

# Review of Green and Sustainable Indicators for Indian Supply Chain Networks

Anoop A.T., Nithin Joseph, Regi Kumar V.

**Abstract:** Sustainability and Green are the thrust areas rising to prominence across every part of business, environment and society in the twenty first century. The mounting anxiety with the environment, in particular the possibility of climate change due to global warming has led to the attention on how human and economic activity has the potential to harmfully impact the sustainability of the planet. In this age of ambiguity, with the scarcity of resources and competing demands, finding the identical resources is the key challenge that supply chain managers are facing. The supply chain fulcrum that balances the demand and supply defines sustainability as “meeting the needs of the present without compromising the ability of the future generations to meet their own needs”. This paper reviews a set of open, inclusive and natural set of indicators to measure sustainability of the supply chains. The main objective of this study is to differentiate the green and sustainable concepts in the literature and to identify the stand alone indicators in association with the future supply chain models. This study reviews a publically available indicator set and provides a categorization of indicators that are quantifiable and clearly related to supply chains. The work is also envision to establish an integrated sustainability indicator array as means to provide a common access for academicians to learn about current indicators and measures of sustainability. This paper considers Indian scenarios of growth as the reference framework for sustainability and development.

**Index Terms:** Green, Sustainability, Sustainable Development, Sustainability Indicators, Sustainable Supply Chains

## I. INTRODUCTION

Industry plays a predominant role in fuelling economic development and expansion because of its transformative effect on production processes and the capital it creates through the addition of value to primary resources. Industry offers the foundation for entrepreneurship, helps business investment, advances technological up gradation and dynamism, progresses human skills, generates jobs and creates opportunities from which both agriculture and services might expand.

Rapid growth in Indian economy in the past two decades procured tremendous benefits, yet it has also highlighted the demand for energy and natural resources. Between 1980 and 2010, India mark it a growth of 6.2% while the world as

whole pick up a growth rate of 3.3%. India’s share in global GDP more than doubled from 2.5% in 1980 to 5.5% in 2010.

For India, eradication of poverty and inclusive growth should be the governing objectives of the activities in the post 2015 development agenda.

While sustained growth is vital for further rising living standards, convening India’s poverty reduction objectives, as well as food and energy needs, it ought to be made greener and sustainable. Attempts are therefore needed to increase energy and resource efficiency, especially through lower fossil fuel consumption, acceptance of clean technologies, sustainable agriculture, effective waste management, sustainable logistics management, etc. [1]

A continuous growth is important to meet the priorities and to further increase the living standards. Making inclusive growth demands high, sustainable economic growth. The economic growth rises the level of energy and material consumption which subsidize to the environmental issues and resource exhaustion problems. As an outcome of the redoubled economic activity all over the world, the level of greenhouse gases has risen substantially over the years. It has become significant for organizations fronting competitive, regulatory and community pressures to poise economic performance and environmental performance. Nowadays, ‘go green’ attempts are increasingly accepted by forward thinking organizations as concern to environmental sustainability. It is difficult to get universal agreement on the best means for limiting greenhouse emissions, there is a wide spread acknowledgement that action is required.

Instead of limiting the focus of attention to reducing greenhouse gas emissions, it is significant to identify the effect of economic activity on the use of scarce resources across the value chain as a whole. Whilst there is an understandable concern that the supply chains carbon footprint should be minimized, it must also be recognized that supply chain decisions have a broader impact on resources generally. Sustainability creates and maintains the condition under which humans and nature can exists in productive harmony, that fulfilling the social, economic and other requirements of present and future generations. [2]

The sustainable drive from the grassroots to the global level has been enriched by the many different versions of sustainability articulated in scholarly and popular writings and international conferences. This paper reviews a set of open, inclusive and natural set of indicators to measure sustainability of the supply chains. The main objective of this study is to differentiate the green and sustainable concepts in the literature and to identify the stand alone indicators in association with the future supply chain models. This study reviews a publically available indicator set and provides a categorization of indicators that are quantifiable and clearly related to supply chains.

**Manuscript published on 28 February 2014.**

\* Correspondence Author (s)

**Anoop A.T.\***, M.Tech Scholar, Department of Mechanical Engineering, College of Engineering, Trivandrum, India.

**Nithin Joseph**, M.Tech Scholar, Department of Mechanical Engineering, College of Engineering, Trivandrum, India.

**Dr. Regi Kumar V.**, Associate Professor, Department of Mechanical Engineering, College of Engineering, Trivandrum, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

The work is also envision to establish an integrated sustainability indicator array as means to provide a common access for academicians to learn about current indicators and measures of sustainability. Indian scenarios of growth as the reference framework considered for sustainability and development.

### II. GREEN VERSUS SUSTAINABILITY

A broad range of activities and issues are encompassed in green and sustainable concepts. The latest expression of this cacophony is evidenced in the emergence of green talk and growing substitutions of varieties of 'greener' for sustainability and sustainable development. Today, green has established itself in our vocabulary as an adjective, noun and verb. Green and sustainability often use interchangeably, yet both are different axioms.

Green isn't sustainable. A car can be considered green simply because it manages to deliver good mileage and less emission but it's considered unsustainable if it still demands the extraction of fossil fuels. In the same way, any product made of wood is clearly green but isn't sustainable if they are harvested in a destructive way. Sometimes both these terms are used interchangeably. When green talks and green practices are promoted by fundamentally unsustainable companies they easily congeal into a deceptive ideology known as 'green washing'. To overcome the confusion between green and sustainability, a thorough examination of both axioms is needed.

#### A. Green Terminology

Green is characteristically associated with individual products and processes that try to find the 'low hanging fruit' that is available in abundant supply in a country where waste remains a scandal in many realms of market and industry. Green represents the environmental-friendly look of products, process, systems and technologies. Most companies in developing countries take up green solutions to their businesses tries to reduce the negative environmental effects rather than adopting a proactive approach to reduce the sources of waste or pollution. Green practices are ideologically clean practices that do not fundamentally disturb the driving forces of economic growth and cooperate profit making. [3]

#### B. Sustainability

Sustainability is a multilevel attempt which considers product, processes and entire supply chain networks. Its opportunities break through the mass production and consumerist consumption without boundary, signaling for an elevation in the outlining of human wants. Sustainability at all levels will act as a driver for innovation, business growth, environmental protection and social well-being.

Sustainability is attached to the complete system of which individual consumer products and other commercial material are a part. Organizations deliver sustainable strategies through markets. The raising number of businesses and the liberalization of markets making more competition which claim new business strategies to sustain in the market. The posture of 'zero impact' will be substituted by sustainable strategies which will make a positive influence without affecting the triple bottom line criteria.[4] To achieve excellent triple bottom line performance, new modes of economic, social and environmental strategies are essential. Competing organizations must shift from natural agitation to

new forms of symbiosis, to grasp areas that none of the partners could hope to achieve on their own.

Sustainability and Green are connected axioms. Green isn't totally sustainable, but sustainability features 'green' in it. Green covers the triple bottom line of sustainability with more focus on the environmental and economic dimension. To achieve a long run effect on growth, sustainability is the effective and efficient standpoint that a strategic manager should consider while decision making. For even and sustainable pathways, green practices can do miracles in creating social, economic and environmentally sustainable production and consumption modes. By greening or sustaining the natural resources and ecosystem services, the current generation steward's or supports future generations to meet their needs.

### III. INDICATOR SET REVIEW

An indicator set is a group of indicators that contains a universal view of sustainability. The categorization delivers a rational structure to inclusively integrate all the possible indicators. Organizations can choose to evaluate sustainability for their products and processes associated with manufacturing. Merging indicators and evaluating them together in different dimension is a practice to calculate the sustainability. Interpretability of an indicator set is an important issue because of the complications in the cross-relationships of indicators. Also, a number of different conclusions exists about the level of sustainability, the measurement of sustainability and what can be done to improve it. Because of these difficulties, a number of Sustainable and Green indicator sets and indices have been developed by organizations for an attempt to match the various levels of decision making for sustainability. Examples are Global Report Initiative (GRI), Dow Jones Sustainability Indexes (DJSI), Environment performance index (EPfi), United Nations Indicators for sustainable development (UN-CSD), Organization for Economic Co-operation and Development (OECD) etc.

Compared to indicator sets, indices deliver a more conventional conclusions on the level of sustainability because they depends on weight based mathematical methods to aggregate many indicators into a single score. With this single score, a sustainability level can be set and used as a metric for performance. [5] Environmental indicators specify effective means by which multifaceted environmental data can be converted into easy to use communication and decision making tools that can trace the state of environment and measure progress towards sustainability. To measure the state of the environment and the relationship between environmental, economic and social development, indicators play a key role. Various sustainable measurement tool kits are openly available in the public literature, for organizations to provide simple aggregations through point by point consideration of indicators. Many sets and indices have a focus on the sustainable development of region or country. Examples are Environmental Sustainability Indicators (ESI), EPfi, Environmental Pressure Indicators for European Union (EPri), European Environmental Agency Core Set of Indicators (EEA-CSI) and International Organization of Standards (ISO 14031).



A set of indicators, Sustainable manufacturing tool kit published by OECD is a good reference for organizations under developing countries. It provides 18 indicators on input, operation and products. Standard indicators provides a dependable and repeatable means for organizations when they evaluate their level of sustainability and allow comparison between products, processes, companies, sectors, or countries. After reviewing the publically available indicator sets, we selected, defined and categorized a set of indicators that can be used for Indian supply chain networks. Engineers and Managers can consider this set of indicators for measuring the sustainability and the greenness of their organizations.

IV. SUSTAINABLE SUPPLY CHAIN INDICATORS

All supply chains have a ‘center of gravity’ compelled by demand and supply. The current situations of demographics and spreading of wealth across the globe generates market instability and unpredictability causing a rethink on current supply chains structures. In order to assist massive markets with wide range of products to supply for customers with greater flexible spending power demands innovative supply chain changeovers. Future supply chains with high levels of structural flexibility are fit to deal with the levels of volatility that are feature of the twenty first century business environment.

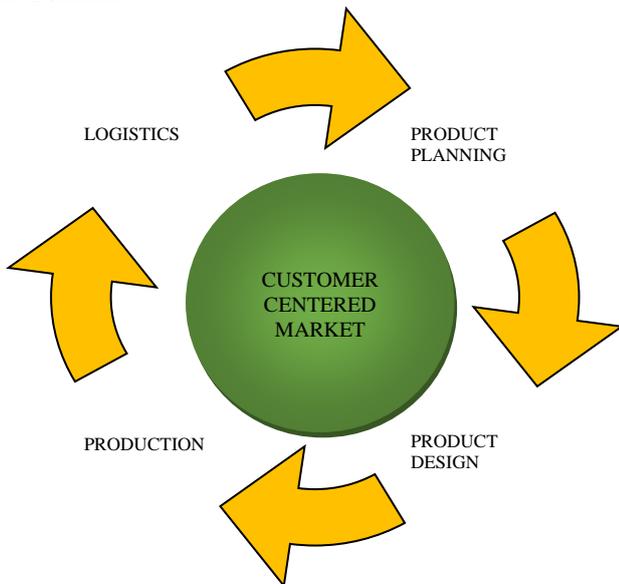


Figure 4.1 Supply Chain Centre of Gravity, Buyer's Market

Indicators are well established means for defining, tracking and improving sustainability. A good indicator should be measurable and reliable. The data can be easily accessed and acquired within the organization or product system. The evaluation for an indicator must be done in a timely manner. Indicators should be long term oriented, relevant and understandable. The main attributes given to an indicator in the literature are - Identification, Name, Definition, and Measurement type, Unit of measurement, References and application level. [6]

OECD's indicator categorization is built upon the basic three dimensions of sustainability – Economic, environment and social. Categorizations is based on the basic relations ship between the product and the environment and it considers Inputs (Materials and intermediate products used), Operations (Activities necessary to operate the production

process) and Products (Use and treatment till end of life).

V. INDICATOR CATEGORIZATION APPROACH

Green and sustainability management continues to be an important research agenda among the researchers. There is still limited of studies to investigate green and sustainable adoption and implementation in developing countries. Some studies in the literature discussed implementation and adoption in developing countries like Malaysia, China, and Singapore. Some studies discussed drivers, practices and performance in developing countries. [7] Sustainability and green concepts have many dimensions in literature but the most common and the basic concept is from the roots of Economic, Environmental and Social province. This work considered sustainability and green under the future supply chain concepts. We mainly focused in the process manufacturing industries in India where waste becoming an important issue in the day to day life. We focused on the Environmental and Social aspects of sustainability and categorized the indicators in the materials flow direction. We considered. Three stages are Inputs, Operations and Outputs.

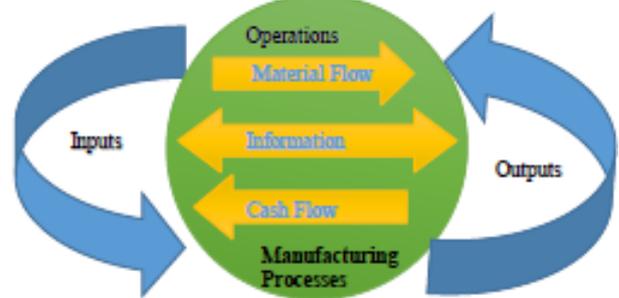


Figure 5.1 Stages of Material Flow in Supply Chain

A. Inputs

At this stage, Suppliers play an important role. The supply of raw materials needs to be examined carefully at this stage. Main indicators that can be used in view of Reduce-Reuse, Recycle process industries are

- i) Recyclable Content of Material(RCM)
- ii) Recyclability of Material Used(RMU)
- iii) Toxic Level Intensity(TLI)
- iv) Non-Renewable Materials Intensity(NRMI)

Most renewable and recyclable materials ends up with the product itself but some might also be end up as waste. Therefore it is significant to account for the non-renewable, recyclable materials at the input level. These indicators measures the intensity of the facility relative to a normalization factor of own choice.

B. Operations

- i) Water Release Intensity(WRI)
- ii) Renewable Energy(RE)
- iii) Green House Emission(GHE)
- iv) Residual Intensity(RI)
- v) Air Release(AR)
- vi) Landfill Used(LU)

Water covers the two-thirds of the earth's surface and is renewable on a global gage. Water withdrawn for industrial processes, if not restored to the same process contribute to the depletion of natural resources.



Usage cannot be easily be substituted or reduced. Using renewable energy is an important way to reduce the demand for non-renewable sources such as fossil fuels. Ideally, a manufacturing facility should operate like a closed system with no energy wastage and all outputs are supposed to be inputs to another production processes. These indicators measures the intensity of each process inside the manufacturing boundaries.

C. Outputs

- i) Reused Content of Product(RCP)
- ii) Recyclability of the Packing Material(RPM)
- iii)Renewable Material Content of the Product(RMCP)
- iv)Renewable Intensity of Packing Materials(RIPM)
- v) Restricted Substances in Used Product(RSUP)
- vi)Green House Gas Emission from Products(GHGEP)

Though, the reused matter of the material tracks the materials consumed in the production stage, the demand of these materials is driven by the product design. Incorporating a higher proportion of reused materials into the product will lower the demand for new materials.

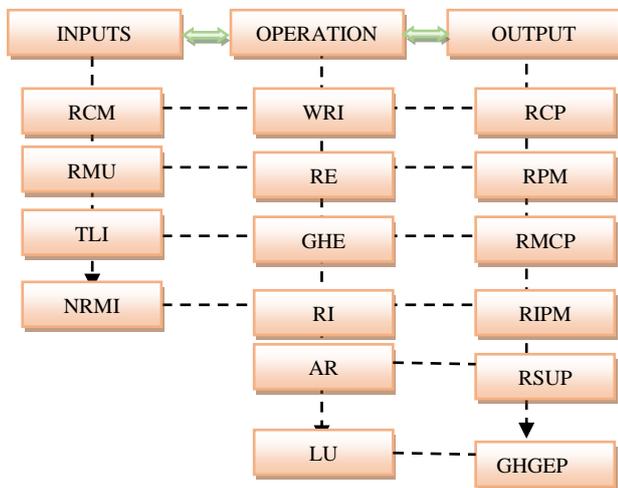


Figure 5.2 Indicator Categorization Approach

VI. CONCLUSION

This paper reviews a set of sustainable indicators for the Indian Supply Chain Networks. The purpose of this study was to distinguish between various Green and Sustainable concepts available in literature and to identify them in context of Indian Process manufacturing Industries. An extensive review of publically available literature is conducted and we identified sixteen indicators that can be applied to Indian scenarios and distinguished them in measurable terms for the future works. This review also aims to provide an infrastructure to convert green and sustainability into easily measurable platforms for getting socio-economic and-environmental friendly benefits. The broader social and economic factors should be integrated for sustainability to balance the growth. A systematic procedure might identify dependence relations among the clusters. For Indian scenarios, political and cultural aspects of business also should be considered for measuring sustainability in a wider angle that continues to be the future work. Studies suggests that the present system is deteriorating and irrevocable damages are being made to the Environment. It can be concluded that the Green and Sustainable ideologies are inevitable and appropriate methodologies should be adopted to minimize the harmful effect on the environment. Between

the conceptual debates, going green and achieving sustainability are real stakes that hang in the balance.

VII. ACKNOWLEDGMENT

The authors thank *Adhub Bin A. Salam* and all the friends and faculties of College of Engineering Trivandrum for the help and assistants given.

REFERENCES

- [1] Rajesh Kumar, Rituraj Chandrakar, “Overview of Green Supply Chain Management: Operation and Environmental Impact at Different Stages of the Supply Chain”, *International Journal of Engineering and Advanced Technology (IJEAT)* ISSN: 2249 – 8958, Volume-1, Issue-3, February 2012.
- [2] Noor Aslinda Abu Seman, Norhayati Zakuan, Ahmad Jusoh, Mohd Shoki Md Arif “Green supply chain management: Review and research direction” in *International Journal on managing value and supply chains (2012)* Vol. 3, No.1
- [3] Chiau-Ching Chen, Hsu-Shih Shih, Huan-Jyh Shyur, Kun-Shan Wu, “A business strategy selection of green supply chain management via an analytical network process” in *Computers and Mathematics with Applications* 64 (2012) 2544–2557
- [4] McCool,S., Stankey G. “Indicators of sustainability: challenges and opportunities at the interface of science and policy” in *Environmental Management* 33(3) (2004) 294-305
- [5] Katarzyna Grzybowska, “Sustainability in the Supply Chain: Analysing the Enablers”. Available: <http://www.springer.com/978-3-642-23561-0>
- [6] Che B. Joung, John Carell, Prabir Sarkar, Shaw C.Feng “Categorization of indicators for sustainable manufacturing” in *Ecological Indicators* 24 (2012) 148-157
- [7] Aref A. Hervani and Marilyn M. Helms, “Performance measurement for green supply chain management”, *The Emerald Research Register*. Available: [www.emeraldinsight.com/researchregister](http://www.emeraldinsight.com/researchregister)
- [8] Ali Diabat, Kannan Govindan, “An analysis of drivers affecting the implementation of green supply chain management” in *Resources, Conservation and Recycling* 55 (2011) 659-667
- [9] Mary J. Meixell, Vidyarnya B. Gargeya “Global supply chain design: Literature review and critique” in *Transportation research E*41(2005) 531-550
- [10] Yijie Dou , Qinghua Zhu , Joseph Sarkis, ” Evaluating green supplier development programs with a grey-analytical network process-based methodology”, in *European Journal of Operational Research* (2013)
- [11] Susana G. Azevedo, Helena Carvalho, V. Cruz-Machado, “Proposal of a conceptual model to analyse the influence of large practices on manufacturing supply chain performance”, *Journal of Modern Accounting and Auditing*, ISSN 1548-6583, February 2012, Vol. 8, No. 2, 174-184.
- [12] Helena Carvalho and V. Cruz-Machado, “Integrating Lean, Agile, Resilience and Green Paradigms in Supply Chain Management (LARG\_SCM)”, *InTechOpen* (2011)
- [13] Environmental Signals, Canada’s National Environmental Indicator Series2003,(2013,December).Available:<http://publications.gc.ca/collections/Collection/En40-775-2002E.pdf>
- [14] CSD Indicators of Sustainable Development – 3rd edition, (2013, December). Available: <http://www.un.org/esa/sustdev/natlinfo/indicators/factsheet.pdf>
- [15] A Framework for Sustainability Indicators at PA, (2013, December) Available: <http://www.epa.gov/sustainability/docs/framework-for-sustainability-indicators-at-epa.pdf>
- [16] Indicators of Sustainable Development: Guidelines and Methodologies, (2013, December). Available: <http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf>.
- [17] Indicators of Sustainable Development: Guidelines and Methodologies, (2013, December). Available: <http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf>
- [18] Ana Marie Francia, ” Indicators of Sustainable Development: Guidelines and Methodologies”. Available: <http://www.un.org/esa/sustdev/publications/indisd-mg2001.pdf>.
- [19] Industry for inclusive and sustainable development, United Nations Industrial Development Organization. Available:



- [http://www.unido.org/fileadmin/user\\_media\\_upgrade/Who\\_we\\_are/Industry\\_for\\_inclusive\\_and\\_sustainable\\_development.pdf](http://www.unido.org/fileadmin/user_media_upgrade/Who_we_are/Industry_for_inclusive_and_sustainable_development.pdf)
- [20] Gyaneshwar Singh Kushwaha, "Sustainable Development Through Strategic Green Supply Chain Management", *International Journal of Engineering and Manufacturing Science.*, VOL. 1(1): 7-11 ISSN 2229-600X.
- [21] José Antonio Ocampo, Aaron Cosbey, Martin Khor, "The Transition to a Green Economy: Benefits, Challenges and Risks from a Sustainable Development Perspective" (2010). Available: <http://www.unep.org/greeneconomy/Portals/88/documents>
- [22] John Elkington, "Partnerships from Cannibals with Forks: The Triple Bottom Line of 21st Century Business", *John Wiley & Sons, Inc.* (1998) 1088-1913/98/0801037-15.
- [23] Fortes, J., (2009) "Green Supply Chain Management: A Literature Review", *Otago Management Graduate Review*, 7, pp 51-62.
- [24] Srivastava, S.K., (2007) "Green supply-chain management: a state-of-the-art literature review", *International Journal of Management Reviews*, Vol. 9, No. 1, pp 53-80.
- [25] Diabat, A. & Govindan, K., (2011) "An Analysis of the Drivers Affecting the Implementation of Green Supply Chain Management", *Resources, Conservation and Recycling*. 55, pp 659-667.
- [26] Darnall, N., Jolley, G.J. & Handfield, R., (2006) "Environmental management systems and green supply chain management: complements for sustainability?" *Business Strategy and the Environment*, article in press, DOI: 10.1002/bse.557.
- [27] Eltayeb, T. K. & Zailani, S.H.M., (2011) "Greening Supply Chain through Supply Chain Initiatives towards Environmental Sustainability". *International Journal of Managing Value and Supply Chains (IJMVSC)* Vol. 3, No. 1, March 2012.
- [28] Zhu, Q., Sarkis, J. & Lai, K., (2008) "Green supply chain management implications for "closing the loop", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 44, No. 1, pp 1-18.
- [29] OECD Sustainable Manufacturing Toolkit, Seven steps To Environmental Excellence. Available: <http://www.oecd.org/innovation/green/toolkit/48661768.pdf>
- [30] Martin Christopher, "Logistics and Supply Chain Management", *Financial Times* (2011). *Fourth edition*, Pearson education limited



**Anoop A.T.**, is an M.Tech Research Scholar in Industrial Engineering under the Department of Mechanical Engineering in College of Engineering Trivandrum, Kerala, India. He is a graduate in Mechanical Engineering and have one year industrial experience in Product Design and Development. He is currently researching in Supply chain Networks and System Modelling under University of Kerala as part of his Master's Program.



**Nithin Joseph** is an M.Tech Research Scholar in Industrial Engineering under the branch of Mechanical Engineering, College of Engineering, Trivandrum, Kerala, India. He has earned his B.Tech, under University of Kerala in Mechanical Engineering. He got one year industrial experience in mechanical system maintenance. He is currently researching in sustainability modeling in inbound chain under University of Kerala as part of his Master's Program.



**Dr. Regi Kumar V.** is an Associate Professor in Mechanical Engineering, College of Engineering, Trivandrum, Kerala, India. He has earned his M.Tech. in Industrial Engineering and PhD in Management Studies from University of Kerala and MBA from Indira Gandhi National Open University. He currently teaches Supply Chain & Logistics Management, Management of Projects and Operations Planning and Control for the Graduate and Master's program students in Industrial Engineering of University of Kerala. He is an active researcher in supply chain management and Industrial Engineering and presented more than thirty five papers. He got about seven years of industrial experience and thirteen years of teaching experience. He presently engaged as Member (Board of Studies – University of Kerala), Question Paper setter and PhD examiner for various Universities, External Expert in different interview boards and possess life membership of ISTE and IIE.