (4.000/3.521 = 0.2840).

6. At node 22, there are 17 organizations with a mean of 3800, which have gone for green logistics (GL). These 17 organizations have further integrated green process and product design (SRM) in their supply chain system. 8 out of 17 organizations (node 23) show variance of 3.656/3.912 = 0.93), whereas 9 organizations (node 30) show variance of (4.139/3.912 = 1.05). This means that organizations at node 23 are having better environmental performance. These 8 organizations (node 23) are further split to find out which reflects lesser variation after integrating green logistics (GL). There are 3 organizations (node 24) with variation of (3.375/3.656 = 0.92), 2 organizations (node 28) with variation (3.750/3.656 = 1.025) and 3 organizations (node 29) with variation of (3.875/3.656 = 1.05). 3 organizations (node 24) showing more variation are further split to find the impact of Green Procurement (GP). This split leaves 1 organization at (node 25) with a variation of 3.250/3.375 = 0.96), another single organization at (node 26) with a variation of 3.500/3.375 = 1.03) and one organization at (node 27) with a variation of (3.375/3.375 = 1.00) which is optimal.
7. 9 organizations at (node 30) are further split on the basis of integration of Green Procurement (GP). Out of these 9 organizations, 8 at (node 31) show a variation of (4.078/4.139 = 0.985) and one organization at (node 32) show a variation of (4.626/4.139 = 1.11).
8. Now further split is not possible as the *p*-values are insignificant and it leads to no-formation of the tree structure.

CHAID analysis provides a foundation to understanding the involvement or exclusion of green practices along the various steps or processes of the entire supply chain and the final outcome. As it is clearly visible from the reading of CHAID tree diagram, the organizational environmental performance which is the root node in the present context, gets affected by various green practices referred as parent node. Green Procurement-GP; Green Logistics-GL; Green Process and Product Design-SRM; and Regulatory Framework-IF are taken as the parent nodes here. After dividing the parent node, we get child nodes which are sub-practices of respective green practices or parent node (cf. Table 1). Now out of these child nodes, those sub-practices having maximum impact on root node or environmental performance in this case have been categorized as terminal node. These terminal nodes or maximum impact factors are branching out from a green logistic parent node. As we can see that commonly adopted practices by majority of organizations come under the category of green logistics, so this green practice is supporting organizations to achieve their sustainability goals.

The application of CHAID algorithm gives a clear indication of GL-Green Logistics as the most important variable having a maximum impact on the environmental performance of the organizations. When organizations aim at '*Recovery of the company's end of life products*', '*Environmental Improvement for Packing*', '*Taking back of packing material*', '*Eco product life-cycle approach for distribution*'-and focus on '*Strategic factors in reverse logistics including cost, overall quality, customer service, environmental concerns and legislative concern*',, then they achieve their desired results. Other variables in order of importance are: Regulatory Framework (IF), Green Process and product Design (SRM) and Green Procurement (GP).

Main findings and discussion

Manufacturing sector in India, which is one of the key drivers of India's economic growth, is on a high-growth trajectory after major initiatives were taken by present government. Though

it is facing challenges like underperformance and lower productivity due to multiple reasons, yet it has started to show a sign of improvement leading to better outputs. One of the reasons of such a better reasons is the implementation of green practices by leading manufactures across the country. The organizations in plastic and steel units, automotive, and machinery clearly have stronger commitment towards a cleaner, greener and sustainable development and they excel in energy and environmental efficiency.

This sector has effectively adopted waste minimization strategies like recovery and recycling and conservation at source-utilization of waste through internal recycling and selling to outside agencies. Most of organizations in this area are converting to the railway mode of transportation in order to reduce vehicular pollution, and they use conveyor belts for movement of raw material inside manufacturing facilities. Increasing environmental concerns, stringent government rules and environmental policies have brought the desired results like reduction in particulate matter emissions, specific effluent discharge, reduced carbon dioxide intensity, and lesser water consumption.

Following them closely are organizations in the categories of rubber and lubricants which have adopted cleaner technologies and various pollution control systems. Other categories are ranked in descending performance order as: textile products and cement; wood and wood products; food products; graphite electrodes and electronics industry; food beverages and pharma industry.

The organizations from and basic and fabricated metals, electrical goods manufacturing and optical instruments backgrounds need to go for sustainable systems for supply chain competitiveness by building a value chain inclusive of all stakeholders, training through workshops leading to responsible utilization of resources. Out of all green practices, Green logistics (GL) has been valued the most for improving the Organization's environmental performances, as indicated by the results of CHAID algorithm.

Managerial implications

From the above discussion it is evident that various stages of green supply chain have major impact on the environmental performances of organizations. Since research has been undertaken on decision trees and CHAID analysis have been used for finding the best result, it is expected that the present study gives decision makers or scientist in this field some insights which they need to make some new developments. Our study can help the strategist to capitalize on future trends in the supply chain sector, and devise strategies to respond to challenges before they happen.

In the area of Green Procurement, the structure of operation and technology opted by the suppliers needs managerial interception for a better degree of control. This will help them to first select and then improve their supplier's technologies and alternates for an enhanced green performance. When it comes to 'green product and process design', frameworks are definitely there but visibility on the success of a particular framework is not so evident. More research or managerial interventions should be focused on exploring the finding out the barriers which are hindering the adoption of green process and product designs. Green logistics has been favoured in the present context as a major winner yet there is a need for better green performance measurement strategies. Furthermore, there is a lack of literature on packaging practices of the organizations and environmental audit of suppliers, which need more research.

While going through the process of research, it has become evident to the researchers that there is a lack of knowledge and a lack of coordination between the green models selected by the organizations and actual operations conducted by them. Most of the managers here need to ensure that there is a perfect match between selected policies and models and operational executions. As they move along the length of supply chain process, development, validation and application of various policies and models require a definitive green process oriented framework, coordination and cooperation among crucial players, and flow of control at an individual stage of green process. This will enable to keep the representation and working of green supply chain smooth by eliminating complexities rooted within the individual stage of green process and, hence, will impart detail and clarity at individual and entire process level.

Limitations

This research was carried out on the organizations situated in Pune Nashik belt according to the convenience of the data collectors. To generalize the results for larger groups, the research should be conducted in other organizations, spreading across different cities of the country. Eventually, the organizational performance has been measured from the environmental perspective only. The economic and social performances have been left out. Further studies should be conducted to cover the areas that had to be left unattended in our present investigation.

Conclusions

Global markets are under pressure for sustainable environmental and business performances. Therefore, modern organizations are improvising their manufacturing style to green manufacturing for competitiveness and for promoting the organizations environmental and financial performance simultaneously.

The paper presented the result of the survey conducted on manufacturing organizations in Pune Nashik area with the purpose of finding the better performing manufacturing activities responsible for greener and sustainable development and improved energy and environmental efficiency. Manufacturing organizations in plastic and steel units, automotive, and machinery categories have managed to deliver desired results though not up to the expected standards when the scientific journey has begun. This study has also identified crucial categories like basic and fabricated metals, electrical goods manufacturing and optical instruments which need to consider on areas found lacking. Using CHAID algorithm the effect and impact of green practices/enablers –green procurement, green logistics, green process and product design, and regulatory framework on organization's environmental performance-is calculated. Green logistics has the competitive edge over others in improving the business performance and reduction of environmental pollution.

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Appendix

Table 2 Industry analysis based on Summary statistics of the sample

Frequency	(%)
Valid Automotive	14 (25.9)
BasicMetals and Fabricated Metal	1(1.9)
Cement	2(3.7)
Electrical goods manufacturing	5(9.3)
Electronics Industry	2(3.7)
Food & Beverages	1(1.9)
Food Products	3(5.6)
Graphite Electrodes	1(1.9)
Lubricants	1(1.9)
Machinery	6(11.1)
Optical Instruments	1(1.9)
Pharma	4(7.4)
Plastic Products	3(5.6)
Rubber	3(5.6)
Steel Unit	2(3.7)
Textile Products	1(1.9)
Wood & Wood Products	4(7.4)
Total	54(100.0)

Table 3 Division of responding organization based on presence and absence of CSR

Categories of manufacturing sector	CSR Present		
Y	CSR absent		
N	Total		
Automotive	13	1	14
Basic Metals and Fabricated Metal	0	1	1
Cément	1	1	2
Electrical goods manufacturing	5	0	5
Electronics Industry	1	1	2
Food & Beverages	1	0	1
Food Products	3	0	3
Graphite Electrodes	1	0	1
Lubricants	1	0	1
Machinery	6	0	6
Optical Instruments	0	1	1
Pharma	3	1	4
Plastic Products	3	0	3
Rubber	3	0	3
Steel Unit	2	0	2
Textile Products	1	0	1
Wood & Wood Products	1	3	4
	45	9	54

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