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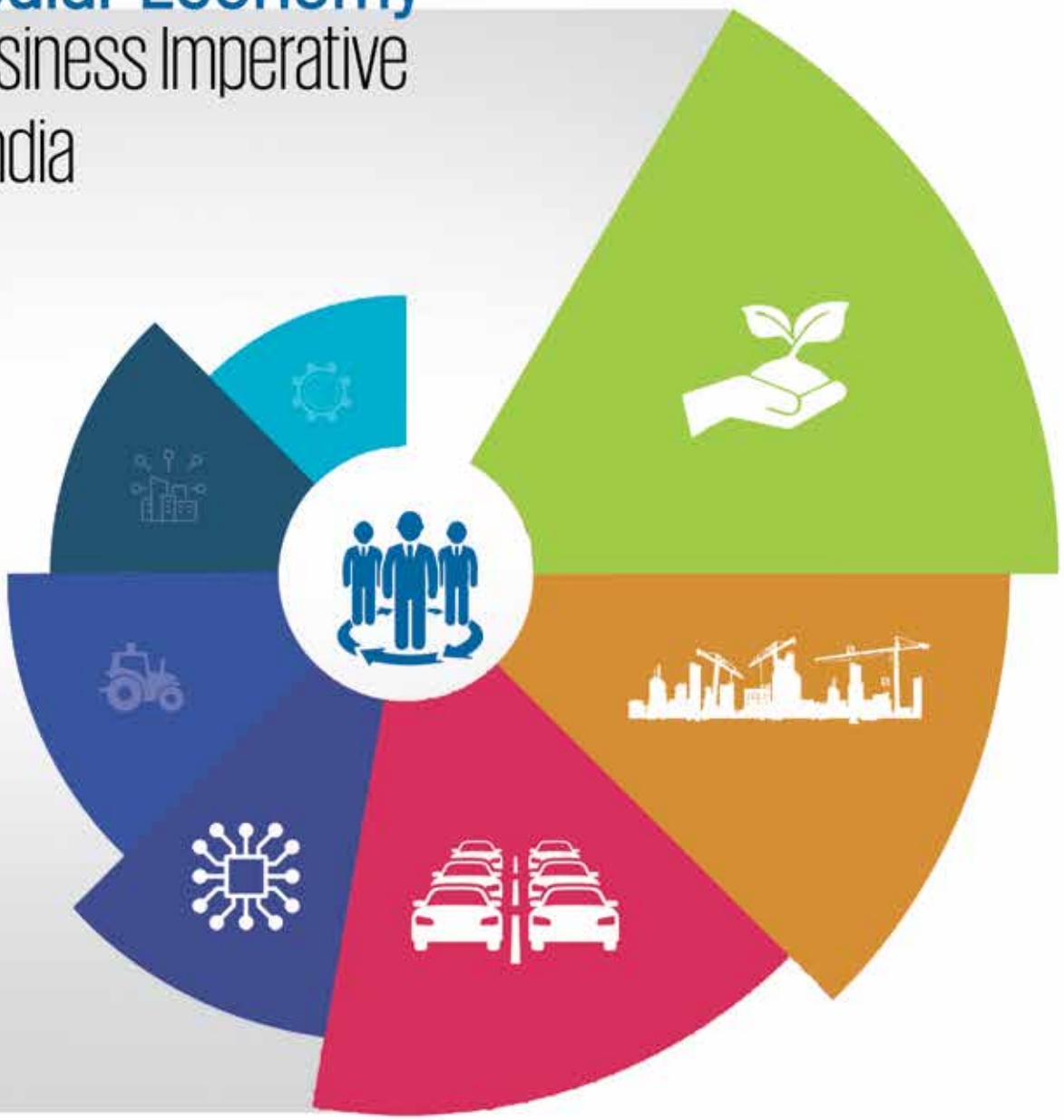
Circular Economy
A Business Imperative for India



TITLE	**Circular Economy: A Business Imperative for India**
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SURESH PRABHU

सत्यमेव जयते

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भारत सरकार, नई दिल्ली
MINISTER OF COMMERCE & INDUSTRY
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स्वच्छ भारत
एक कदम स्वच्छता की ओर

MESSAGE

If energy security was a major concern for India in the twentieth century, it will be resource security in the new century that is likely to bother policy makers and other stakeholders the most. Harnessing renewable energy, continuing economic growth and raising standards of living of the people will require more and more resources. Meeting the resource needs is a challenge for India as it has limited domestic resources. India boasts about 18% of the world population while occupying only 2.4% of the world surface. That is to say, India claims only a small share of global resources.

Generation of huge wastes due to changed consumption pattern has posed serious challenges. Being a densely populated country, India is finding it difficult to get land for dumping waste. Hence, it needs to decouple resource use from its economic growth to minimize waste generation. Thus, it is essential that we develop a vision for a circular economy in which resources, once accessed, continue to be used in perpetuity or given back to the nature so as to put a decisive stop to generation of any wastes through economic activities.

Realization of the vision of a circular economy requires a development of business models that will involve appropriate technologies and financial innovations.

I am glad that TERI and YES Bank have joined hands to conduct this study to look into these issues. I thank them for taking this pioneering initiative which, I am confident, will generate a huge interest in the subject among stakeholders, and make significant contributions in promoting a circular economy and raising our country to the status of a leader in propounding this unique economic philosophy.

I extend my best wishes for the efforts being put in by TERI and YES Bank.

(Suresh Prabhu)

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FOREWORD

Circular Economy: A Business Imperative for India

Over the years, mankind has emerged as the most dominant force shaping the world's physical, economic and social environment. This anthropocentric approach has led to the depletion and in some cases exhaustion of natural resources. With the world population moving towards the 9 billion mark, increase in demand for natural resources is inevitable. However, the world has already reached limits of most resources, with oil reserves remaining only for the next four decades and natural gas for the next five decades. Further, the new year came in with the alarming news of Cape Town going dry, clearly a sign of climate change and resource scarcity that the world would face in the coming times.

India has traditionally been a frugal society eschewing wastefulness, reusing and recycling products, making these last beyond its intended purposes. However, with the advent of consumerism, growing purchasing power and higher standard of living, it is a challenge to sustain Indian population (which is 17% of the global population), on 2% of world's landmass with 4% of total freshwater resources.

In a world of finite resources, it is crucial to identify and innovate a new and restorative economic model for the world. The concept of circular economy promises a way out, through improved longevity of products, waste minimization, sharing, renting, repair and reuse to maximize product value before returning it to the environment safely. Given its USD 4.5 trillion global opportunity, innovative businesses and start-ups are already venturing into this space.

YES BANK and TERI in this report, '**Circular Economy: A Business Imperative for India**', establish the business case for adopting this model by presenting economic arguments, beyond the environmental considerations and good corporate citizenship. The report presents specific opportunities in four sectors that are cornerstones to the Indian economy – Agriculture, Automotive, Construction and Electronic & Electricals. These sectors have high potential for growth and are assessed for benefits accrued by adopting circular economy.

Specifically for businesses, the report offers 'Material Circularity Indicator' which would act as a self-evaluation tool for businesses looking to assess their current circularity status. Further, the report highlights the policy framework and financing mechanisms required for transitioning India's growth from the current linear economy towards a futuristic circular economy, through carefully selected case studies.

I am confident that this report will provide a fresh outlook at the way an economy needs to function in an increasingly resource constrained world, and the insights provided would stimulate Indian businesses to adopt measures necessary for this imminent transition to circular economy.

Thank You.

Sincerely,

Rana Kapoor

Managing Director & CEO YES BANK

Chairman YES Global Institute

Preface

The concerns for resource scarcity were raised at least a couple of centuries ago. However, people almost forgot it till the early 1970s; when the first oil struck the world which also led to the Club of Rome and its concerns for environment and resources. In the first decade of the new millennium, rising prices of resources raised serious concerns, which fell a bit since the onset of 2010 but rising again now.

While, the concern of Malthus was based on the limited quantity of land, scarcity of which was overcome by technology that involved use of several other resources, current concerns are due to the emerging scarcity of all types of resources. With the change of development and technology paradigm and need for new resources (e.g., rare earth), concerns are also changing.

While scarcity of resources was felt from time to time, the lately scarcity has been felt largely due to emergence of China and India as global economic power, as the additional demand on resources is quite high as these are large countries. It is now well acknowledged that if the whole world gets a standard of living and lifestyle comparable to the US, we will need at least four earths. Obviously, this is impossible to achieve, but one cannot also ignore the aspirations of the people around the world.

The challenge, therefore, is to raise the standard of living throughout the world that will be comparable to the US, but it would be manageable within the finite resources available on earth and also ensuring that their use remain sustainable, hence the need for resource efficiency.

Decoupling economic growth from natural resource use is fundamental to sustainable development. Global figures, however, point to worsening trends: domestic material consumption (the total amount of natural resources used in economic processes) increased from 1.2 kg to 1.3 kg per unit of GDP from 2000 to 2010. Total domestic material consumption also rose during the same period from 48.7 billion tons to 71 billion tons. The increase is due in part to rising natural resource use worldwide, in particular in Eastern Asia. Thus we need a paradigm shift in the process of development where achieving substantial resource efficiency which entails getting more output from the same resources and minimization of waste – decoupling of economic growth and resource use is just the first stage.

However, even such decoupling might not be good enough, and what we need is the establishment of a circular economy – resource once used will continue to be used or given back to nature with zero waste generated. Sustainable Development Goal no. 12 on sustainable consumption and production has envisaged important role for both resource efficiency and circular economy. Once again technology will play an important role in promoting circular economy. However, it is also important to ensure that such technologies are adopted and diffused very fast. For India, it is even more important as India is not only a major importer of resources but it is also the home of 18% of world population while occupying only 2.4% of the world surface, and hence, by implications, commanding only a small share of global resources.

Hence, it is imperative that India takes a lead in promoting circular economy without which it would be difficult to fulfil the aspirations of the people. Accessing resources from the global market for the growing Indian population along with improved standards of living will be a challenge which will be difficult to face without substantial resource efficiency and a circular economy approach. This will require development of appropriate business models that will require technologies and appropriate financial innovations.

We are glad that YES BANK that has been at the forefront of responsible and green banking joined hands with TERI to conduct this study. The report reviewed the status in select sectors vis-à-vis resource efficiency and the policies and practices that can promote circular economy. It also explores the possible business models and financing mechanisms. This is only a preliminary assessment, and hopefully, this will generate debates and discussions on the subject and will also generate interests among the business community who might eventually come out with hundreds of business models, contributing to promoting a circular economy in India, and setting an example for the entire world.

Dr Ajay Mathur
Director General, TERI

EXECUTIVE SUMMARY

The Economic Survey of India 2017-18 showcased a resurgent manufacturing sector, contributing up to 18% to the GDP of India, riding on the favorable policies of the Government, like Make in India. This growth of India's manufacturing sector is largely based on the conventional, 'take, make and dispose' economic model, which runs up against the nation's ability to provide and replenish finite resources. At the current rate of growth of the economy, India's resource requirements are projected to be nearly 15 billion tonnes by 2030 and little above 25 billion tonnes by 2050. With material requirements outstripping the supply, there is an urgent need for decoupling economic growth from resources, which can be achieved through a circular economy approach.

This report, '**Circular Economy: A Business Imperative for India**', charts a clear pathway for the transition of the Indian economy to a more circular model, emphasizing on the principal of 5Rs – Reduce, Reuse, Recycle, Re-produce and Refurbish. As a comprehensive policy framework is yet to be established, the report delves deep into the existing policies, with elements of circularity, across the 5 main stages of a typical product life cycle – mining, product design, manufacturing, consumption and disposal. A few of the policies, like the Zero Effect, Zero Defect in manufacturing stage, National Electricity Mobility Mission Plan in consumption stage, and the various Waste Management Rules of 2016 in disposal stage, if tweaked properly, can be the ideal for integrating circular economy into the fabric of the Indian economy. These can be further supported by policy development for effective technology and finance mechanisms, across various sectors of the economy.

There are four sectors of particular interest – Agriculture, Automotive, Construction and Electronics, which account for two thirds of the expenditure of an average Indian household. A sectoral analysis on their respective value chain highlights enormous potential in augmenting resource efficiency, recycling and innovative applications. In agriculture, there exists multiple points for interventions that include adoption of resource efficient input technologies (such as drip irrigation), biomass energy generation, cold chains, and shelf life enhancing packaging. Along the value chain of automotive sector, small and medium enterprises hold the most potential for resource efficiency across the value chain, while managing End of Life Vehicles (ELV) would be critical in view of 21 million vehicles reaching the end-of-life stages by 2030. Processing and recycling of construction and demolition wastes is critical in aligning the construction sector with circularity. In electronics, designing upgradable and repairable products and establishing a functional reverse logistic network are the two most important focal points.

Apart from an enabling policy, realization of these opportunities require adequate financing. Innovative financing instruments, such as blended finance and risk guarantees would be crucial to attract private investments. Green bonds, municipal bonds, SDG-aligned bonds, green asset backed securities and sovereign bonds along with impact investing provide opportunities to channelize funds towards creation of circular infrastructures. Also, assessing circularity at both the product level and organization level is necessary that could allow corporate to align their performances in line with principles of circularity and highlight untapped opportunities. Finally, platforms for bringing together private and public sector leaders and innovators from across the nation would be crucial to generate, test and implement solutions for a circular economy.

Overall, ensuring the transition to circular economy in India calls for extensive collaborative efforts between key stakeholders, including regulators, policy makers, corporates, and financial institutions would need to work to adopt circular business models, supported by innovative technological and financial solutions.

Namita Vikas
Group President & Global Head, Climate Strategy & Responsible Banking YES BANK
Distinguished Fellow YES Global Institute

Acknowledgement

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- Mr. Gaurav Bhatiani, Chief Operating Officer, Infrastructure Leasing & Financial Services (IL&FS) Ltd.
- Mr. Arvind Singh, Vice President, Marketing, IL&FS Environmental Infrastructure and Services Ltd.
- Mr. Vaibhav Rathi, Manager-Environment Management and Product Development Domain, Development Alternatives

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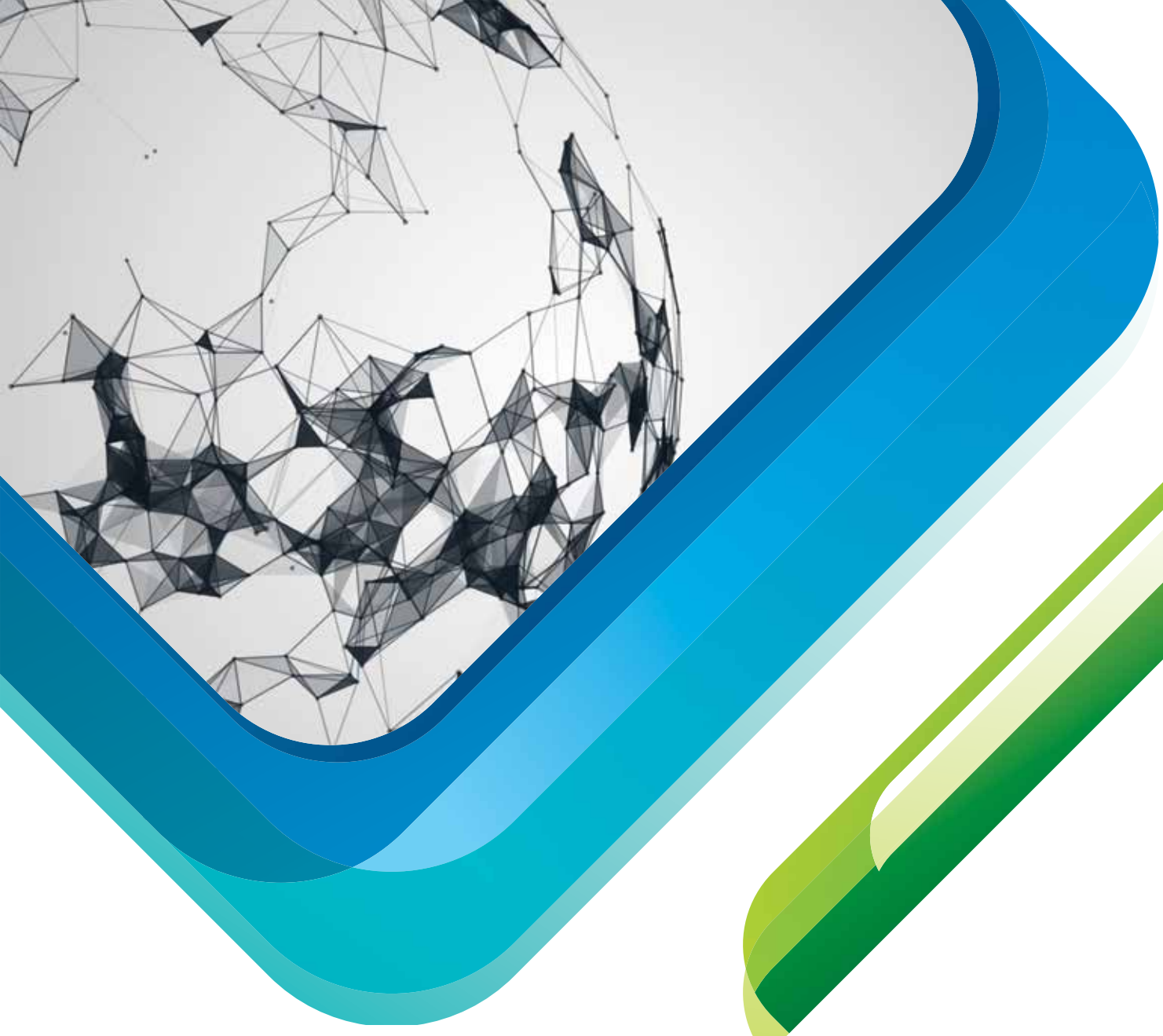

Section I

Background

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Background

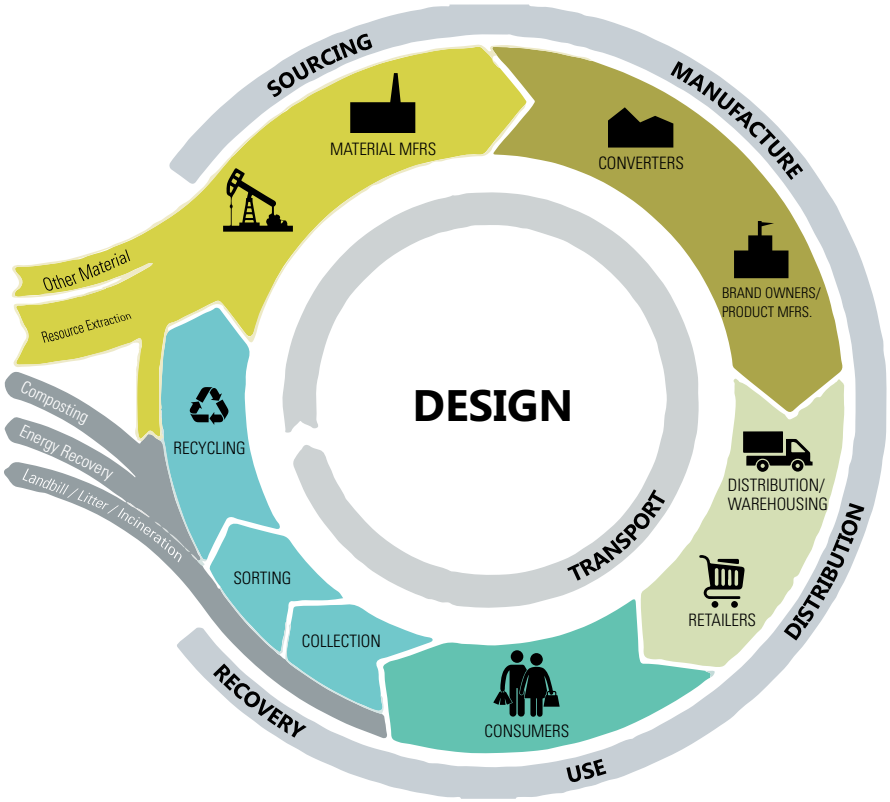
Overview

India has been one of the fastest growing economies and is tipped to become the fastest growing major economy in the world. This robust economic growth coupled with rising household incomes have resulted in increased consumer spending, which is expected to reach USD 4 trillion by 2025. With a population of 1.3 billion people, accounting for 18% of the global population, living on only 2.4% of the world's surface, India is poised to face significant resource constraints. In order to sustain this growing population, achieve the desired economic growth rate and tackle the issue of resource scarcity, the country must embark on a positive, inclusive and environmentally sustainable model of development. Unlocking circular economy opportunities holds the key to lead this transformation towards building a low carbon resource efficient economy.

The conventional growth model of India's manufacturing sector, largely predicted by a linear 'take, make and dispose' economic model, is running up against the planet's ability to provide and replenish finite resources. Additionally, the traditional linear economy approach results in massive waste generation at all stages of a product life cycle right from resource extraction, processing, value addition, consumption to end of life stage. Fuelling this burgeoning manufacturing sector requires adopting a growth path which not only utilizes the virgin resources diligently but also focuses on secondary resource management to substitute secondary materials for primary resources.

Decoupling economic growth from resource use can be achieved by a circular economy approach based on sharing, leasing, reusing, repairing, refurbishing and recycling, in an (almost) closed loop, to limit the leakage of resources as much as possible. Essentially, circular economy goes beyond recycling and is based around a restorative industrial system geared towards treating waste as a resource. In practice, this would imply that whenever a product reaches the end of its life, there is an attempt made to keep the materials within the production boundary and use them productively enough to create further value out of it (Ellen McArthur, 2015). Figure 1 depicts a diagrammatic representation of a circular economy.

Figure 1: Diagrammatic representation of a circular economy



Source: spcadavance.com, 2015

Characteristics and principles of circular economy

Circular economy has become a widely studied discipline by corporates, Governments, NGOs and academicians. The following '5R' principles lies at the heart of achieving circularity in any product, process or service:

- **Reduce:** The emphasis is on achieving resource efficiency by prioritizing use of regenerative and restorative resources. The underlying production process must ensure renewable, reusable and non-toxic resources are utilized as sources of materials and energy in an efficient way

- **Reuse:** This encompasses two aspects – first is to reuse the useful parts / components of a product, wherever possible and second is to promote greater use of product-as-a-service through sharing platforms. The aim is to encourage sharing of under-utilized assets or creating a web of shared services, whereby the service provider typically has ownership of the product throughout the lifecycle, and the customer pays for the time or usage of it, governed by either a short or long term contract

- **Recycle:** Focus is on creating a closed loop system to utilize discarded material as a source of secondary resource, through extensive recycling

- **Re-manufacture:** In this approach, idea is to create new products by utilizing waste streams through cooperation and collaboration between multi-sector industry actors or symbiotic relationship between a network of companies in a particular value chain

- **Repair / refurbish:** The aim is to preserve and extend the life of a product that is already made by designing for the future. It is important to ensure at the design stage itself that the product is designed for appropriate lifetime and extended future use. While products are in use phase - maintain, repair, refurbish and upgrade them to maximize their lifetime and give them a second life through take-back strategies, when applicable

Traditionally, India has been a frugal society and has practiced circularity as part of day-to-day life. This includes high levels of repair and reuse of products, as well as valorization of post-use materials present in the products, through recycling. However, the rise in consumerism has led to more frequent replacement of assets on account of increased spending power and economies of scale. This trend has stagnated the adoption of circularity and increased the dynamics of waste produced. Going forward, there is a dire need to move from this linear thinking to a circular life cycle approach that calls for application of the 3R (*Reduce, Reuse and Recycle*) principles at every stage of the value chain.

The factors determining successful adoption of circular economy includes a viable market for resource efficient products and greater consumer awareness, who can make informed choices at the point of purchase. While technological development and process innovation play an important role in adopting circularity during the production phase, mindset transformation and behavioural change promoting life cycle thinking at the consumption phase holds the key to unlock adoption of circular economy.

Business case for adopting circular economy: Multi-stakeholder perspective

The argument for a circular economy has moved beyond environmental concerns or good corporate citizenship. It is seen as an emerging opportunity and a profitable way of doing business. Circular economy is a key idea which is emerging in political mainstream and has been one of the important discussion point in G20 Agenda, whereby G20 countries are integrating circular economy as part of implementation strategies for Sustainable Development Goals (SDGs) . The current Indian Government has launched many ambitious programmes to support India's commitment towards achieving the SDGs and Paris accord commitments, which have certain elements of circularity enshrined. Examples include reducing the emission intensity of its GDP and generating electric power from non-fossil fuel based energy resources. However, these policies still focus on individual areas and themes, and tend to be fragmented, lacking a systemic approach. This poses a challenge for businesses that want to adopt circular economy models. Businesses often find that they lack the critical mass and financial support needed to start large-scale efforts to substitute scarce resources or hazardous materials with cleaner, restorative or more regenerative ones. Necessary mechanisms of incentives and dis-incentives holds the huge potential guiding the transition and Government needs to act as a catalyst in this watershed movement.

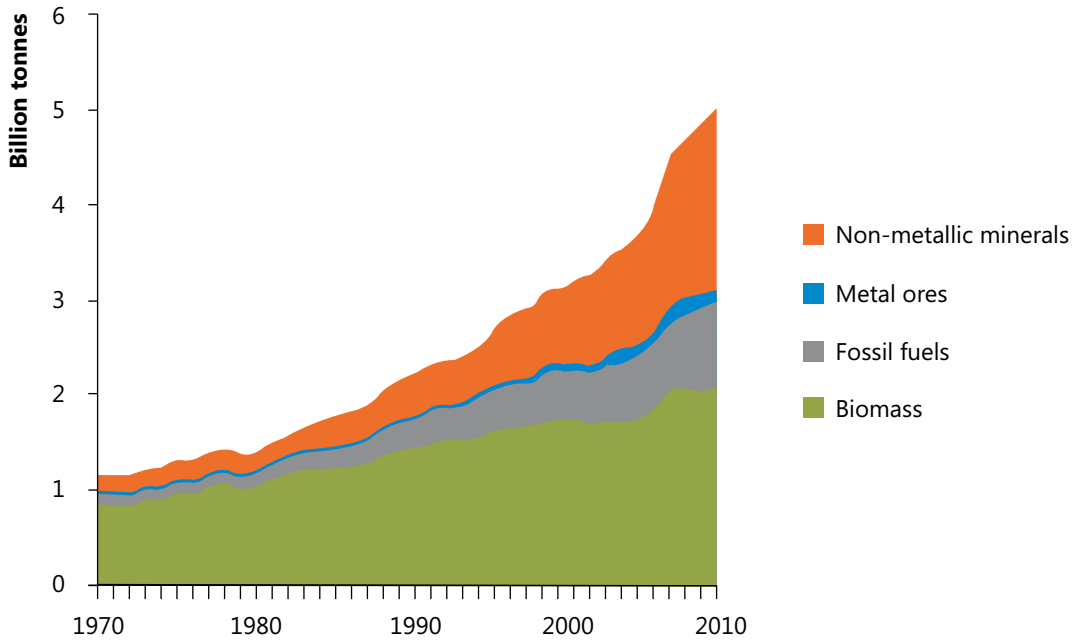
Need for adopting circularity

With economic growth and urbanization taking place at an unprecedented pace in India, there is increased demand for natural resources, be it land, soil, water or mined materials. With their impending depletion and the threat of serious scarcity in the future, it is imperative that we find more efficient ways to use them. Another menace due to rapid urbanization is the increase in waste generation volumes. Landfills, burning waste and other old age solutions only add to the existing problems. Therefore, there is an urgent need to adopt new age technologies and

practices for sustainable resource utilization and waste management. Facilitating design for reuse, remanufacture and recycle through innovation would lead to development of disruptive technologies and practices, which then would contribute towards waste minimization.

India's material consumption in the past few decades exhibits a pattern typical of countries making a transition from an agrarian society to an industrial society, where the consumption of non-renewable materials increases, in particular minerals and metals required for building infrastructure and fossil fuels for energy supply (Dittrich, 2012). In India, extraction of primary raw materials increased by around 420% between 1970 and 2010. According to United Nations Environment (UNE), India consumed about five billion tonnes of materials in 2010 (Figure 2), out of which about 42% are renewable biomass and 38% are non-metal minerals (IRP, 2017).

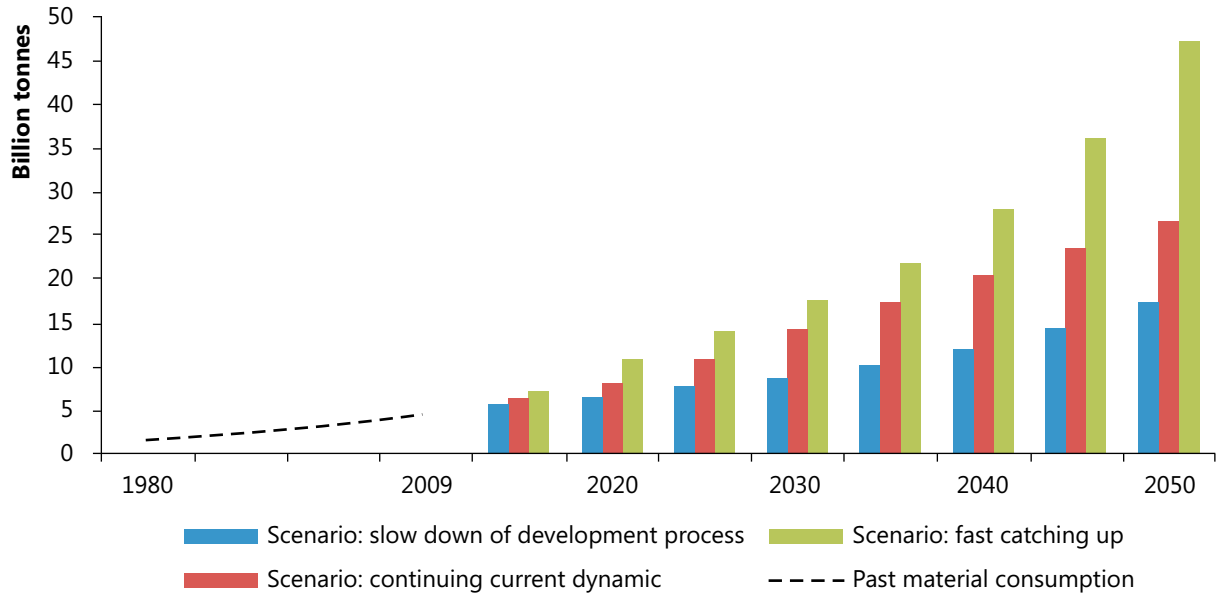
Figure 2: Trend and composition of Material consumption in India, 1970 – 2010



Source: UNEP-IRP, 2016

In 2010, India's material demand was the third largest in the world, after China and the United States. India consumed about 7.2% of globally extracted raw materials in that year. If current trends in economic growth, population and urbanization continue, it will lead to a concomitant rise in material requirements. IGEP (2013) study compared three different scenarios reflecting the impact of different development paces until 2050 depicted in the figure 3 below.

Figure 3: India's future material demand projections until 2050 under 3 scenarios



Slowdown of development process: High population growth, stagnation or depletion of resources with a GDP growth of 5% p.a.

Current dynamic: Medium population growth, new resources and technologies developed with a GDP growth of 8% p.a.

Fast catching up: Low population growth, new resources and technologies developed with a GDP growth of 12% p.a.

Source: IGEP (2013)

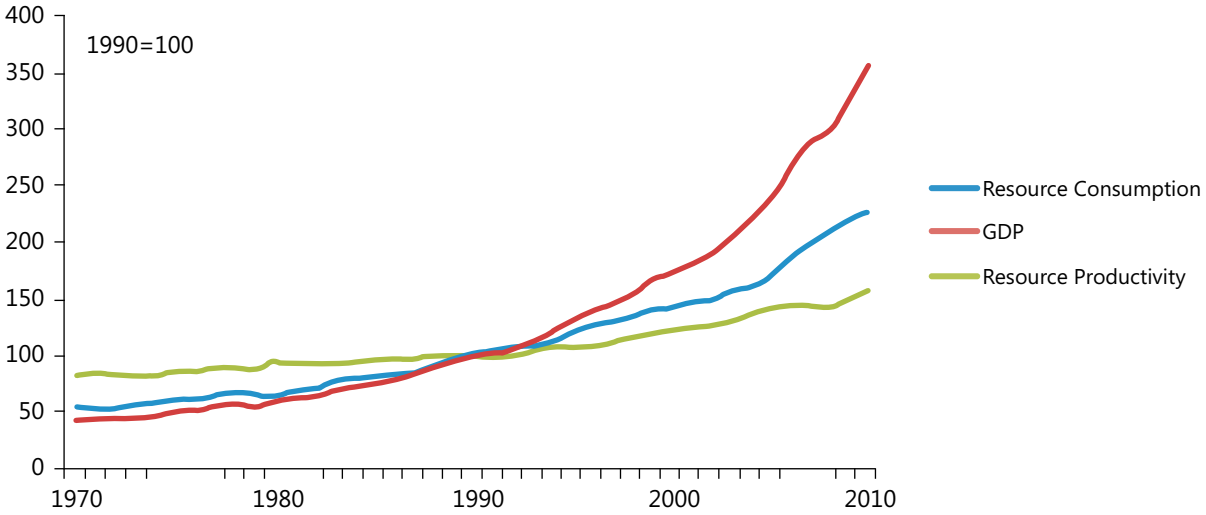
Figure indicates that India's material requirements are projected to be nearly 15 billion tonnes by 2030 and little above 25 billion tonnes by 2050 under medium growth scenario. This means that India would nearly triple its demand on primary materials compared to 2010, particularly the demand of energy carriers, metals and non-metal minerals. Increased domestic resource extraction will exert increasing pressure on natural resources such as land, forest, air and water. Extraction per acre can be used as an proxy estimate of environmental pressure, which in India, is already the highest in the world, at 1,579 tonnes per km2 land area compared to the global average of 454 tonnes per km2 (IGEP, 2013).

Additionally, India is entirely import dependent for certain critical minerals including copper, cobalt, nickel and rare earths. India's dependence on the international market for accessing critical resources have been on the rise in recent years largely due to shrinking reserves, technical constraints on resources exploration and increased conflicts in mining locations. Supply risks and price shocks can not only have severe economic consequences, at the same it will engender political conflicts at the regional, national and international level, where countries may adopt stringent trade policies for resource security. Adopting the principles of circularity would reduce the vulnerability posed by these threats.

Further if we look (Figure 4) at the trend in resource consumption and resource productivity measured as Gross Domestic Product (GDP) / Domestic Material Consumption (DMC), it clearly highlights that India has experienced a remarkable growth of GDP, resource consumption and resource productivity. Resource productivity increased slightly until around 1990 and faster during

the last decade. However, resource productivity increases in India has lagged behind many other comparable countries which indicates much room for improvement (IREP, 2017).

Figure 4: Trends in Resource consumption, GDP and Resource Productivity in India, 1970 - 2010



Source: Sources: DMC based on UNEP, 2016; GDP based on Government of India, 2016 (http://indiabudget.nic.in/es2015-16/estat1.pdf)

All the above data and analyses points out that adopting circular economy can contribute significantly towards achieving SDGs, especially Goal 11 on making cities and human settlements inclusive, safe, resilient and sustainable and Goal 12 on ensuring sustainable consumption and production patterns. Achieving circularity would help in keeping global warming less than two degree Celsius above pre-industrial levels, taking a step closer to meeting the NDC targets. Thus, integrating the principles of circularity seems to be a 'win-win' strategy essentially on all fronts.

Section II

Circular Economy in India – An overview of Policy framework, availability of technology and financial mechanisms

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Circular Economy in India – An overview of Policy framework, availability of technology and financial mechanisms

Policies for promoting circular economy in India

Introduction

India is currently in a unique position as there is a growing demand of resources to meet growing human aspirations for better living, however mounting challenges for the economy is to secure these resources at affordable rates with minimum environmental consequences and maximum positive social impact.

The challenge for the policy makers is to create the right balance between the developmental requirements as well as minimizing the negative externalities linked to resource use. Designing novel policies can create an enabling framework for achieving resource efficiency, thereby addressing larger goal of circular economy.

One of the most notable policies that India introduced a decade ago that articulated the spirit of sustainable development was the National Environment Policy (NEP) of 2006. It mentions that only such development is sustainable, which respects ecological constraints and the imperatives of social justice.

Over the years, India has gradually moved from a command and control type of regulation towards regulation based on use of economic instruments. For example, India's policy statement for abatement of pollution, by the then Environment ministry, aimed at giving industries and consumers clear signals about the cost of using environmental and natural resources. India

has deployed various policies for circularity which include financial support for research and development, eco-mark / eco-labelling standards, public procurement, tradable permits & certificates and self-regulation. Even rationalization of unwarranted benefits in the subsidy reform played in instrumental role towards sustainable consumption of resources. The following sections briefly describe key policies in India that have been formulated keeping the larger goal of resource efficiency in mind.

Key policies across life cycle stages

Enabling resource efficient mining practices

India's most of the material requirement (more than 95%) is met from domestic sources. Thus marginal improvement in resource efficiency at the mining stage can lead to substantial savings not only for the sector but also for the economy. Enhancement of resource efficiency in this sector would mean improved mining practices leading to minimal wastage, beneficiation, better transportation, as well as fewer environmental and social conflicts.

National Mineral Policy (2008)

The National Mineral Policy of 2008 highlights the importance of resource conservation and making zero waste mining as the national goal. The Policy further suggests value addition through latest technologies of beneficiation, calibration, blending, sizing, concentration, palletisation, purification and general customising of product. It suggests use of equipment and machinery that will improve efficiency, productivity and economic viability of mining. It also suggests strengthening research by technical organizations under the Ministry of Mines particularly with regard to mineral beneficiation. It acknowledges the environmental issues with regard to mining and suggests ways of prevention and mitigation of adverse environmental effects including orderly and systematic closure of mines .

Sustainable Development Framework for Mining Sector in India (2011)

The Ministry of Mines published the Sustainable Development Framework for the mining sector in 2011 , which highlighted the importance of environmental and social sensitivities during granting of mining leases. The framework envisions mining to be "financially viable; socially responsible; environmentally, technically and scientifically sound; with a long term view of development; uses mineral resources optimally; and ensures sustainable post-closure land uses".

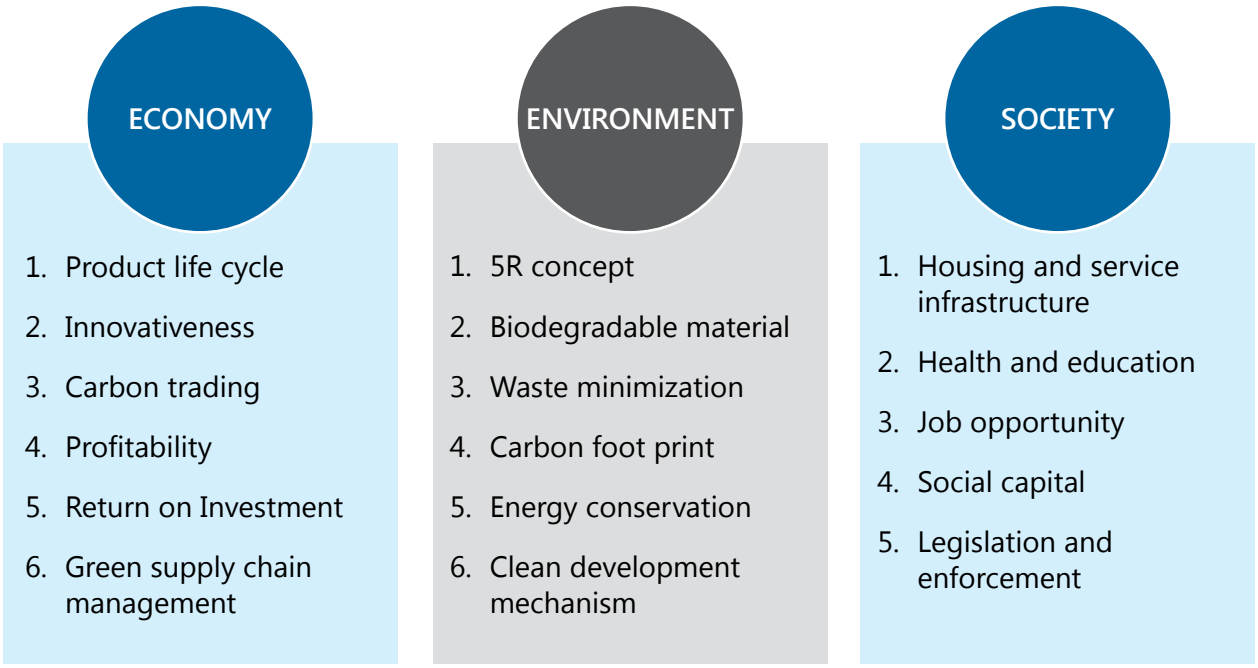
Minerals and Mining Development Regulatory Act (MMDR) (2016)

The MMDR Act, apart from setting other guidelines, particularly recommends evaluation and implementation of sustainable development frameworks for the sector. It empowers the central Government to issue directions with regard to reduction of wastes, and adoption of waste management practices and promotion of recycling of materials, mitigation of adverse environmental impacts on ground water, air, noise and land, as well as minimizing impacts on bio-diversity, flora, fauna and habitat. Further it empowers the government to formulate strategies for restoration and reclamation activities that would help in optimal use of mined out land resource. Other relevant policies in this context will include Sustainable Sand Mining Management Guideline (2016), and Star Rating System for Mining industries in India as well (MoM, 2017).

Enabling resource efficiency during product design phase

Designing environmentally benign products is key to achieving sustainable consumption and production goal of SDGs. Resource efficiency at design phase can be in the form of improving durability of products, use of sustainable/recycled materials, product labelling for better understanding of reusability and recyclability potential. The following parameters are some of the key determinants in ensuring sustainability of products under the three sustainable development pillars (as shown in figure 5).

Figure 5: Sustainability aspects of products



Source: Gupta, et.al. (2015)

Integrated life cycle assessments of existing products can often help in identifying opportunities of making them sustainable through proper product development and design. It is equally important that such products have necessary certification or labels that would increase market acceptability, and enhanced credibility.

National Design Policy (2007)

Given the strategic importance of design for product competitiveness, the Department of Industrial Policy and Promotion (DIPP), Government of India came out with the National Design Policy, with an objective to promote a "design enabled Indian industry" which could impact both the national economy and the quality of life in a positive manner . The policy, among other things, aims to promote a brand image for Indian designs by awarding India Design Mark on designs which satisfy key design criteria like originality, innovation, aesthetic appeal, user-centricity, ergonomic features, safety and Eco-friendliness. India Design Mark was introduced as a design standard that recognizes good design which symbolizes excellence in form, function, quality, safety, sustainability and innovation and communicates that the product is usable, durable, aesthetically appealing & socially responsible (DIPP 2017).

Science, Technology and Innovation Policy (2013)

The key objective of the policy is to enhance sustainable and inclusive growth based on science, technology and innovation. The policy aims to increase employment generation through R&D in science and technology. A major aspiration of the policy is 'fostering resource-optimized, cost effective innovations, across size and technology domains'. Part of the policy focus on 'providing incentives for commercialization of innovations with focus on green manufacturing ' (DST 2013).

Bureau of Indian Standards Act (2016)

The Government of India introduced the Bureau of Indian standards (BIS) Act 2016, in 2017 that repealed existing Bureau of Indian Standards Act, 1986. The BIS certification cover a wide range of products across different sectors like textiles, plant machinery, building materials including paints and chemicals, plastics and their products including packaging and their impact on the environment. The Act provides additional powers to the Government where it can issue compulsory certificates for any article or goods from a scheduled industry, process, system or service that may be considered important in the public interest or for the protection of human, animal or plant health, safety of the environment, including prevention of unfair trade practices/ national security . BIS recognizes environment friendly products through its labelling scheme Eco-Mark. The Scheme provides certification of consumer products that meet certain environmental specifications (including quality standards) for these products as required in the Indian conditions (BIS 2016).

Enabling resource efficiency in manufacturing in India

Over the years India's manufacturing sector has emerged as a key economic sector. The guiding policy document towards bringing transformation in the sector has been the National Manufacturing Policy of 2011. To address the renewed commitments of the Government on 'Make in India', 'Digital India', and 'Skill India', the earlier National Manufacturing Policy has been modified. Apart from increasing income and employment, the policy aimed at enhancing global competitiveness of India's manufacturing sector, increasing domestic value addition and strengthening technological depth that supports environmental sustainability.

National Manufacturing Policy (2011)

The national manufacturing policy was introduced in 2011, in order to increase India's manufacturing share in the national income. The policy identifies the importance of green manufacturing and provides incentives for acquiring technologies that are environmentally friendly and thereby controlling consumption of key resources like water and energy (PIB 2011).

National Policy on Electronics (2012)

The policy aims at making India a globally competitive electronics manufacturing hub that can meet India's growing demand as well as that of other countries. It aims to streamline implementation of e-waste rules in the industry including facilitation of extended producer responsibility under the e-waste (Management and Handling) Rules of 2011 (MEITY, 2017).

National Manufacturing Competitiveness Program (2014)

The National Manufacturing Competiveness Program was launched in 2014, with an aim to enhance the competitiveness of Micro, Small and Medium Enterprise (MSME) sector. The MSME

sector forms of the backbone of the India's manufacturing sector and effective policies will go a long way in bringing resource efficiency in the sector. Key schemes under the NMCP presented in table 1.

Table 1: Various schemes under National Manufacturing Competitiveness Program

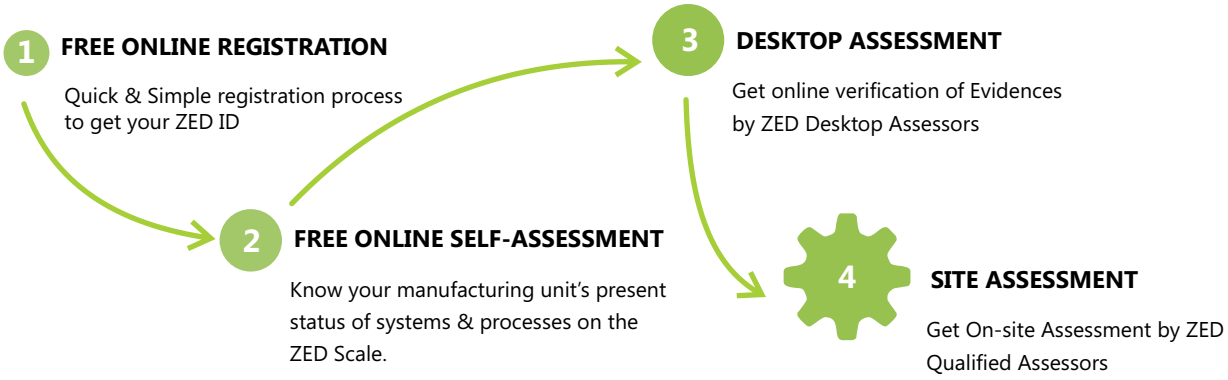
Sl. No	Name of the Scheme	Brief Description
1	Credit Linked Capital Subsidy for Technology Upgradation	The scheme provides 15% subsidy for additional investment up to INR 10 million for technology upgradation by MSMEs
2	ISO 9000/ISO 14001 Certification Reimbursement	The scheme provides incentives to those MSMEs/ancillary undertakings that have acquired ISO 9000/ISO 14001/HACCP certification. The scheme is enlarged so as to include reimbursement of expenses in the acquisition of ISO 14001 certification
3	Marketing Support/ Assistance to MSMEs	Adoption of international numbering standards used in Bar-Coding/E-commerce applications
4	Lean Manufacturing Competitiveness for MSMEs	Financial assistance is provided for implementation of lean manufacturing techniques, primarily the cost of lean manufacturing consultant (80% by government of India and 20% by beneficiaries)
5	Design Clinic for Design Expertise to MSMEs	Funding support of (1) INR 60,000 per seminar and 75% subject to a maximum of INR 0.37 million per workshop, (2) To facilitate MSMEs to develop new Design strategies and or design related products and services through project interventions and consultancy
6	Technology and Quality Upgradation Support to MSMEs	The scheme advocates the use of energy efficient technologies (EETs) in manufacturing units so as to reduce the cost of production and adopt clean development mechanism
7	Entrepreneurial and Managerial Development of MSMEs through Incubators	It provides early stage funding to nurture innovative business ideas (new indigenous technology, processes, products, procedures) that could be commercialized in a year. The scheme provides financial assistance for setting up business incubators
8	Enabling Manufacturing Sector to be Competitive through QMS&QTT	The scheme endeavours to sensitize and encourage MSMEs to understand and adopt latest Quality Management Standards (QMS) and Quality Technology Tools (QTT)

Source: Ministry of Micro, Small and Medium Enterprises (2017)

Financial Support to MSMEs in ZED Certification Scheme (2017)

This is based on the government's objective of promoting Zero Defect Zero Effect (ZED) across all manufacturing and service sector industries with a specific emphasis on the MSMEs. This includes production mechanisms wherein products have no defects as well as the production process has zero adverse environmental and ecological effects. The ZED rating scheme is a pan-India drive for creating awareness in MSME clusters about the benefits of the zero defect manufacturing and how enterprises can quickly adopt programme through financial assistance. The increased productivity and reduced wastages would lead to substantial increase of India's vast MSME sector in the global production chains. India's ZED rating process in presented in figure 6.

Figure 6: The Four Step Rating Process



Source: Ministry of Micro, Small and Medium Enterprises (2017)

Enabling resource efficiency at the consumption phase

Resource efficiency at the consumption phase has a lot to offer in terms of material savings. In recent years, the Government has introduced new policies and as well modified earlier policies with a larger objective to promote sustainable consumption and production.

Labelling schemes

Eco mark 1991: Eco-mark is one of India's earliest voluntary labelling schemes for identifying environment friendly products. The scheme, launched in 1991, by the then Ministry of Environment and Forests, and is administered by the Bureau of Indian Standards (BIS). The scheme defines an environmentally friendly product which is made, used or disposed of in a way that significantly reduces environmental impacts. The definition considers a cradle-to-grave approach that includes raw material extraction, production and disposal.

Bureau of Energy Efficiency- Star Labelling Program 2006: The energy efficiency product labelling scheme was launched in 2006 with an objective to provide consumers informed choice about purchase decisions thereby saving their electricity bills. The scheme is expected to bring a substantial energy savings in the residential and commercial buildings in the medium and long run. Key appliances that are covered under the scheme include room air conditioners (Fixed Speed), ceiling fans, colour television, computer, refrigerators, distribution transformers, domestic gas stoves, frost free refrigerators, general purpose industrial motor, pumps, stationary type water heater, submersible pump set, washing machine, ballast, solid state inverter, office automation products, diesel engine driven, diesel generator set, led lamps, room air conditioners (variable speed), chiller, variable refrigerant flow, agricultural pump sets, microwave oven, etc. (BEE 2017).

Biofuel Programme (2009)

To meet the increasing energy needs of the country and to provide Energy Security, National Policy on Biofuels was announced in December 2009. The major goals of the policy are development and utilization of indigenous non-food feed stocks raised on degraded or waste lands, thrust on research and development on cultivation, processing and production of biofuels and a blending mandate of 20% Ethanol and Bio-diesel by 2017.

Renewable Energy Certification (RECs) (2010)

India's Electricity Act, 2003, and the various policies under the Act, as well as the National Action Plan on Climate Change (NAPCC) provide a clear roadmap for increasing the share of renewable energy in the total generation capacity in the country. Indian states having abundant renewable energy can produce excess electricity and sell it to those states where the renewable energy potential is less. In 2010, the Central Electricity Regulatory Commission (CERC) introduced Renewable Energy Certificates (REC) program so that distribution companies can meet Renewable Purchase Obligation targets while incentivizing green energy generation.

Perform Achieve and Trade (PAT) scheme (2012)

In order to promote energy efficiency in energy intensive industries in India, government introduced the Perform Achieve Trade (PAT), a market-based trading scheme under the National Mission on Enhanced Energy Efficiency (NMEEE) and administered by the Bureau of Energy Efficiency (BEE). Specific targets have been assigned for energy consumption in designated industries. Based on the efficiency gained by the designated consumers, these industries can trade energy efficient certificates in energy-intensive sectors.

Auto Fuel Policy (2015)

In 2002, an expert Committee on Auto Fuel Policy, was formed for laying out the road map regarding vehicle emissions and fuel norms. The aim is to promote fuel economy and is being done through levy of differential tax on two wheelers and passenger cars/jeeps (MoEF, 2011). In 2015, Auto Fuel Policy and Vision for 2025 was introduced that would promote improved fuel quality as well as stricter emission norms for the sector (MoPNG 2015).

National Electric Mobility Mission Plan (2015)

India introduced National Electric Mobility Mission Plan 2020 that is expected to bring paradigm shift in the automotive and transportation sector. It envisages introducing 6–7 million battery operated electric/hybrid vehicles on Indian roads by 2020. Promotion of electric vehicles not only has environmental benefits but will also help India in saving foreign exchange in importing crude oil. In order to promote faster adoption of electric vehicles, Government of India is preparing to offer incentives in cities having population more than one million. This initiative is a part of FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) India scheme that aims to promote multimodal public electric mobility. Almost all the global auto players have planned to launch electric vehicles in the coming years (DHI 2017).

Enabling resource efficiency through efficient disposal of waste / end of life products

Fly Ash Utilization Policy (1999)

The notification on fly ash utilization was first issued in the year 1999 and since then, the fly ash utilization in the country has increased to almost 60%. Recently, the Environment ministry revised some of the norms to diversify its application/use across other sectors, and mandating power generating companies to provide fly ash free of cost to consumers within 300 kms. It also mandated cement industries, that are operating within a radius of 300 kms of a coal based thermal power plant, to use fly ash for cement manufacturing as per BIS. The cost of transportation of fly ash is to be borne collectively by the thermal power plant and the industry concerned (MoEF&CC 1999).

Batteries (Management and Handling) Amendment Rules (2010)

The rules of 2001 were amended in 2010 to include provision for sale of batteries through registered dealers, assigning responsibilities to bulk consumers. Rules apply to manufacturer, importer, re-conditioner, assembler, dealer, recycler, auctioneer, bulk consumer and consumer to ensure collection, recycling, transportation and sale of batteries (MoEF&CC, 2010).

Solid Waste Management Rules (2016)

The Government of India in 2016 notified the new Solid Waste Management Rules (SWM), 2016, thereby replacing the earlier rules 16 years ago in 2000. The new rule explicitly mandates source segregation of waste for creating opportunities of value addition and promote recovery, reuse and recycle. The local bodies have been assigned power to levy 'user charges', or impose 'Spot Fine' for littering and non-segregation. The industrial estate/SEZ/industrial park developers need to allocate at least 5% of the total project area for resources recovery from wastes and build recycling facility. The policy calls for increased production of compost and mandates the department of fertiliser for increased marketing of these products. Further, it emphasise promotion of waste to energy plant. The urban local bodies need to create infrastructure for segregation as well as easy access to waste pickers and recyclers for collection of segregated waste (MoEF&CC 2016).

Construction and Demolition Waste Management Rules (2016)

The government of India notified the construction and demolition waste management rule in 2016. The rule assigns responsibility to waste generators for their storage and transportation to collection centre as provided by local bodies or to be handed over to authorised processing facilities. The rule suggests administrative and other logistic supports from the State Governments to the business in the C& D Waste Management Sectors (MoEF&CC 2016).

E-Waste (Management) Rules (2016)

The E-Waste rules were notified in 2016, with the objective of properly channelizing e-waste for formal treatment and resource recovery. The rule mandates setting up of collection centres which were not mandated under Extended Producer Responsibility (EPR) Authorization. Using best available technology will help in environmentally sound recycling and recovery of various metals thereby leading to low GHGs when compared to extraction of these metals from ores (MoEF&CC 2016).

Plastic Waste Management Rules (2016)

Government notified the Plastic Waste Management Rules in 2016 that will bring responsibilities in system of collecting back plastic wastes, use of plastic waste for road construction as per Indian Road Congress guidelines or energy recovery, or waste to oil etc. for gainful utilization of waste (MoEF&CC 2016).

Hazardous and Other Wastes (Management and Transboundary Movement) Rules (2016)

The rule emphasises on the recovery and reuse of materials from hazardous and other waste materials generated from a process thereby ensuring sound management of all hazardous and other waste materials (MoEF&CC 2016).

Reduction in GST on waste products 2017

Recently the GST Council significantly reduced the rates on electronic waste from 28% to 5% while for plastic wastes as well as other waste or scrap of glass and rubber waste, the rates have been reduced from 18% to 5%.

Technology development ecosystem and circular economy

Research and development around resource efficiency measures is a basic source for addressing sustainable development issues. It helps in the transformation of knowledge into development of processes, products and services that promote economic growth, thereby generating employment. Department of Science and Technology (DST) has been supporting basic research around circularity for quite some time primarily channelling resources to Council of Scientific & Industrial Research (CSIR), which is also among the largest government supported R&D organization in the world. For supporting development and commercialization of local and indigenous technologies as well as faster adaptation of imported technologies, the government of India established the Technology Development Board (TDB) under DST. There is also a 'Seed Support Scheme' that promotes technology start-ups through Technology Business Incubators and Science and Technology Parks. These enterprises can explore partnership with various R&D institutions in India through collaboration and take up technologies for commercialization, (CII 2014). For instance, DST and Ministry of Railways developed a joint R&D initiative that aims to develop new technological solutions for fuel efficiency, alternate fuels and emission control for railways.

In 2000, DST set up the National Innovation Foundation (NIF) for strengthening grassroots innovations in technologies and outstanding traditional knowledge. Till date, the foundation has a database of over 225,000 technological ideas and traditional practices from across 585 districts. One of the unique features of the foundation is the setting up of the augmented Fabrication Laboratory with support from the Massachusetts Institute of Technology (MIT).

Role of finance in promoting circular economy and existing financial mechanisms

Transition to a circular economy presents enormous challenges and opportunities for policymakers and businesses alike to innovate and introduce enabling policies and disruptive business models. This unique transformation of moving away from a linear way of doing business requires financial institutions to also innovate and respond, thereby acting as a catalyst facilitating this transition. From a financial institution perspective, the success lies in maximizing the returns on investment, while minimizing the risks involved in making the switch happen. The financial industry as a key enabler can mainly contribute in two ways by facilitating the companies in this transition through financial support and greening their internal operations to embed the principles of circular economy.

Financial community needs to be aware about both the risks and opportunities that the transition would bring. Opportunities include leveraging the new business avenues created and serving new markets (like Consumer to Consumer and Consumer to Business) by developing innovative financial mechanisms and instruments that go beyond the conventional lending. The projected annual benefits from three key sectors of Indian economy transitioning to circular economy path is equivalent to 30% of India's current GDP . Investments in sectors which deliver environmental, social and economic benefits requires increased understanding of the inherent risks in these emerging sectors to develop new pricing and valuation tools, thereby leading to internal capacity building. By developing this competence, banks can meaningfully contribute to the national growth story by

achieving SDGs and the Paris Agreement. This in turn helps in meeting the internal sustainability targets and incorporating environmental and social concerns in core business strategies, which is increasingly becoming a prerogative for financial institutions. Proactive investments in the climate-aligned sectors provides banks access to low-cost capital mobilized by Development Finance Institutions (DFIs) and supranational funds including Green Climate Fund (GCF).

Despite these promising opportunities, financing circular economy business models comes with a set of unique risks and challenges, given the changing nature of cash and material flows. Some of the risks from a financial institution perspective include uncertainty about consumer behaviour in terms of the acceptance of the circular products, posing payment-related risks. Absence of proven past performance track record of the new product / technology might inhibit investors to undertake robust risk analysis. There are also concerns about the residual value of products in second hand markets, which may impact financeability of such circular economy models. In case of product-as-a-service business model, the issue regarding the ownership of the asset becomes a point of consideration. There are financial implications with respect to balance sheet extensions due to retained ownership of assets and the valuation of residual value of the products. Given that the payment or cash flow by consumer of the service is spread over time, creditworthiness of the consumer deserves attention, as supplier and financial institution run the risk of bankruptcy of the consumer. There are other contractual and legal risks related to leasing agreements.

Given the unique risk-return profile of the circular economy projects and business models, there is no one-size-fits-all financial product that can be availed. ING Bank in its report 'Rethinking circular finance in a circular economy' concludes that multiple forms of capital are needed to finance circular economy.

Table 2 below shows the basket of financial products that can be tapped to mitigate the risks discussed in the section above and switch to a circular economy business model:

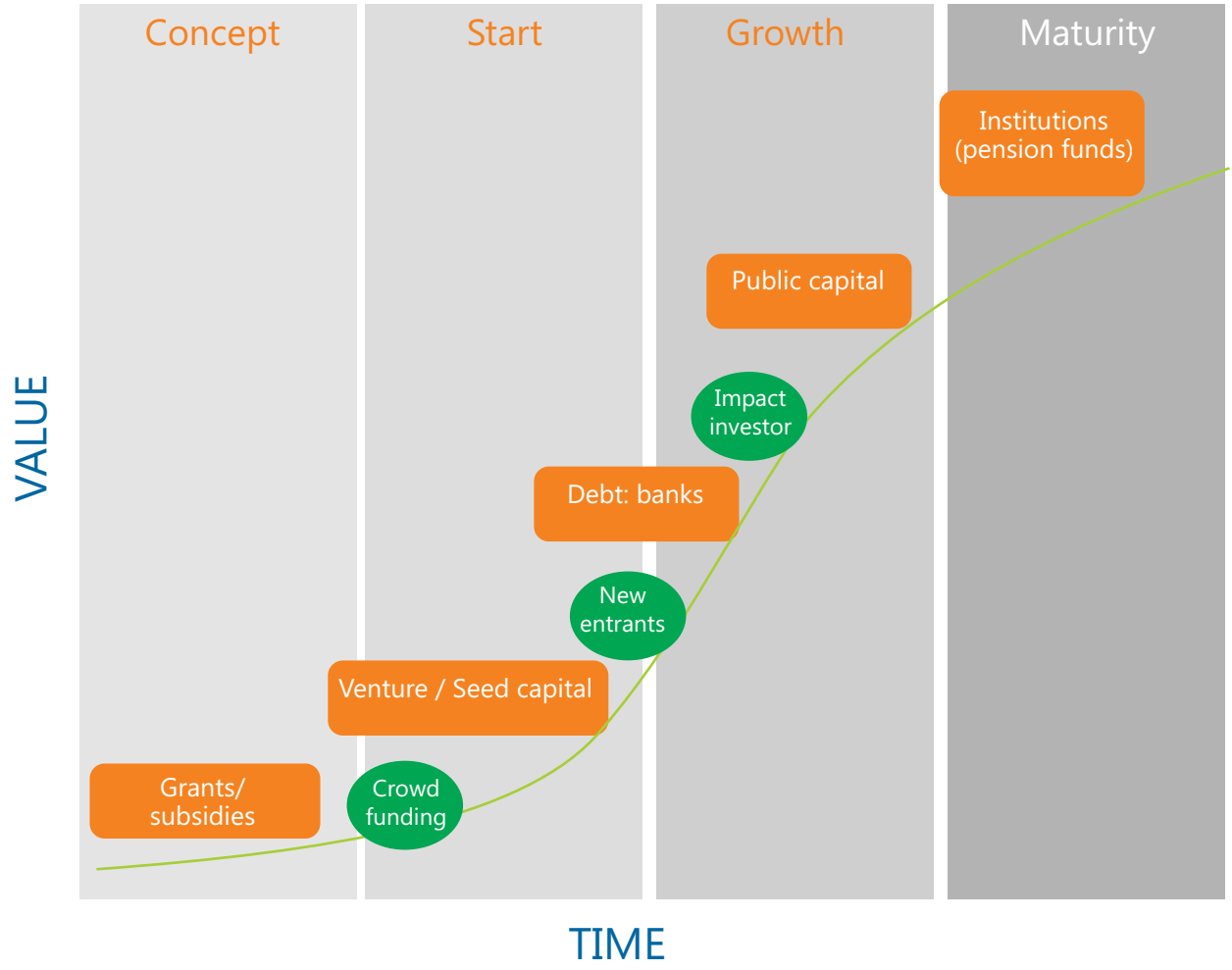
Table 2: Financial instruments for adopting circular business models

Source of Finance	Financial Instruments
Banks & Non-Banking Financial Institutions	Debt Finance
	Supply Chain Finance
	Blended Finance
	Credit enhancements
Development Finance Institutions and Multilateral Development Banks	Green mortgages
Capital Markets	Green bonds, SDG bonds
Foundations and Impact Investors	Seed funding, impact bonds
Venture Capital and Private Equity Funds	Private equity
Crowd Funding Platforms	Seed funding
Institutional Investors	Pension funds
Specialized funds like Green Climate Fund	Debt, grants

(Adapted from ING Report 'Rethinking circular finance in a circular economy')

Selecting the right financial mechanisms not only depends upon the inherent risk, but also depends upon the maturity of the business model and the life cycle stage the business is currently in. For instance, in the transition phase when a business is moving from a liner business model to a circular business model the risk profile may be more suited to higher-risk capital through the injection of equity or internal capital. Once the transition is complete the move to lower-risk capital through specialist asset lending and generic debt facilities may be more appropriate. Figure 7 below shows the various sources of funding across the various life cycle stages:

Figure 7: Financial Instruments required across life-cycle stages for adopting circularity



(Source: 'Money makes the world go round')

Below are the case studies from some Indian companies who have been deploying innovative financial instruments and blending various sources of finance to fund their sustainable business models.

Case studies of Indian companies

Jaipur Rugs – Taking LOCAL art GLOBAL

Jaipur Rugs, India's largest manufacturer and exporter of hand-knotted carpets celebrates the revival of the dying art through a unique and inclusive business model leading to socio-economic

development of the artisan community at the grassroots level. The company presently engages 40,000 artisans spread across 600 villages in rural India and connects these local artisans with urban consumers in over 50 countries globally. Jaipur Rugs aims to work towards ensuring the wellbeing of rural artisans in the carpet value chain by enabling them to have sustainable livelihood and creating avenues for overall economic and social development.

There are three major areas of innovation in the company:

- **Business Model Innovation** - Jaipur Rugs empowers rural women as local Managers in the communities where products are being made, to maintain very high standards in the production cycle and control the quality, leading to zero wastage in the production process. Moreover, the company provides the after sale services in terms of customized repair, maintenance and washing of the carpets, which increases the effective useful life of the product. Carpets utilize natural fibres like wool and silk, which are hand spun on a rudimentary 'charkha' (spinning wheel) by over 2,500 women yarn spinners. The organization's goal is to mitigate the environmental footprint through minimal use of technology and machinery. To utilize leftover yarns and resources, Jaipur Rugs has initiated Artisan Original Project, which enables weavers to design and create something entirely on their own

- **Social Innovation** - Selecting local indigenous people across the carpet value chain for the concerned job/process to leverage the experience, expertise, and connections with the community

- **Community Innovation** - Jaipur Rugs offers a whole-spectrum experience to all its stakeholders with a strong focus on its employees and the community here it operates. The top management frequently visits the weavers in India and connects them with the global carpet trends related to innovation, technology, connectivity and design to develop the creative capacities of artisans. The company also focuses on connecting the artisans with the end consumers to convey the authenticity and craftsmanship that goes into making the rugs, one knot at a time.

In August 2011, Jaipur Rugs joined the Business Call to Action (BCtA) with a pledge to provide sustainable livelihoods for 6,000 underprivileged women and deliver skills training to 10,000 of the poorest people in rural India. Surpassing these goals by 2015, Jaipur Rugs renewed its commitment in 2016, pledging to enhance the creative capacities of 15,000 artisans, provide sustainable livelihood opportunities to 9,000 marginalized women and lead a range of grassroots leadership programmes targeting 15,000 artisans in India's carpet value chain – all by 2022

Financial arrangement: Jaipur Rugs came into existence in 1978 when Mr N K Chaudhary (Founder) borrowed a sum of INR 5000 Rupees from his father. Over the years the humble beginning transformed Jaipur Rugs as a global conscious brand, connecting rural artisans with the clientele across the world, who subscribe to a common philosophy of responsible manufacturing. The organization raises capital from leading national banks against revenues from their exports.

Waste Ventures India – Waste to Manure

Waste Ventures India (WVI) is a waste management social enterprise innovating environmentally and financially sustainable models to tackle the country's solid waste problem. The enterprise offers professional waste collection and processing services to households, corporate and waste pickers. For organic waste thus collected, WVI has developed a scientific, fly-less and odourless

process to produce high quality organic compost under the brand name 'Sanjeevini'. While doing so, compliance with the local laws of the land including Municipal Solid Waste regulations is also adhered.

For dry waste, WVI ensures pre-scheduled, hassle-free and convenient doorstep pick-ups of the waste, digital weighing, and on-spot payment done to the waste providers. The enterprise engages with a network of Pollution Control Board certified recyclers to ensure that all the waste finds a green end point. WVI boasts of offering Hyderabad's first digital doorstep recyclable pickup service.

Financial arrangement: In order to finance its operations, WVI used start-up capital from foundations and social-impact investors to help waste pickers form waste management corporations. The enterprise ensures adequate capacity building of waste pickers on technologies and best practices to harvest maximum value from trash. The organization sees the waste management sector as ideally positioned to attract funds from impact investors, given the tangible and measurable results (job creation, volume of waste that is composted and/or recycled and the percentage of waste diverted from landfills). WVI has also been working on a franchise model, for which WVI is raising funds, with the goal of diverting >90% of waste away from landfills, while doubling the incomes of the waste pickers.

The various partners in this journey are Swedish International Development Agency, PEERY Foundation, Village Capital, Marshall Foundation, Impact Assets, Geneva Global, Sorenson Impact Foundation and Millennium Alliance.

Ganesha Ecosphere – Recycling for the Future

Ganesha Ecosphere (GESL) is a Kanpur based Post-consumer PET bottle scrap (Poly-Ethylene Terephthalate) recycling company, which has been in the PET recycling business since 1995. The organization is fully committed to play its part as a socially and environmentally responsible corporate by embedding the ethos of sustainability in the core business strategy. The company is the largest player in the PET recycling industry (market share of 25%) with an installed capacity of 87,600 MT of recycled polyester staple fibre (RPSF); 7,200 MT of recycled polyester spurn yarn (RPSY) and 3,000 MT of dyed and texturized/twisted filament yarn.

The PET recycling industry in India has grown to INR 35 billion (as of 2017), processing ~0.85 million MT of waste, with the organized sector cornering ~65% share of the total pie. The industry is gaining momentum owing to the rise in consumerism and Government's impetus on effective waste management.

The innovations in the business model include:

- **Technological advancement**: The company continuously focuses on deploying advanced technology (imported from Korea, China and Germany) to consistently narrow the gap in quality between virgin and recycled polyester fibre and increase the variety of value-added products
- **Continuous supply of raw materials through symbiotic relationship with value chain actors**: GESL has edge over its peers in sourcing raw materials (majorly post-consumer PET bottles) because of pan-India network of over 20 collection centers, which provides about 40% of company's raw materials. The company has institutional tie-ups with hotels, malls, restaurants and exhibition centers. The company has also joined hands with beverage giants like Bisleri and Co-

ca-Cola India for sourcing waste PET bottles. Finally, the company also engages with informal sector mainly rag pickers to ensure uninterrupted supply of raw materials

Financial Arrangement: In order to finance its operations, GESL employs conventional lending instruments, comprising of debt from commercial banks, private equity from FII and investments from international institutional investors. Given GESL's improving debt profile and increasing market capitalization, the company is able to arrange the requisite funds in timely and cost effective manner, ensuring financial sustainability of the business model.

Section III

Circular economy models amongst businesses

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Circular economy models amongst businesses

Sectoral Analysis

In order to provide a perspective of implementation of circular economy business models in India, the study focuses on the following sectors - automobile, construction, agriculture and electronics & electrical equipment. The sectors have been carefully chosen given that an average Indian households reports more than two third of its expenditure in the aforementioned sectors. Agriculture and construction are the largest employment generating sectors in India. Construction, automotive and electronics represent sectors where highest growth is expected. For instance, construction is an important sector as urbanization is taking place at an unprecedented pace and two-third of buildings are yet to be built. Recent study by International Energy Agency (IEA), predicts that passenger car ownership in India will grow by whopping 775% over the next 24 years, from 20 vehicles per 1000 people to 175 by 2040. With India becoming the second largest market for smartphones, surpassing the US, the country is embracing the digital revolution. Guided by circular principles and enablers such as asset tracking and sharing, the sector can yield significant benefits.

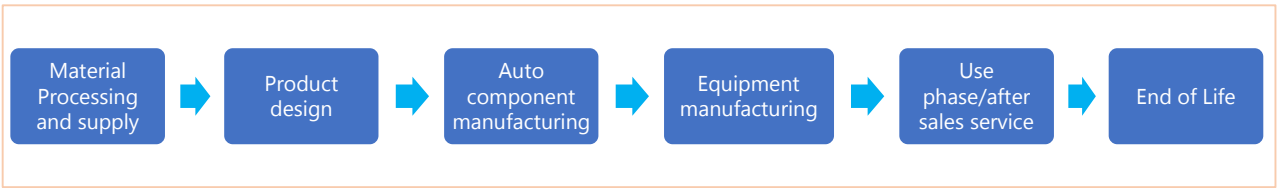
Automotive sector

Introduction

With an annual production of more than 25 million vehicles, India is one of the largest automotive manufacturing countries in the world. It contributes 7.1% to India's GDP and almost 49% to the nation's manufacturing GDP (FY 2015-16) . The supply chain of India's automotive industry is quite complex. An average vehicle may comprise up to 20,000 components with about 1,000 sub-assemblies or modules. These components are manufactured from materials such as multiple variety of steels (conventional steel, high strength steel, stainless steel), iron, aluminium, rubber, plastics/composites, glass, copper and brass and zinc.

A typical value chain of the automotive sector is represented in the figure 8.

Figure 8: Automotive sector value chain

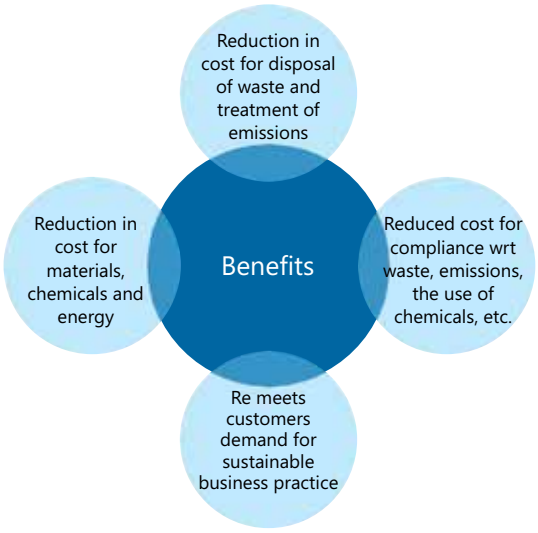


Source: Developed by the authors

Material demand for the automotive sector over the next 15 years (i.e. 2030) will increase from 14 million tonnes to more than 100 million tonnes. The estimated total demand for iron and steel in 2030 from the automobile sector will be almost 80 million tonnes, followed by aluminium (11 million tonnes), plastics and composites (8 million tonnes), copper (0.6 million tonnes), zinc and nickel (0.7 million tonnes) (TERI-GIZ-DA(2016)). India is import dependent on many of these resources. Further the price volatility, procurement challenges and increased transportation costs would increase the final factory gate cost of materials thereby putting pressure on the bottom line of the component manufacturing companies and hence the Original Equipment Manufacturers (OEMs).

Needless to mention, improving resource use efficiency will benefit businesses and the environment in many ways. These include reduced cost of purchased metals and other raw materials through process improvements (fewer off-cuts and rejects), minimising waste treatment and disposal costs, reducing environmental impacts associated with extraction, processing, waste disposal, and consumption of limited resources (reviewing purchasing practices or testing the suitability of recycled or non-composite materials that can be separated and recycled if they meet customer specifications and requirements), improving the reputation of businesses and employee satisfaction through promoting an environmentally responsible image and providing a safer and more comfortable workplace. These benefits can be represented in figure 9.

Figure 9: Expected benefits from resource efficient practices



Source: Developed by the authors

Assessing benefits along the value chain

The following sections briefly presents industry wide good practices adopted in India and internationally by various stakeholders along the value chain with regard to adoption of resource efficient practices.

Product design and component

In a rapidly evolving global automotive market, where industries are increasingly witnessing issues associated with resource availability at affordable prices as well as countries adopting stringent environmental regulations and policies for the automobile sector, eco-design in the automobile sector holds immense relevance in not only pursuing resource security strategy but also deliver products that conform to the relevant standards as mandated by regulations. Resource efficiency is being increasingly looked as a competitive advantage.

Many automotive companies are investing time and money into understanding and assessing environmental impacts across the value chain of use of various materials and as well evaluating quality that may help in material selection for eco-design practices . Composite reinforced with natural fibres and/or biopolymers have drawn significant interest from equipment manufacturers due to their biodegradability, low cost, low relative density, high specific strength and renewable nature.

BMW uses hemp as well as natural fibres along with acrylic polymers for manufacturing interior door panel. Ford uses bio-polymers from Soya bean along with Polyurethane to manufacture head rests, in their selected models. Nissan Leaf uses natural fibres from corn along with Sorona (polytrimethylene terephthalate) for manufacturing of rugs and mats.

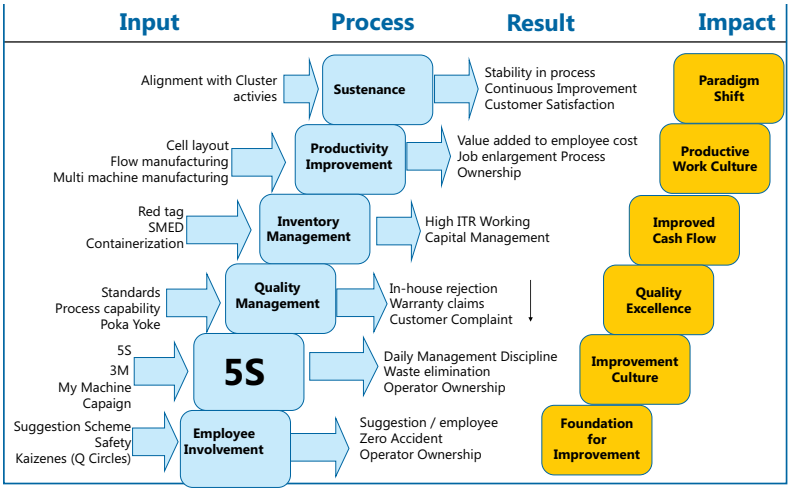
Almost two decades ago, Toyota was one of the first companies in the automotive industry to introduce ISO 14001, the international standard for environmental management systems, for its vehicles design and development. In 2005, the company introduced the 'Eco-Vehicle assessment system (Eco-VAS)' a comprehensive environmental assessment system, which is based on the approach of Life Cycle Assessment (LCA), through the entire vehicle development process. 'Disassembly facilitation marks' were added to show key points for easy disassembly for instance points at which the load required for peeling door trim off can be reduced by 30% were identified, and marked with easy to dismantle mark .

Component manufacturing

Increased competition as well as consumer expectations are forcing automotive component manufacturing companies to improve productivity thereby lowering cost and as well retain excellent product and service quality. The component manufacturing in India is undertaken both in the formal (largely medium and small scale) and informal sectors. While the organized sector contributes around 80% of the production of components (in value terms), the unorganized sector caters to low value products that find place entirely in the aftermarket category. But even among the organized players, there is a vast majority of the companies operating at the bottom of the pyramid that promises significant resource efficiency potential. The growing demand/requirement of industrial materials primarily from these smaller companies can be met sustainably through improvement of resource use recovery and recycling thereby reducing costs and increased material productivity.

United Nations Industrial Development Organization (UNIDO) in collaboration with the Government of India and Automotive Component Manufacturers Association (ACMA) launched the UNIDO-ACMA partnership programme for the Indian auto component industry. The model essentially has five major components that includes understanding change, the input required, the expected results and its impact on business. This is presented in figure 10 below:

Figure 10: UNIDO- ACMA model



Source: Jadhav, et.al. (2015)

The initiative has helped a number of companies across the broad spectrum of component manufacturing sector to achieve high material productivity, reduce wastage with almost no rejections. For example: Sandhar Automotives, a major auto component manufacturer in India, faced continuous customer complaints and high internal rejection rates leading to substantial wastage of materials before the intervention. Post the ACMA-UNIDO cluster program, the company was able to reduce its in-progress rejection by more than 70%, defects due to machines by more than 90%, and reduction in scrap yard area by 50% .

Karnataka Automats, is a leading component manufacturer in India. The company experienced problems with regard to under-utilization of resources, high rejections, and issues with regard to availability of space. Series of initiatives defined under the UNIDO-ACMA model helped the company to improve the overall productivity. There was a 100% improvement in no rejections, reduction in scrap yard area by 99%, and over all equipment efficiency of 25%.

Precision Galvanizing GmbH, Germany, galvanises around 10,000 tonnes of steel per annum at a high temperature. Most parts that are galvanised are small components. The new method of galvanisation uses inductors for the heating process instead of gas burners, which allows a constant heating for a more efficient melting process. With the generated temperatures and a special operation mode, thinner layers of zinc with the same quality are possible. Galvanising 5,000 tonnes of steel, leads to an annual saving of 64.5 tonnes zinc with a same quality of coating compared to the conventional methods. In addition, the new process doesn't use lead, which results in a saving of 0.9 tonnes lead per year .

Equipment manufacturing

OEMs can play an important role in promoting resource efficiency in the sector. For example Ford uses recycled aluminium that helps in reducing energy consumption by 95%, use of recycled aluminium waste chips generated from stamping windows into body panels reduces consumption of virgin material by more than 40% .

Maruti India has been able to reuse the scrap generated from press shop operations by supplying them to component manufacturing for production of child parts, thus maximising steel sheet utilisation. The suppliers send back these child parts to the company for use in vehicle manufacturing. In 2013-14, items that were sent to component manufacturing were trim scrap (very small pieces which are used for melting and made as ingots), and flat scrap (bigger pieces which are used for making child parts). The volume of scrap generated that was recycled under these two categories were 56,324 tonnes, 24,375 tonnes respectively.

Nissan uses recycled materials in Nissan Leaf that amounts to 25% of the total weight of the car. Most of the recycled material comes from recycled steel. Discarded cloth is used to make sound deadening panels, the upholstery is made from recycled soda bottles, and recycled plastics from discarded household appliances provide the raw materials for most of the plastic parts.

Use phase/after sales service

After-sales service has emerged as a critical part of the automotive value chain as number of on-road vehicles has proliferated in recent decades. Since this part of the value chain involves oil and lubricant replacement, intensive cleaning of vehicles, replacement of parts, interventions are required to optimize material use and minimize wastes. Maruti has been able to introduce certain practices that have reduced wastage of many of these resources. For example, the automated

oil management system has been implemented in dealer workshops in order to minimise the oil spillage and to reduce the time and effort required to issue the oil, which improves the overall productivity of the workshops. It provides control and monitoring of oil quantities so that wastage can be identified and controlled. Paintless dent repair system has been introduced in workshops for repairing minor dents without stripping the paint leading to an environment friendly, faster and cost effective way of repairing dents. Further dry wash system involves cleaning using special wash chemicals thereby reducing water consumption by around 5 crore litres per annum (in 2014) across its numerous service centres across the country.

Tata Motors Prolife is a pioneering after-market product support strategy for Tata Motors customers. The company has realized the value of remanufacturing components in their commercial vehicles as these vehicles have long use cycles, are very sensitive to cost increases, and are often managed as a fleet, making the use of remanufactured parts more attractive, especially with a warranty. Tata Motors Prolife buy backs, or exchanges the used vehicle parts like engine, gearbox or alternators. The company then remanufactures the returned part and offers the remanufactured product with a warranty. This approach allows longer use of parts, reduces demand for energy and materials, thereby creating new revenue streams for Tata Motors Prolife. Tata prolife business reconditions about 23,000 equivalent engines in a year. Recently, the company has expanded further by commissioning their 4th reconditioning plant at Hyderabad, exclusively for reconditioning TM SCV engines following up on the success of the units in Coimbatore, Lucknow and Surat (Tata motors, Sustainability report 2016-17).

Bosch also as a part of its exchange program offers more than 11,000 remanufactured parts across 34 product groups ranging from the starters, alternators and electronics product sectors, as well as from brake, gasoline and diesel fuel-injection systems. (Bosch Sustainability).

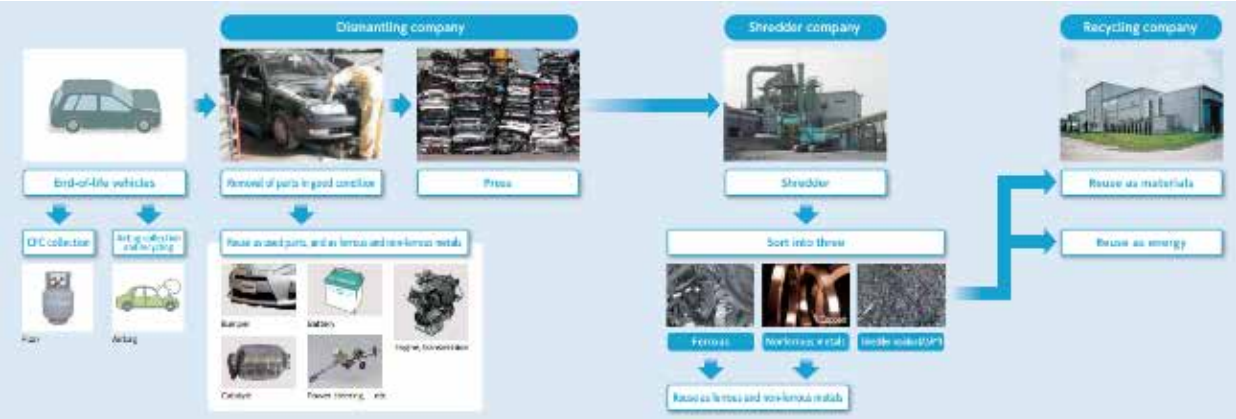
End of Life Phase

Estimates for India suggest that more than 8.7 million vehicles have reached the end-of-life phase by 2015, and this number is expected to rise to 21 million in 2025 (Akolkar.et.al, 2015). In India, Central Pollution Control Board (CPCB) recently introduced 'Guidelines for Environmentally Sound Management (ESM) of End of Life Vehicles (ELV) with an objective to regulate the sector and promote disposing of ELVs in an environmentally friendly manner based on 'shared responsibility' involving all stakeholders (CPCB Guidelines, 2016).

However, much before the regulation, businesses have introduced circularity given its business case. In the early 1990s Toyota Motors along with Toyota Metal Co., Ltd. developed auto shredder residue recycling technology. Based on this a recycling plant was developed which started operating in 1998, recycling on a mass production basis. The average number of cars recycled in a month is 15,000. To use automobile shredder residue, it is necessary to return it to the basic materials of products. Since separation is important to increase purity, the company developed special separation technologies using wind and magnetism, thus making shredder residue reusable.

Electric steel furnaces use heat sources and carbon additives as they melt ferrous scrap to turn it into steel. By adding an appropriate amount of the resin sorted out from Automobile Shredder Residue (ASR), it has become possible to achieve a heating efficiency usable as a heat source and also to use the resin as an alternative to the re-carburizer. The Automobile Recycling Law calls for the ASR recycling rate to be raised to 70% by 2015, but Toyota already reached that target in 2007. The resin that is the largest ingredient of ASR, by weight, is used as an alternative fuel (Toyota Motor Corporation, 2014). Figure 11 gives a generic overview of the recycling process at Toyota.

Figure 11: ELV management system of Toyota



Source: Toyota Motor Corporation, 2014

Electronic and Electrical Equipment

Introduction

With an 'emerging middle class' population of more than 500 million, 65% of the population aged 35 or below, increased income levels, lower technology cost and digitization, Indian consumers today are looking to improve their homes and lifestyles through technology. Fuelled by the falling prices of consumer electronics, these radical demographic shifts are expected to further transform the Appliance and Consumer Electronics (ACE) market in India. The ACE market is expected to grow at a compound annual growth rate (CAGR) of 9% between 2017 and 2022 (PWC, 2017). Currently 65% of the demand for electronic products is met through imports, and the market is expected to be USD 29 billion by 2020 from approximately USD 10 billion currently (EY and FICCI, 2015).

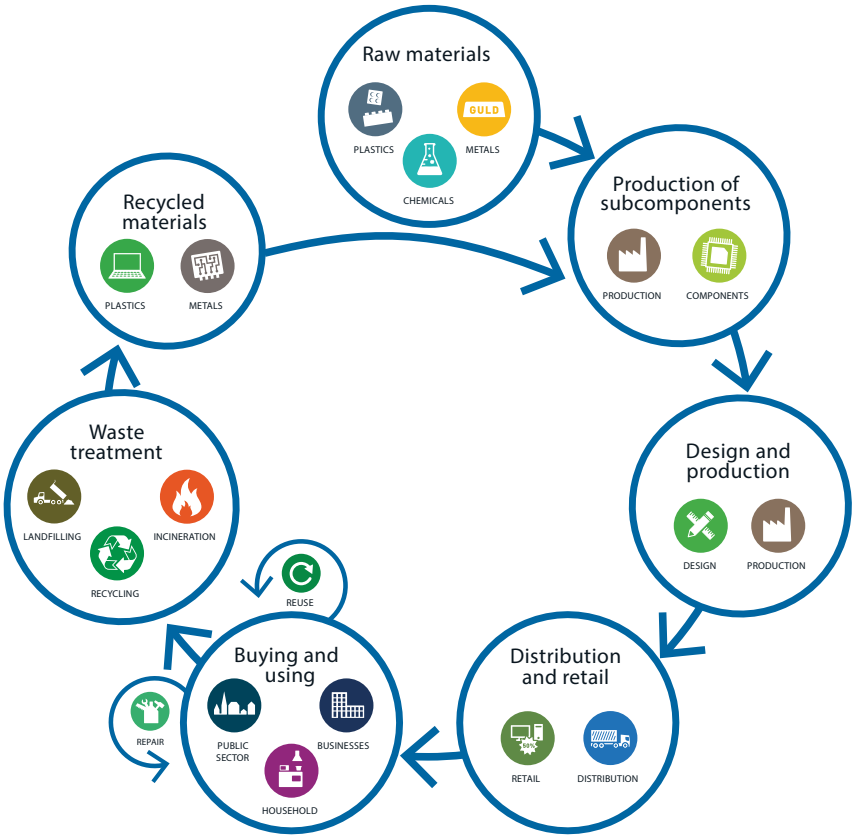
Figure 12: Informal e-waste recycling in India

Source: The Indian Express, 2014

As per Industry body ASSOCHAM, e-waste generation is likely to increase by nearly three times, from 18 lakh metric tons (MT) currently to 52 lakh MT per annum by 2020 at a CAGR of about 30% (Pandit, 2016). A mere 1.5% of India's total e-waste gets recycled, with over 95% of it being managed by the unorganised sector (figure 12) and scrap dealers in this market, which down-cycles the end-of-life products instead of recycling it. It has severe environmental implications as materials which fetch marginal or no value are simply discarded in nearby water bodies or are often burnt.

A typical value chain of the Electronic and electric equipment's sector would include raw materials supply, production of sub-components, designing & manufacturing, distribution & retail, use phase, waste treatment and recycling as represented in figure 13.

Figure 13: Circular economy value chain of EEE



Source: The Danish Government, 2015

Assessing benefits along the value chain

To study the adoption of strategies for cycling resources, three lifecycle stages in EEE can be considered of particular importance- Sourcing of raw materials; Design & production and End-of-life stage. The input stage includes the extraction and use of raw materials to manufacture consumer electronics where maximum energy gets consumed; hence using recycled material/ secondary resources holds the potential to yield significant savings. Limited success has been achieved in phasing out the use of hazardous material and it continues to remain a concern going forward. Table 3 shows energy requirement and savings in Kilo joules

Table 3: Energy Requirement and savings in Kilo joules

S.No.	Material	Primary (kj/kg)	Secondary (kj/kg)	Savings (%) (due to secondary material usage)
1.	Aluminium	47000	2400	94.89
2.	Copper	16900	6300	62.72
3.	Ferrous	14000	11700	16.42
4.	Lead	10000	130	98.7
5.	Nickel	20640	1860	90.98
6.	Tin	18200	200	98.90
7.	Zinc	24000	18000	25
8.	Paper	35200	18800	45.59

Almost 70% of the total energy used during the life-cycle of a laptop is used during its manufacturing (World Economic Forum, 2013)

Source: Grimes. S, Donaldson. J and Gomez. G.C. (2008)

Further consumer appliances need to be designed for easier repair and reuse with the objective of prolonging its in-use life. The design needs to be receptive to use secondary resources and enable greater recovery when recycled at its end-of-life. Effective end of life management calls for building robust reverse logistic network and recycling infrastructure as e-waste being toxic in nature poses severe environmental and health hazards.

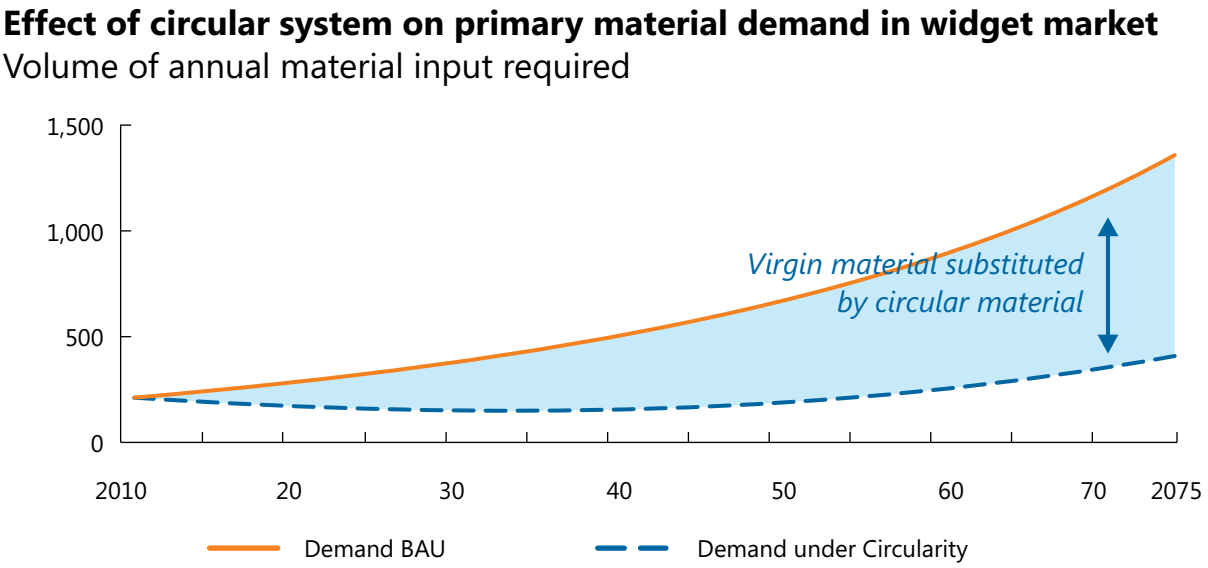
Input stage

With time, EEE material composition has changed drastically and is still changing due to rapid advancements in technological solutions including miniaturisation and increased understanding of hazardous components. For example, certain metals are being replaced with plastics to reduce the weight of the product, certain hazardous substances have been banned for usage in EEEs and various new rare earth materials are being used to reduce the size of the equipment. With the trend to go 'smaller and sleeker', not only more exotic metals are used but a smaller amount per product provides a smaller recovery value (NEW_InnoNet, 2016)

Multi-national companies such as Acer, Apple, Samsung, LG, Lenovo, Dell and HP made commitments in 2009/2010 to phase out Polyvinyl chloride (PVC) and Brominated Flame Retardant (BFR) from their products, to stem the tide of toxic e-waste. However till date, only Apple and Google have made their products free of BFR and PVC (Elizabeth, 2017)

World Economic Forum (2013) highlighted the effect of circular system on primary material demand in widget market. Figure 14 depicts the volume of annual material input required will be 80% lesser by 2050 and about 70% lesser by 2075 (shown in dotted line) as compared to business as usual scenario (shown in solid line) and the blue area shows the reduction in requirement of virgin material through greater use of recycled material.

Figure 14: Reduced demands for virgin material as a result of using circular material



Source: World Economic Forum, 2013

At the input stage, a few EEE manufacturers have started incorporating recycled materials like plastic and metals to close their loop. Even though this has been happening globally for some time, little progress has been made on this front over the past decade. Examples of few companies leading the initiative are highlighted in table 4.

Table 4: Best practices Input stage

Company	Intervention
Dell	Dell uses the recycled plastics derived from water bottles and old computers that they get through the ' take-back' system in their monitors and OptiPlex desktops. Labels are put into the recycled materials for identification of such products and re-using them in the best way possible (Elizabeth, 2017). The company also remains the first ones to get a certification from Underwriters Laboratories Environment practicing closed loop recycling. Dell's OptiPlex 3030 All-In-One computers are verified to contain a minimum of 10% post-consumer closed loop recycled content. By reusing plastics already in circulation, Dell is cutting down on e-waste, saving resources and reducing carbon emissions by 11% compared with virgin plastics (UL Environment, 2014) .
Fairphone	Tons of mobile phones are thrown away every year, because we replace them so frequently. With the aim to improve the lifecycle of a phone, the company collected 3.1 tons of scrap phones from Ghana and sent them to Belgium for formal recycling. So far company as collected almost 1 million phones and it uses recycled plastic, copper and tungsten in manufacturing new phones (Kluijver. J, 2016) .

Design stage

The design of a product should be such that it extends the useful life, however faced with market saturation for their devices, companies are designing products for single use and shorter lifespans thereby accelerating their replacement cycle. A longer life-span not only saves on the material resources but allows the carbon footprint of the product to be spread out over a large number of years. There is a greater need to design electrical equipment that is easier to upgrade and repair.

Table 5: Best practices Design stage

Company	Intervention
Dell	The company uses standardized parts which are easily removable making it easier to repair or recycle them. Company has cut down on the number of screws in their products, and the ones that remain are easier to access and more consistent in type making it easily separable with commonly found tools. Since Glues and adhesives can create processing challenges for recyclers, Dell uses other methods, such as innovative snap fits, to accomplish the same design goals. There are restrictions on paints and exterior coatings, which can interfere with the recycling process or degrade certain plastics during processing is preferred by Dell. If paint remains the only option, they choose the ones that are compatible with recycling (Elizabeth, 2017).
Company Elgama Elektronika Ltd.	Intervention Company manufactures multifunctional electricity meters ranging from single-phase electronic meters for domestic use to three-phase electricity meters meant for industrial uses. The depth of the meter was increased to minimize the outer electromagnetic influence. Size was reduced to use lesser plastic. This objective was realized by reducing the thickness of parts and optimizing the positioning of the components. It was possible to reduce the use of wires, through channeling the outside contacts on the printed circuit board. The wires powering Printed Circuit Board were replaced by screws. Steel screen were removed its function was to protect the components from outer electromagnetic influence. The increased depth eliminated the need for the screen and hence reduced use of earthing wires. Recyclable parts including plastic body, cover of the battery, strands, clips, contact screws etc were marked for easier repair and greater material recovery without breaking off parts thereby reducing the amount of waste generated. As a result of the interventions introduced at the design stage material requirement for casing was reduced by 22%, reduced use of wires by 3 meters. Further it reduced the environmental footprint at the production stage, by using lead free components and solder. New design of PCB resulted in sharp reduction of waste at the assembly stage and the optimization of the end-of-life systems with the help of information on disposal of hazardous substances, marking of plastics, and through the symbol indicating separate collection of EEE (Gurauskienė. I and Varžinskas. V, 2006).

End of life stage

Establishment of reverse logistics network remains the key towards setting up a formal recycling system. It is imperative that collected materials get into quality recycling process in a cost effective manner. E-waste management rules 2016, clearly identifies that producers have to set up a collection mechanism under the Extended Producer's Responsibility (EPR) or arrange for a buy back mechanism. It recommends that Deposit Refund Scheme (DRS) shall be introduced, wherein the producer charges an additional amount as deposit at the time of sale and returns it to the consumer when the end of life equipment is returned. DRS to be implemented through dealers and retailers. Urban Local Bodies (ULBs) have been assigned the task of collection and channelization of orphan e-waste to authorized recyclers or dismantlers (MAIT, 2016).

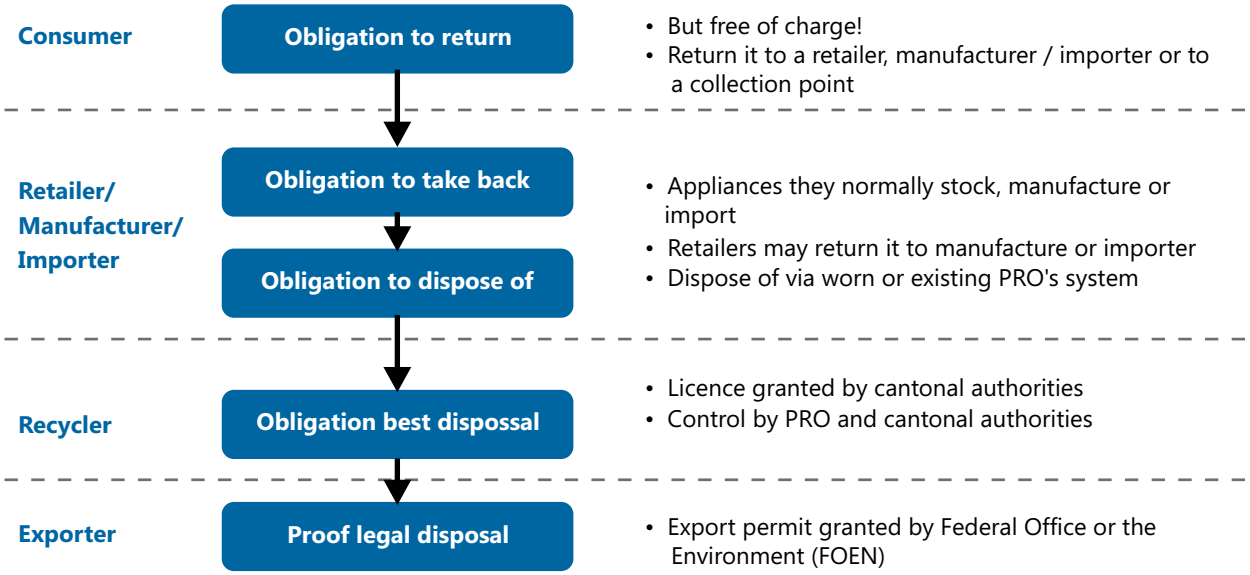
Best Practices: Creating a Reverse logistic Network

Switzerland's Advance Recycling Fees system

Switzerland remains one of the first countries in the world to be able to set up a completely formal system of e-waste management. SWICO Recycling, SENS and SLRS (Swiss Lighting Recycling Foundation), are the three national, not-for-profit organizations responsible for taking back discarded electronic and electrical equipment and processing it. As far as the financing is

concerned, advance recycling fees is charged from all consumers at the time of purchase of the electrical equipment. The fee collected is then used to fund collection, transport and recycling facilities. The consumers return the used EEE to retailers, manufacturers or importers free of charge and the latter are obligated to accept the Waste Electronics and Electrical Equipment. These regulations are contained in the Swiss Ordinance in Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE). After collection of Waste Electrical and Electronic Equipment (WEEE), specialized disposal companies dismantle the equipment manually and mechanically. Fragments that are remaining are separated and recycled separately. Figure 15 illustrates stakeholders' obligations as per the Swiss WEEE legislation (Federal Office for the Environment, 2017 and Schluep, 2014).

Figure 15: Stakeholders Responsibility



Source: Schluep. M (2014)

E-waste Management in Norway

Ministry of Environment of Norway in 1998 initiated the process of setting take back companies collecting e-waste, and subsequently formulated the e-waste regulation in 1999, making producer responsible for managing e-waste and pay a membership fee to the take-back companies. This is how it provides the funding for collection and treatment of the e-waste. The price for membership differs according to product type. Currently, there are five approved take back companies in Norway with 5000 member producers/importers (Sadia Sohail, 2015). The take back companies in Norway need to get an approval from the NEA (Norwegian Environment Agency). The approval process includes a verification of nearly 50 criterions, besides third party certification. The process includes providing a plan detailing how they will collect e-waste and treat it in an environmentally sound way.

They also need to ensure that they will collect all e-waste from their market share which is determined by how much of electronics is put into the market by their members. The take back companies report back to WEEE registrar and also finance its recycling. WEEE register is managed by the government and maintains all records regarding e-waste in the country. Huge amount of recycling and recovery of e-waste in Norway has only been possible due to the presence of efficient

take-back system and the collective interest of the producers to comply with the legislations (Sadia Sohail, 2015).

Amazon Recycling Initiative

Recognizing the importance of recycling electronic equipments at its end-of-life stage, Amazon one of the leading online retailing platforms has come up with an initiative offering a recycling program for an array of electronic items including cell phones, digital cameras, GPS devices and even graphing calculators and compensates customers through their Amazon accounts according to the trade-in values of the products being turned in. Amazon has authorized Li Tong for collection of e-waste from consumers, for material reclamation and further disposal of such e-waste as per the E-Waste Rules. Li Tong Group provides reverse supply chain optimization services to technology, electronics, and telecom sectors (Li Tong Group, 2014).

Mumbai e-waste collection centre

Sixty five Indian cities generate greater than 60% of this entire e-waste generated in the country, with Mumbai generating 24% of total e-waste (Chatterjee, 2011). In January, 2016 Brihan Mumbai Municipal Corporation (BMC), along with Eco Recycling Limited (Ecoreco) a waste management company, established e-waste collection centres in different location across the city, which collected waste from thousands of eco-bins placed in educational and spiritual places (DNA, 2016). Further citizens can surrender their old electronic items which are not in working condition to the authorized facilities and get compensated accordingly. BMC has planned four e-Waste collection centres in every 24 Administrative zones in Mumbai. Once collected, all the waste is taken to special recycling centres where it gets processed as per the BMC guidelines.

Best practices: Processing e-waste

Apple's innovation in pre-processing of electronic waste using robot 'Liam'

Liam is an Apple R&D project focused on new disassembly technologies. It utilizes a fully autonomous, clean take-apart process to liberate and separate individual components for target material recycling. When the efforts to repair and/or extend useful life of a device seems to be a failure, one moves on to material recovery - extent to which individual components can be separated and thereby processed. Traditional e-waste recycling can only recover a handful of the materials actually used in today's electronics due to the challenges faced in pre-processing where highly complex electronics have to be shredded and are separated into only a few different material streams that aggregate many individual materials. This shredding process leaves significant room for improvement in material recovery rates and in quality and purity of recovered material. Liam addresses this problem by producing eight different material streams that can be sent for targeted material recovery. As a result, end-processors can recover a more diverse set of materials at higher yields than ever possible before. Many of the additional metals made recoverable by Liam are also widely considered to be critical metals by the US Department of Energy and other government agencies. The automated disassembly system was custom built for the iPhone 6 with the ability to disassemble 1.2 million iPhone units per year (Rujanavech, C. et.al, 2016).

Construction

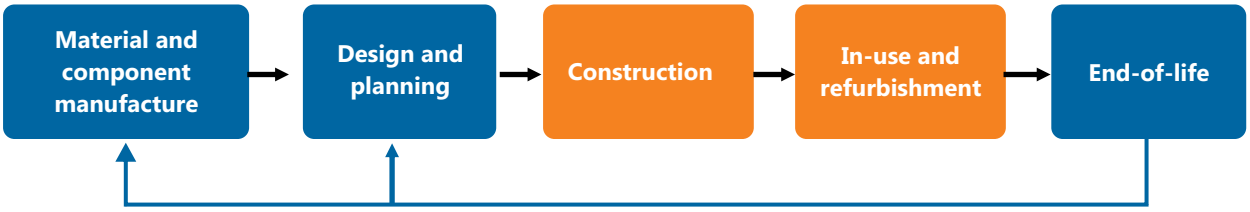
Introduction

India is currently experiencing a boom in the construction sector which is fuelled by rapid urbanization, Government schemes like 'Hosing for all', rising per capita income and population growth. India is poised to become the third largest construction market globally by 2018, with major construction in the residential and commercial sectors (Global Construction Perspectives and Oxford Economics, 2013). With a current contribution of 8% to India's GDP, the sector is the second largest in terms of employment generation after agriculture. The major material resources used for construction include sand, soil, stone and limestone. These critical resources are finite and take a long time to replenish. Since over 70% of the buildings estimated by 2030, are yet to be built (NRDC-ASCI, 2012), demand and pressure on limited stocks of these materials is expected to increase tremendously (TERI, GIZ, DA 2016).

Value Chain in Construction

To study the adoption of strategies for recycling resources, three lifecycle stages can be considered of particular importance: (a) Material and component manufacture, (b) Design and planning, and (c) End-of-life (as shown in figure 16). This is because companies need to adapt the design of buildings to enable recovery of construction material at the end-of-life and its reintegration in new construction projects.

Figure 16: Illustration of the construction value chain

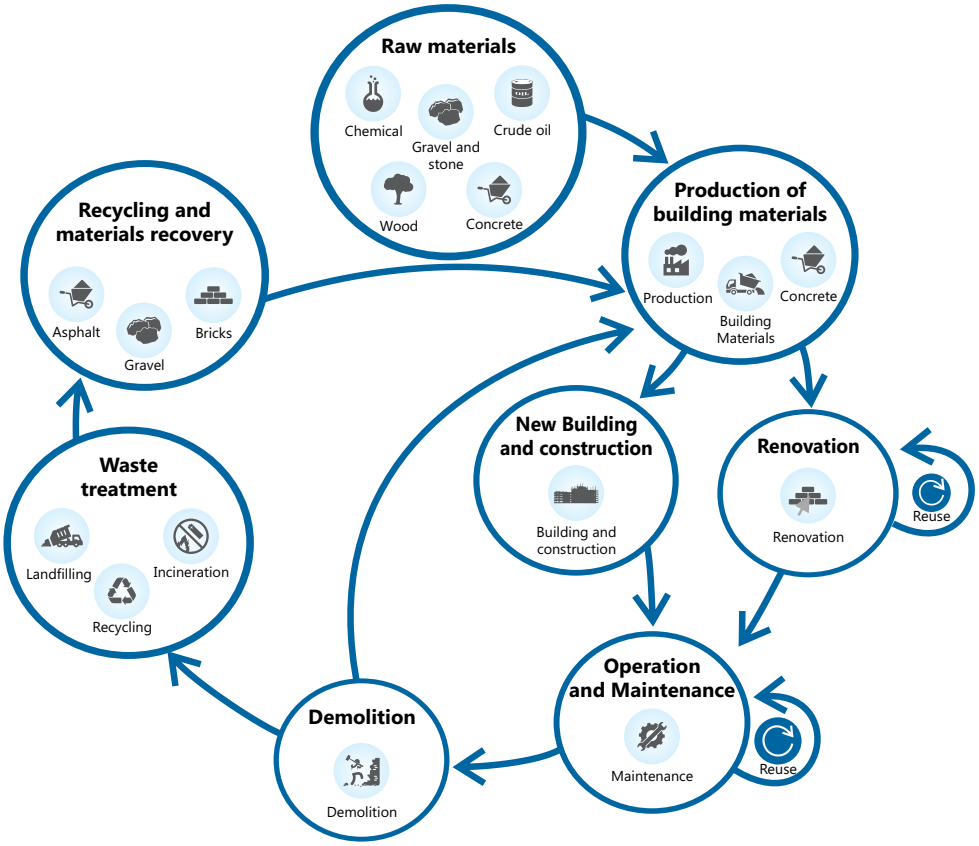


Source: Nussholz and Milios, 2017

Opportunities across the value chain

World Economic Forum (2016) points out that adopting the principles of circularity in the building sector would help many countries to cut emission rates cost effectively and achieve energy savings of more than 30%. Figure 17 shows the opportunities for closing the loop:

Figure 17: Circular Economy opportunities in the construction value chain



Source: Denmark without waste II: A Waste Prevention Strategy, 2015

A range of circular strategies that cycle resources at product, component or material stages can be adopted for savings on resources and energy consumed. These circular strategies aim to first prolong the useful life of products and components (e.g. trough repair, refurbishment, or remanufacturing), and then close material flows (through recycling) once the end-of-life is irreversibly reached (Nussholz and Milios, 2017). This has the potential to maintain the quality of resources over time beyond a single life and reduce resource extraction and limit the waste going to landfill.

Total Construction and Demolition (C&D) waste generated in the country in 2015 was estimated to be 716 million tonnes. Based on the material composition of the waste estimated by Technology Information Forecasting and Assessment Council (TIFAC), the embedded amount of resources in C&D Waste is shown below in Table 6.

Table 6: Embedded material resource in C&D waste

Resource Material	Quantity in million tonnes per annum
Limestone	35
Iron and Steel	29
Sand	153
Soil waste	213
Waste stone	254

Source: TIFAC (2001), GIZ (2015b)

Table 7 below elaborates on the potential usage of some secondary raw materials in the construction sector. However mainstreaming the usage of these raw materials requires drivers in the form of favourable regulation, availability of appropriate technology, and suitable market mechanisms.

Table 7: Opportunities of using the secondary raw materials in the construction sector

Primary Resource	Secondary Raw Material	Source	Application
Soil	Fly ash Industrial wastes like marble sludge	Thermal power plants Industries	Fly ash Atternates / waste based bricks
Stone	Demotition waste	C&D waste	Recycled aggregate Replacement in ashait mixtures, Portland cement concrete
Sand	Demolition waste Natural stone	Construction Sites Quarry	M-sand
Limestone	Crushed limestone Calcined clay	Low quality limestone Overburden from clay mines Thermal power plants Sponge iron industires	Blended cements

Source: TERI, GIZ and DA 2016

Positive Developments

The Government has taken initiatives to encourage utilization of fly ash, slag and red mud in concrete as substitute for other binders. The use of blended cements like Portland Pozzolana Cement and Portland Slag Cement has become popular in the country. By-products and waste from other industries and manufacturing processes have been used to substitute clinkers to reduce the use of carbon-based raw materials. Current practices routinely replace up to 30% or more of the Ordinary Portland Cement with blended materials, most commonly fly ash. The market share of blended cements increased to 67% of the total cement produced in 2010-11, from 37% in 2000-2001 (WBCSD & IEA, 2013). In fact, MOEFCC (2015) notification mandates the utilization of fly-ash in building construction. Fly-ash is vastly used for manufacturing regular blocks, Aerated Autoclaved Concrete (AAC) blocks and Cellular Lightweight Concrete (CLC) blocks. Fly-ash can also be utilized in the concrete manufacturing directly as per the Concrete Mix Design. There is a huge potential of this waste to be used as coarse aggregates in roads and concrete after proper processing and grading. Building materials such as paving blocks and curb stones have been successfully produced from C&D waste in India in pilot projects in Delhi and Ahmedabad. But due to low awareness about these products, they have struggled to find a market in the construction industry. Steps are being taken by the Bureau of Indian Standards (BIS) to formulate standards for using C&D waste as coarse aggregates in concrete.

Best Practices/ Case Studies:

Limestone Calcined Clay (LC^3) Material (at the raw material stage)

Cement is one of the largest produced construction materials in the world, accounting for 3-7% of total emissions. India being the second largest producer of cement in the world after China contributes to about 7% of its Carbon dioxide (CO_2) emissions (via only clinker production).

India produced 280 million tons of cement in 2014 and projected maximum production in 2027 is estimated to be about 1240 million tons, three times the current production (Development Alternatives Newsletters). Apart from CO_2 emissions, cement production also consumes huge volumes of limestone. To produce a ton of cement about 1.4 tons of limestone is utilized in India. It is estimated by Ministry of Commerce and Industry that all cement grade limestone resources in India will be exhausted in 41 years owing to ever increasing demand of cement (LC^3 project).

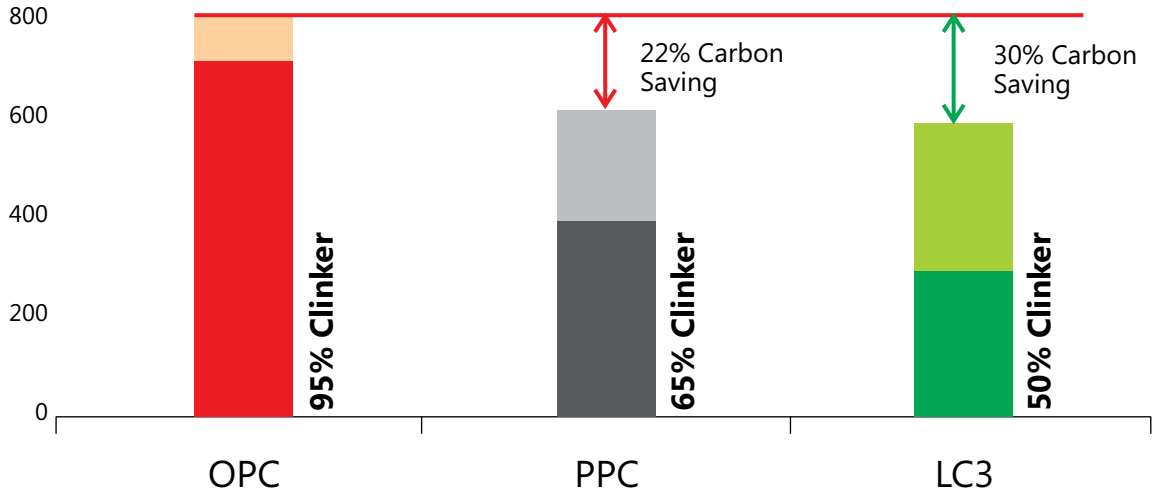
Material composition and process of production

Typically LC^3 cement contains 40% - 65% clinker by weight. The remaining LC^3 cement contains 30% - 38% calcined clay, 15% - 20% of crushed limestone and 3% - 7% gypsum. LC^3 works on the synergy between clinker, calcined clay and limestone phases. Clays containing 40% - 70% kaolinite are ideal for the production of LC^3. Such clays are abundantly available as waste in mines where higher grade clays are used for high value applications. The clays are then calcined at 750^{0}C - 850^{0}C to make them reactive. Calcination requires less than half the energy required for clinker production. Moreover, limestones with as little as 65% carbonate content and impure varieties with quartz and dolomite can also be used, which are often the rejects of cement plant mines. Further to this waste materials from marble and kota stone are also being tested for use in place of limestone (LC^3 project).

Material and emission savings

Life Cycle Analysis reveals that LC^3 production can reduce CO_2 emissions by up to 30% and save up to 50% limestone as compared to conventional cement (Shown in Figure 18). Up-scaling the production of LC^3 could potentially save 300 million tons of CO_2 per year. Besides this LC^3 contributes to material savings as well as it reduces clinker content by 45% as compared to conventional cement and efficiently utilizes low grade mining rejects widely available with the cement industry (LC^3 project).

Figure 18: CO_2 Saving Potential of LC^3



Source: Life Cycle Analysis conducted in Indian cement plant by consortium of École Polytechnique Fédérale de Lausanne (Switzerland), IIT-Delhi, IIT-Madras, Technology and Action for Rural Advancement and CIDem (Cuba) and supported by Swiss Agency for Development and Corporation (SDC).

Note: OPC: Ordinary Portland cement ; PPC: Fly ash based Portland pozzolanic cement ; LC^3: Limestone Calcined clay cement

Current Status

Almost 170 tonnes of LC^3 cement has been produced in the country. The cement is found to have comparable durability and strength with conventional cement. Suitability of the cement for construction has been tested through various demonstration buildings constructed in India. Currently steps are being taken by the Bureau of Indian Standards (BIS) to formulate standards for production of LC^3 cement which will be the key enabler incentivizing industries to take it up on a commercial scale. Globally, Cuban Government has taken the initiative to revise cement standards with a view to accelerate the transition towards LC^3 and shift away from the conventional cements. Examples of successful buildings where LC^3 cement have been used is shown in Figure 19.

Figure 19: Buildings using LC^3 material

The LC^3 building in Jhansi built using the first batch of LC^3 produced in Jhansi

The SDC building at the Swiss Embassy in Delhi having Autoclaved aerated concrete (AAC) blocks made of LC^3

Source: LC^3 project

Case Study at the Design Stage

The 'tightest' loop for building components would be to design for non-destructive disassembly and full reuse of building components in new projects. Even though few buildings today have been constructed with deconstruction and reuse in mind, it is possible to recover significant quantities of construction materials and use them for new buildings. As the reuse of components and recycling of materials proliferates and a new reverse cycle ecosystem emerges, a market will emerge for material 'brokers' connecting suppliers with buyers.

Lendager Up, a Danish construction company was set up with the idea of how the concept of sharing economy i.e. the economic system in which assets or services are shared between private individuals; can be manifested in physical spaces. For instance the Group in one of the projects 'Up-cycle Studios' has used up-cycled windows, which have had a previous life in another house.

The windows are processed, so that they aesthetically appear as newly produced windows both in terms of quality and strength but without actually producing new materials. Recognizing the tendency towards greater urbanization, with people moving from rural areas to urban cities, company sees greater potential in taking away materials from the left over houses in rural areas and using them in new constructions of urban areas. The company has done this in building 'The Resource Rows' urban housing area developed from materials from the old houses. Lendager Up works in close collaboration with Lendager Arkitekter for the development of new innovative building materials and ensures that products adhere to all regulations, standards and legislations (Lendager Group, Denmark)

Project Copenhagen Towers

For the project Copenhagen Towers in Ørestad, Copenhagen, Lendager Group raised the sustainability profile of the project by covering the interior surfaces with up cycled materials.

Up-cycle wood panel

Every year 181,000 tons of wood get burned up in Denmark and around 130,000 tons of new wood is used in the construction industry. Lendager Arkitekter has developed a new type of wall panels made out of recycled wood. For the project Copenhagen Towers in Ørestad, Copenhagen, has up-cycled 60,000 linear metres of wood that otherwise would have been wasted. The wood comes from window frames, doors, floors and old scaffolding wood.

Up-cycle Acoustic ceiling panel

In order to create a suspended ceiling made of recyclable materials, group has developed and designed acoustic panels using plastic waste. The specially developed acoustic ceiling panels consist of a back plate onto which PET felt is mounted in an optimized geometry with high acoustic performance enabling its usage in office settings as well as in homes.

Up-cycle Sail Frame

Carbon fibre sails are exclusive and expensive but have a limited lifespan when used for professional racing. The mainsail can only be used at eight regattas, which is roughly one season. In order to cover a big ventilation system mounted in a vertical steel construction, textile designs were integrated into architecture in a sustainable and resource conscious way. Textile has an obvious advantage over other materials regarding its ability to span large areas despite its low weight. The sails are cut and mounted on frames, creating a beautiful and environmentally friendly covering as it replaced the need of glass covering giving a significant carbon dioxide reduction.

Case study at the end-of-life stage: Utilization of Construction and Demolition waste in India

Construction debris in Delhi has been choking roads, wetlands and green lands and the problem is becoming acute every year. The massive construction and demolition waste generated in the capital is not only polluting the Yamuna banks but creating problems in the entire city (as shown in figure 20, 21). The government's economic survey has put the quantum of daily construction and demolition waste at 3,000 to 5,000 tonnes. A pilot facility was established jointly by Municipal Corporation of Delhi and Infrastructure Leasing and Financial Services (IL&FS) with the objective of demonstrating the possibility and potential of scientifically managed storage, collection, transportation and processing / recycling of C&D waste.

Figure 20: Prior to National Green Tribunal Order (NGT

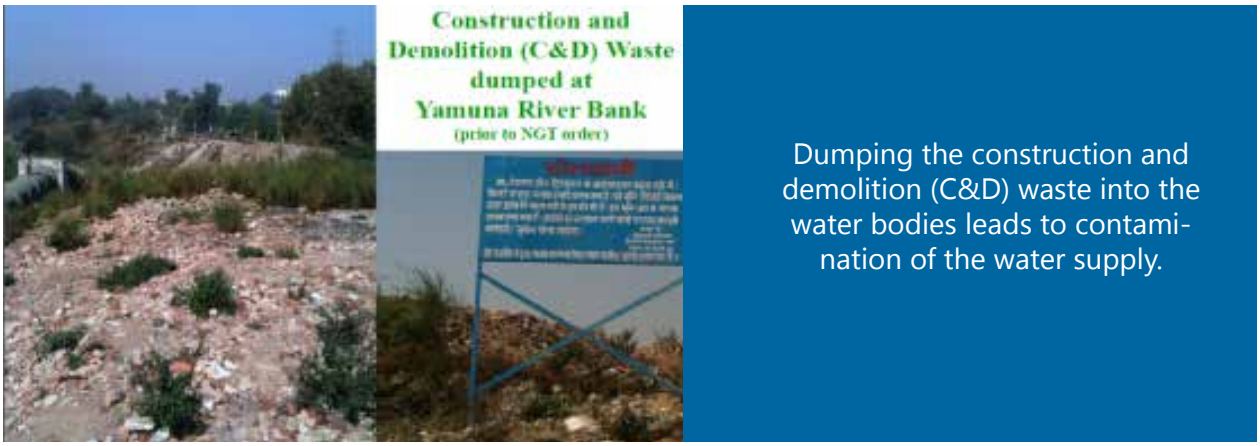
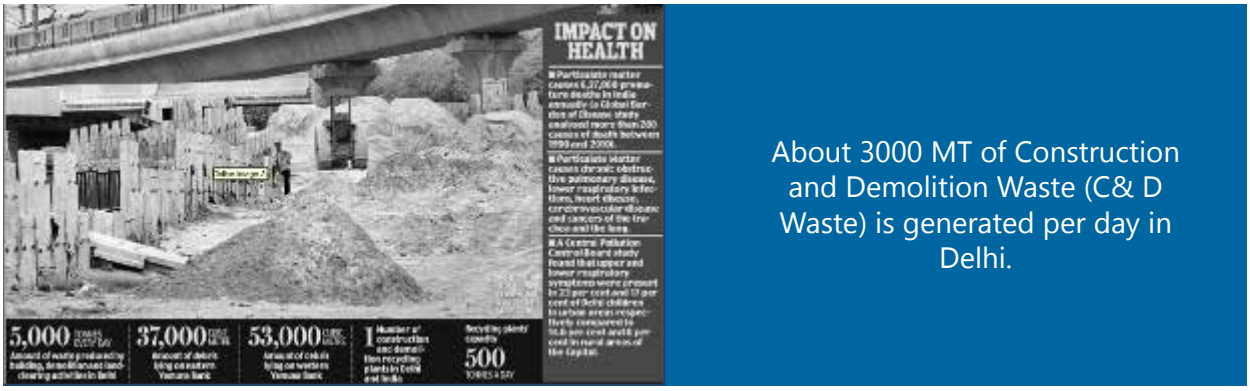


Figure 21: Pollution levels: Construction activities in Delhi



Source: IL&FS Environmental Infrastructure & Services Ltd.

Collection: how does the reverse logistic network work?

In order to source back the C&D waste, IL&FS set up certain designated points which would aggregate debris from waste generators, with tipping trucks being used to transport it to the recycling facility. Collection is being also done by the Municipal Corporation and brought to recycling plant. Large generators, such as, Delhi Metro Rail Corporation (DMRC), Public Works Department (PWD) etc. also truck their bulk C&D waste material to the plant.

Financing of the reverse logistic network:

User charges are collected from generators including transportation fee from private operations and large generators of C&D waste. Alongside Municipal Corporation of Delhi contributes transportation fee for transporting illegal dumped waste if any and charges an environmental fee and disposal fee from Government Organizations.

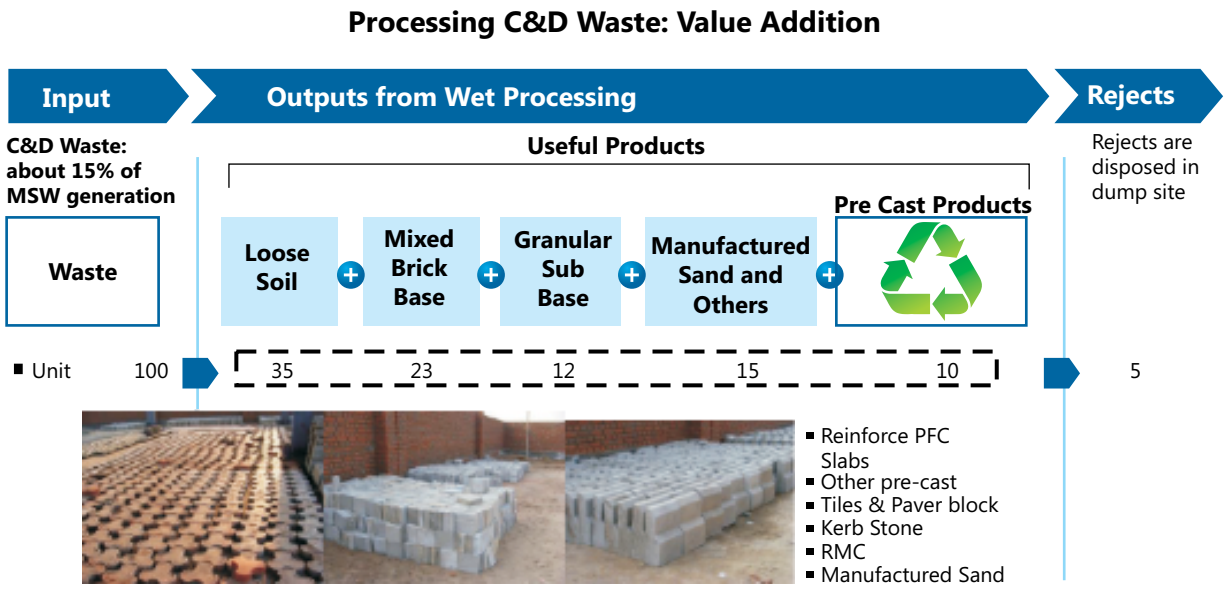
Processing, value addition and creation of market

After C&D waste gets dumped at the tipping floor, two-stage segregation is done as follows:

1. Segregation of undesirable items like rags, plastics, metal, Fibre-reinforced plastic (FRP) sheets etc. with mechanical (JCB) and manual means
2. Remaining waste segregated into 3 parts:
   - Whole bricks
   - Big pieces of concrete and
   - Mixed C&D waste

Post segregation whole bricks are kept separate for internal use and sale whereas large concrete pieces are broken using rock breaker and mechanical hammer (200-400 mm size). Post shredding using horizontal impact crusher, screening of the crushed material is carried out (Fractions of 10-20 mm, 5-10 mm and below 5 mm to 75 micron size). After shredding starts the processing using wet and dry processor. Ready Mix Concrete (RMC) is then used to make kerb stones, paving blocks, tiles etc. including color and pattern of choice. Moulded bricks (cold) are made from mixed aggregate and cement using brick laying machine. With years of in-house R&D in processing of C&D waste, facility is now able to recycle/recover about 95% of incoming C&D waste that comes in mixed form thereby reducing pressure on scarce land (ibid) (Shown in Figure 22).

Figure 22: Processing C&D Waste at IL&FS facility



Source: IL&FS Environmental Infrastructure & Services Ltd.

Figure 23: Material recovered from C&D waste

Source: IL&FS Environmental Infrastructure & Services Ltd.

After multi stage processing facility is able to generate a range of value added recycled green products which can be broadly classified as in figure 23:

Crushed and size-graded products:

- Granular sub-base (GSB)
- Brick pozzolana
- Recycled concrete / stone / tile aggregate of different sizes
- Recycled manufactured sand – mix of coarse, medium and fine

Mixed and moulded products:

- Ready mix concrete (RMC)
- Kerb stones
- Paving blocks and tiles
- Bricks (solid, hollow)

Figure 24: Value added recycled product

From Illegal Dumping to Scientific Processing

Source: IL&FS Environmental Infrastructure & Services Ltd.

Recycled aggregates are then used in pavement construction whereas recycled soil, brick powder is used to make sub base Roads (as shown in figure 23. For instance, all roads inside the IL&FS processing facility have been constructed with recycled GSB material. Public procurement has been the key in terms of creating market for these recycled materials with Municipal Corporation of Delhi providing assurance of buy back in some instances which is further complemented with regulations mandating the usage of recycled C&D waste products for public works.

Impact achieved

Since its inception, facility has processed over 17 lakh tons of C&D waste which would otherwise have been dumped illegally in the river Yamuna and other environmentally sensitive areas. In the process reduced burden on the landfills, saving about 11 hectares of scarce urban land valuing 256 crores (as per circle rates).

Replicability

On the similar lines, Ahmedabad Municipal Corporation became the second Urban Local Bodies (ULB) after Delhi to install and operate a C&D waste recycling unit with a processing capacity of 1,000 tonnes per day. This project is running on a PPP basis with Amdavad Enviro Projects Ltd. (AEP) since June 2014, where C&D waste is processed and recycled into aggregates. These aggregates are used to prepare finished products including paver blocks, kerbstones, concrete tiles, prefabricated structures. Interventions were targeted towards firstly cost reduction of existing products developed by AEP while maintaining quality, wherein a cost reduction of 10% in manufacturing of M30 grade paver blocks were made and a new product - M50 grade paver block was developed at the cost of M30 grade paver block. Secondly in order to create market for C&D waste based products made by AEP, Institute for Certification and Quality Mark (ICMQ)

accredited by European Union for third-party certification of a wide range of green products, buildings, management systems was engaged for product audit. GRIHA certification was obtained for building material with recycled content and M30 paver block added to the GRIHA product catalogue (GIZ and DA, 2017).

Stakeholders Insight

"The idea of embedding Circular Economy in business strategy and undertaking various efforts stems from internal policy of being a sustainability-centric infrastructure company. Segregation of waste at source is one of the main challenges in the value chain, C&D waste often mixed with Municipal waste makes the processing difficult and more expensive. In the next five years all buildings of Colonial times needs to be reconstructed which presents a huge opportunity. For instance demolition in Kidwai Nagar is expected to generate 7000 a tonnes per day of C&D waste which is more than the current processing capacity of all the three IL&FS plants. This presents a greater need to start intervening up the value chain with greater emphasis on 'Deconstruction instead of demolition'. There are technologies available in India for proper effective deconstruction (mainly 4 categories: wood, glass, bricks and sand). But these activities are happening at a relatively minuscule stage and Government needs to incentivize up-scaling these activities. Regulatory requirements mandating use of C&D waste based material in new constructions especially in government buildings would drive up the market for secondary materials and at the same time would make processing of C&D waste economically viable. Moreover, some amount of C&D waste could be utilized by industries at the start of the value chain for instance. Cement industries should also be mandated to blend some part of the C&D waste to produce cement as part of producer responsibility. In recent past, Delhi Government has mandated for projects costing more than INR 500 Crore, to include a clause in their tenders that mandates use of minimum of 2% processed or recycled products from construction waste in all future contracts for building work, and 10% of recycled products from construction waste for road work. These regulatory requirements have provided the requisite push. In addition certifying the recycled products by the GRIHA Council could be the key enabler when it comes to creating the market for these products. Further there is a greater need for ratifying the tax structure as GST rate of 18% make the recycled materials less attractive as compared to virgin material (GST rates should be brought down from 18% to 5% tax bracket)."

Gaurav Bhatiani & Arvind Singh

IL&FS

Agriculture Sector

India is the 2nd largest producer of agricultural products in the world and accounts for nearly 7.68% of total global agricultural output (Ministry of Statics and Programme Implementation). Agriculture plays a vital role in India's economy as it accounts for about 17% of the India's total GDP (Ministry of Statistics and Implementation, 2016-17). It is estimated that over 58% of the rural household depend on agriculture as their principal means of livelihood (India Brand Equity Foundation).

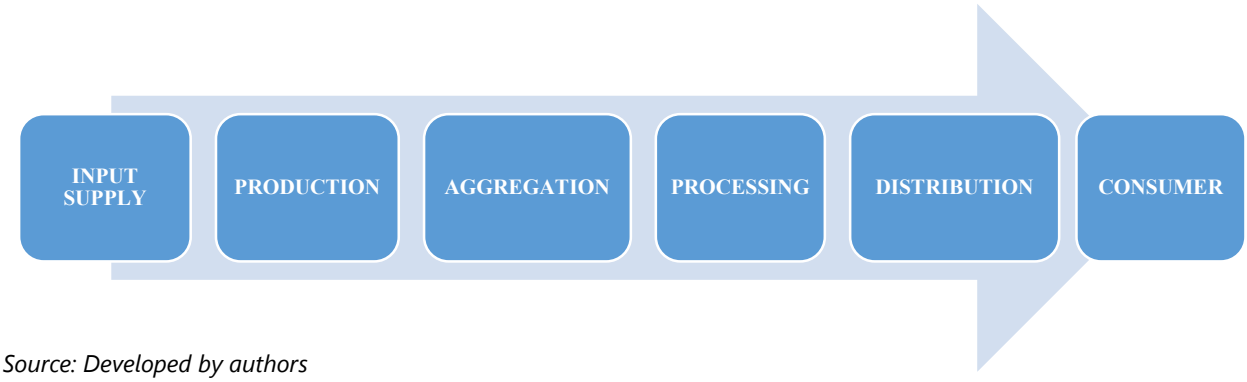
The agriculture system in India has undergone rapid transformations over the past few decades, particularly after the economic reforms of 1990s. However, the food sector is yet to realise its full potential. The sector currently fulfils only 60% of the potential yield for most crops as production levels remains far below global average. For instance, India's recent rice yield stood at 2191 kilogram/hectare while the global average was 3026 kilogram/hectare and in case of wheat, the yield was 2750 kilogram/hectare as against the global average yield of 3289 kilogram/hectare.

Yet for many crops, India does not have global scale processing facilities. In India only 4% of the fruits are processed as compared to China (23%), Indonesia (50%) and Brazil (70%), with India losing about 40-50% of fruits and vegetable's total production annually due to lack of processing infrastructure in the country. Thus extending the shelf life of the produce will not only supplement farmer's income but will go a long way in providing food security. (Kumar and Sharma, 2016 and ASSOCHAM).

Value Chain

The potential for circular economy in the sector centres around the production of agricultural commodities using a minimal amount of external inputs, closing nutrient loops and reducing negative discharges to the environment (in the form of wastes and emissions) by utilisation of by-products and food waste and more efficient food patterns. In order to study the adoption strategies, the report will focus on three different stages of the agriculture value chain i.e. Input Supply stage, Aggregation stage and Processing stage (Figure 25).

Figure 25: Illustration of Value Chain

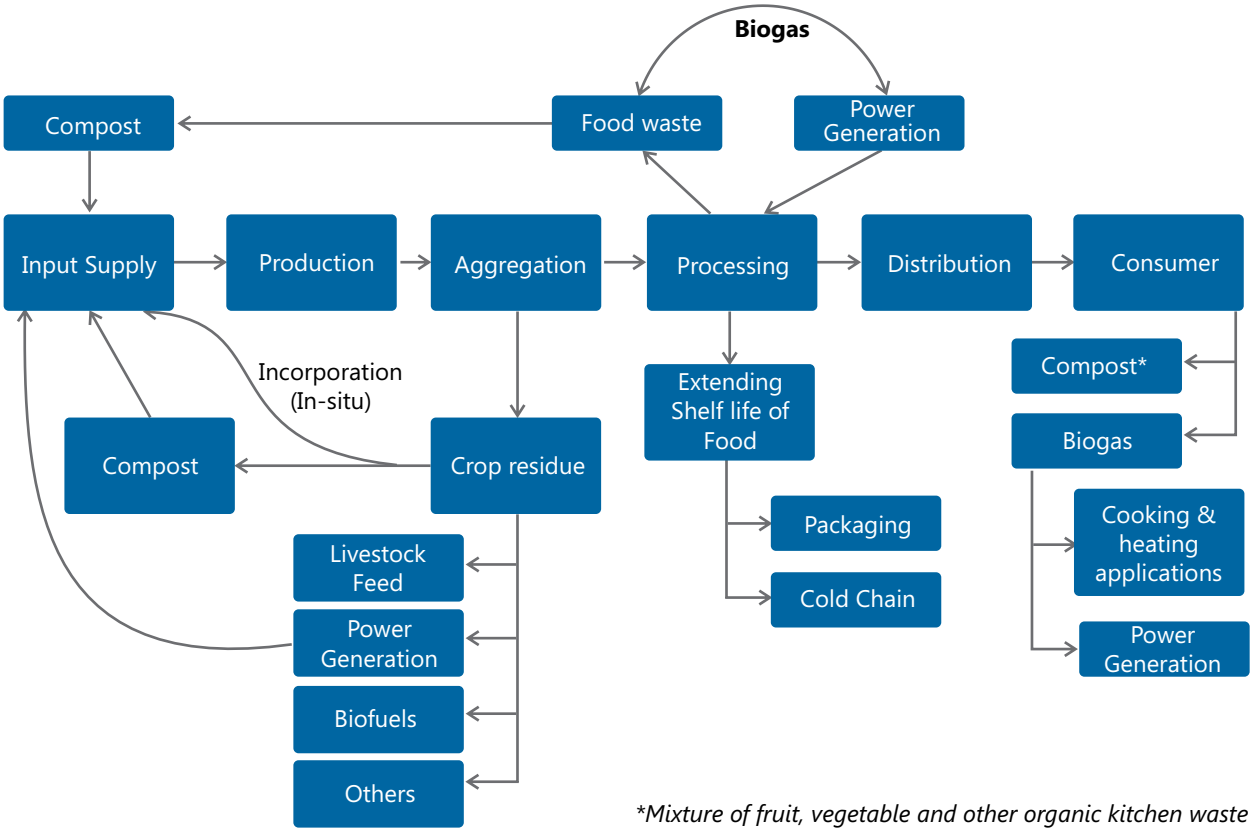


Source: Developed by authors

Opportunities across the value chain

Examining the entire agricultural food system will reveal opportunities at all stages of the value chain, starting from primary production using precision agricultural techniques, to utilisation of food wastes in the bio-economy and retail-consumer nexus. Figure 26 depicts various opportunities underlying circular economy principles at different stages across the agriculture value chain.

Figure 26: Illustration of Value Chain



Source: Developed by authors

But the following section will only bring about resource efficiency strategies and best practices (both national and international) at the three above mentioned stages of the value chain:

Input Supply Stage

Water Use Efficiency in Agriculture

World Bank estimated that 70% of the freshwater in the world is used for agricultural activities. Considering India, it accounts for 4% of the world's fresh water, out of which 80% is currently being used for agricultural activities (Dhawan, 2017).

Since 1970, India has moved to an export intensive regime in virtual water trade with the country ranked third at a value of 125Gm^3/ year in gross virtual water exports. India's water import for food grains is virtually nil and it is estimated that if the current rate of net export of water continues then the country will lose its entire available water in less than 1,000 years. Indian agriculture has become a ground water economy, fuelled by more than 19 million electric and 10 million diesel pump sets. In major crop growing states of India such as Haryana, Punjab and Rajasthan, annual ground water demand has well exceeded its availability while other states are approaching threshold breaching limits (Ghosh, 2016).

For instance, if we compare water requirement for five major crops namely wheat, paddy, maize, sugarcane and cotton with the global averages, India's average water footprint (both direct and

indirect use) and blue water (surface/groundwater) footprint for all these crops are higher than the global average. Further high minimum support prices for water intensive crops add to the water use inefficiencies in Indian agriculture, thereby taking a toll on ground water levels.

Though water use efficiency in agriculture has been extensively researched for years, it is difficult to arrive at universally applicable solutions due to different contexts and high specificity of agricultural practices. However, efficiency gains are often possible through suitable crop selection, proper irrigation scheduling, effective irrigation techniques, and using alternative sources of water for irrigation. Some of these techniques have been discussed in details in the upcoming section –

- **Sprinkler irrigation systems** imitate natural rainfall. Water is pumped through pipes and then sprayed onto the crops through rotating sprinkler heads. These systems are more efficient than surface irrigation but they are more costly to install and operate because of the need for pressurized water. Conventional sprinkler systems spray the water into the air, losing considerable amounts to evaporation. Low energy precision application (LEPA) offers a more efficient alternative. In this system, the water is delivered to the crops from drop tubes that extend from the sprinkler's arm. When applied together with appropriate water-saving farming techniques, LEPA can achieve efficiencies as high as 95%. Since this method operates at low pressure, it also saves as much as 20 - 50% in energy costs compared with conventional systems

- **Drip irrigation** delivers water through the use of pressurized pipes and drippers that run close to the plants and that can be placed on the soil surface or below ground. This method is highly efficient because only the immediate root zone of each plant is wetted. This system also allows precise application of water-soluble fertilizers and other agricultural chemicals. Drip irrigation is reported to help achieve yield gains of up to 100%, water savings of up to 40-80%, and associated fertilizer, pesticide, and labor savings over conventional irrigation systems

Water Footprint Reduction through Drip Irrigation (International Finance Corporation, 2017)

Vegetables and fruit farming in India are predominantly done by small farmers, especially women farmers. South India is particularly facing the problems associated with increasing water shortages due to erratic rains, climate change and unsustainable ground water usage. Hence, limited availability of groundwater constraints the ability of small farmers to cultivate effectively.

In order to overcome the problem of water shortage in agriculture, Jain irrigation systems limited (one of the largest manufacturers of micro-irrigation systems) has come up with a 'more crop per drop' vision for irrigation.

The company studied interrelationship between soil, water, crops, terrain and other agro-climatic condition to design a viable system which delivers measured quantities of water at the roots of plants at regular intervals. This type of irrigation technique ensures that the plants do not suffer from under- or over-irrigation. The company tested their systems for growing dehydrated onions with and without drip irrigation in the Tapi river basin in Maharashtra.

Approximately 1200 litres of water per kilogram of dehydrated onions per year was saved using drip irrigation system when compared with the conventional irrigation systems, resulting in a virtual water trade reduction of 18 million cubic meters annually.

Compared to flood irrigation, the blue water footprint of onion cultivation under drip irrigation is less than one-third (500 litres per kilogram) of dehydrated onions versus 1,796 litres per kilogram without drip irrigation. Similarly for grey water footprint, 13 litres per kilogram of dehydrated onions using drip irrigation technique versus 286 litres per kilogram using flood irrigation.

Apart from efficiency in water use for irrigation, farmers have registered 30% increase in efficiency of fertilizers due to fertigation through drip irrigation systems. In most cases, the crop yields increased by over 50% - 100% under well-tended conditions. Seeing the positive results from use of such drip irrigation technology, Jain Irrigation Systems has been able to convert over 500,000 farmers in the country to drip irrigation.

The company along with IFC also mainstreamed Jain-G.A.P. (Good Agricultural Practice) which is an intermediate and simpler version of Global G.A.P., to reduce the burden of compliance cost for international supply chain standards on small farmers. Till date, the company has sourced over 165,000 ton of Jain-G.A.P. certified white onions, 53,000 tons of bananas and 17,000 tons of mangoes and sold them globally to institutional buyers thereby benefitting small farmers.

- Utilizing treated wastewater is another approach that can provide a feasible alternative source for irrigation water. With the use of modern technology, domestic wastewater can be treated to meet strict health and environmental guidelines, allowing safe use in irrigation. Conventionally, however, use of treated wastewater in irrigation practices has only been possible in farms located in close proximity to cities or towns that are large enough to operate an effective wastewater treatment system. Treated wastewater is already used in irrigation in Jordan and Tunisia and in landscaping in member countries of the Gulf Cooperation Council. With advancements in wastewater treatment technologies, use of treated wastewater on a smaller scale and in a distributed mode is becoming feasible

- **Use of microbe free plants** - The Energy and Resources Institute (TERI) have been contributing towards the principles of circularity for agriculture in the form of TERI's Micro Propagation Technology Park (MTP) where disease free super quality plants are produced. MTP is a facility jointly developed DBT (Department of Biotechnology), Government of India and TERI for mass propagation of cash crops and forest species. TERI's highly aseptic laboratories produce microbe-free plants that make the international transit for these plantlets smooth. Large-scale field demonstrations by TERI prove reassuring for forest officials, private growers, breeders, seed company officials, and others who invest in its expansive services. Amongst other things, the MTP supplies disease free superior-quality tissue-cultured plants, conducts contractual research/production of plants, inoculates tissue-cultured plantlets with efficient mycorrhizae biofertilizers; offers post-delivery field care; and even helps entrepreneurs set up laboratories, greenhouses, and so on. The waste generated at the laboratory, as the used cultured media, is converted into vermi-compost which is used for growing plants. Till date, TERI had supplied over 20 million plants to various state forest departments, non-governmental organizations, agro-based companies, and private growers.

Aggregation Stage

Crop Residue Management

India being an agriculture-dominant country produces more than 500 million metric tons of biomass annually (Ministry of New and Renewable Energy). Large portion of these crop residues are burnt in the fields every year primarily to clear the left-over straw and stubbles, which cause massive air pollution problems. Shifting from manual to mechanical harvesting such as use of combined harvesters, high cost of residue removal and non-availability of labour are few of the reasons behind burning of crop residues in the fields. Burning causes significant air pollution and loss in soil organic matter. Various options are available for management of crop residues which are discussed below –

- **Livestock feed**: Crop residues in India have been utilised as animal feed which is either directly fed to the animals or supplemented with other additives. Over 75% of wheat straw is currently utilized as fodder for animals. However, some crop residues, such as rice straw is low in digestibility and is unpalatable due to its high silica content. Silica content in rice straw is in the order of 12-16% as compared to 3-5% for other crop residues but its nutritional value of can be upgraded by different methods such as physical, chemical and biological treatments to weaken and breakdown lignocellulose bonds (Bisen and Rahangdale, 2017)

- **Compost**: Crop residues are also being used for animal bedding and are then heaped into dung pits for preparation of compost. It is estimated that every kilogram of straw can absorb nearly 2-3 kilograms of animal urine, thus enriching it with Nitrogen. It is estimated that crop residue from one hectare of land can lead to 3 tons of manure (Bisen and Rahangdale, 2017)

- **Mushroom cultivation**: Crop residue such as wheat and rice straw can be used for production of mushrooms. These straws form excellent substrates for the cultivation of two of the four most commonly grown fungi i.e. Volvariella volvacea (straw mushroom) and Agaricus bisporus (white button mushroom). Very high conversion efficiency to fungal bodies is possible when straw is mixed with horse manure, poultry waste and hay (Wuest et al, 1987; Maher, 1991).

Oyster Mushroom Cultivation (Nirakar et al, 2010)

About 82% of the women population living in the Gadiakhalla village of Odisha are landless agricultural labourers and usually the October-February period is a lean period for rainfed agriculture. Hence, these farm women were encouraged by KVK of the Rayagada district to grow Oyster mushroom through Self Help Group intervention to supplement their family income.

Scientists at KVK, Rayagada organised frontline demonstration and training programs of the mushroom cultivation technology from paddy straw in the village. The technology involved in the cultivation of mushroom is very simple and can be acquired by any person through a short training program.

SHG members who have started practicing mushroom cultivation generate a profit of approximately INR 4000/- per month by selling 120 kilograms of mushroom from 100 beds of paddy straw.

Inspired by the easy method of cultivation, good yield and profits, three other SHG's have started practicing mushroom cultivation in small scale. Following which different NGO's in Rayagada district decided to replicate this successful programme in different blocks of the district.

- **Bio-fuel**: Lignocellulosic biomass can be converted into alcohol which is of immense importance as ethanol, which can either be blended with gasoline as a fuel extender and octane enhancing agent or used as a neat fuel in internal combustion engines. It has been theoretically estimated that for certain crop residues such as corn grain, rice straw, wheat straw, bagasse and saw dust, the production of alcohol varies from 382 to 471 litres per ton of dry matter (Bisen and Rahangdale, 2017)

- **Crop residues as biochar**: Biochar can be defined as a fine-grained charcoal with high carbon content which is produced through slow pyrolysis of biomass and can be used to maintain soil health. Biochar can act as a carbon sequester in soil as it contains a unique recalcitrant form of carbon which is resistant to microbial degradation. Biochar can be used to clean water as it has a strong nature for the absorption of contaminants. It can also be added to the soil to improve its texture and carbon content.

- **Crop residue incorporation**: Apart from removal or burning of crop residue, incorporation of crop residue can be considered one of the most effective option as incorporation of residue back into the soil increases its organic matter as well as Nitrogen, Phosphorous and Potassium contents. Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation and nature of soil. The conservation agriculture practices are becoming popular due to farm mechanisation. Since the crop residue helps retaining the soil moisture and prevents growth of weeds, with the added advantage of gradual composting and release of nutrients, the conservation agriculture practices are being followed by large number of farmers

- **Power Generation**: Among the different feedstock available for bioenergy, agricultural crop residues are a reliable and readily exploitable resource for electricity generation. Gasification using biomass gasifier system is one of the effective ways to generate electricity in a clean and efficient manner. In this process, the residue is combusted in a controlled environment to make producer gas which in turn can be used to generate electricity through the use of generator and internal combustion engines. Crop residues can also be burned in boilers for power production with an efficiency of upto 99% (Kumar, 2016). The advantage of crop residue over and above conventional resources is that the residue is a carbon neutral fuel, which will help in reducing the greenhouse gas emissions

Rice Husk Power Plant (Husk Power Systems Private Limited) (Sevea Association, 2013)

Still, majority of population residing in the rural areas of Bihar lives below the poverty line with no access to electricity and this has largely affected development of the state. On the other hand, Bihar faces problem with the management of rice husk as over 1.1 million tons of husk gets generated every year in Bihar.

Husk Power Systems (HPS), a decentralised power generation and distribution company started its operation in 2007 with an aim to provide affordable, reliable and environmentally sustainable energy to rural India by using husk as the fuel.

The company uses rice husk based biomass gasification technology to supply electricity to the villages that have demand of 15 kW and falls within the radius of 3 kilometres from the proposed HPS plant. The company even trains local villagers for the operation and maintenance of the plant thus creating a job platform for unemployed literate/neo-literate villagers.

HPS follows 'Pay-for-Use' business model for raising revenue and supplying electricity. It is estimated that about 300 kilogram of rice husk produces 40 kilowatt of electricity sufficient to supply power to 500 households for 6-12 hours per day.

Rice husk is purchased at a rate of INR 1 per kilogram from rice mills and the plant supplies electricity to domestic consumers for fixed 6 – 8 hours in a day against a charge of INR 150/ month for two 15 watt CFL`s and mobile recharging. While commercial consumers pay an average of INR 300 per month as they tend to use more electricity (60-75W). The company has installed low cost pre-paid meters to efficiently regulate the flow of electricity thus reducing electricity theft to less than 5%.

In order to facilitate job creation at village level, the company hires local villagers for maintenance and operation of the plant. At each plant, the company employs at least 3 local villagers including an operator, a lineman/electrician cum bill collector; and a husk loader. It has also provided entrepreneurship and employment opportunities to rural women as these women are trained to manufacture incense sticks using rice husk char. This enables household to earn upto INR 1,000 per month and save INR 150 on kerosene costs while paying only INR 80 for electricity.

Sustainability:

- The system is sustainable at plant level with a gross margin of 20%
- It usually takes 2-3 months to reach operational profitability and 2.5-3 years to recover capital expenditures with subsidies
- Expected lifetime of gasifier and engine is 12 and 20 years respectively.

As on date, Husk Power Systems is operating over 75 mini-grids with a capacity of over 1.75 MW in Bihar and Uttar Pradesh. Under these projects, the company has created around 205 jobs with 15 full time employees and 80 part-time women employees. By the year 2022, the company aims to commission 400 similar plants with a power generation capacity of 20 MW.

Processing Stage

Extending Shelf Life of Food

As per Food and Agriculture Organization of the United Nations (FAO), it is estimated that around 1.3 billion tons of food i.e. one-third of the total food produced for human consumption in the world gets wasted every year. This includes 45% of all fruit and vegetables, 35% of fish and seafood, 30% of cereals, 20% of dairy products and 20% of meat (World Economic Forum).

Traditionally, fruits and vegetables were consumed close to where they were grown, but development of food processing infrastructure such as cold chain connectivity, improved packaging, gentle processing, microwave sterilization, edible coating, carbon dioxide emitting patches, etc. can cater to the demands of changing consumer preferences across the country. Such kind of infrastructure enables farmers and aggregators to distribute produce not only in the domestic market across the country, but also helps with the exports, as India currently exports merely 1% of the produce (Munjal Institute for Global Manufacturing-ISB, 2016). Few examples of national and international good practices have been mentioned below –

Appropriate Modified Atmosphere Packaging

The British supermarket chain Marks & Spencer in 2014 researched packaging systems to retain the 'freshness' of fruit and vegetables for a longer duration. The company collaborated with PerfoTec (a Dutch company) to implement 'Appropriate Modified Atmosphere Packaging' (AMAP) technology which extended the shelf life of grapes, raspberries and strawberries from 5 to 7 days, 5 to 10 days and 4 to 8 days respectively (Perfotec).

Fresh fruits and vegetables need a minimal amount of oxygen to thrive. If they receive too much oxygen they get old rapidly and when there is too little oxygen, it will lead to a faster decay due to anaerobic condition. Petrofac has developed a laser system of applying miniscule perforations in the packaging using which packaged fruits and vegetables shelf life can last a few days longer. The company's laser system consists of three units: the laser with intelligent camera, the software and the respirator. The system can integrate with all possible packaging machines and aluminium converters, thus making highly accurate round perforations essential for AMAP technology.

As the respiration speed of fruits and vegetables varies according to the season or region, the patented respiration meter measures the breathing speed of fresh products within four hours, allowing companies to respond to seasonal variations in respiration. The device measures the respiration speed (oxygen usage and CO_2 production). Following which these details are converted into the necessary transmission for each packaging. The camera checks every micro-perforation according to diameter and shape. This not only measures the quality but also the oxygen permeation of the perforated packaging.

Flexfresh™

Uflex Ltd., India's largest global flexible packaging solution company has come up with a new packaging technology called Flexfresh™, a film of oxygen and water barrier for packaging fresh produce. Flexfresh™ maintains humidity levels at 98% in the bag, thus keeping the product absolutely dry without allowing any condensation. This results in very low weight loss of the produce as it continues to breathe in hydrated oxygen available inside the bag.

The film provides good release characteristics of CO_2 emitted by the produce. This ensured that the produce in a few cases could be protected naturally from diseases such as botrytis and gray mold. Apart from all these benefits, Flexfresh™ Film is biodegradable by composting and it complies with all international standards and regulations.

Flexfresh™ – The case of Rambutan fruit (Source: Uflex)

India is home to fruits such as Litchi, Rambutan, Mangosteen and their market demand have been increasing year on year at a rapid pace. But the issue with Rambutan fruit is that it has to be consumed within 48 hours of harvest and could only be sold to neighbouring markets as the product loses nearly 8% moisture per day when stored in ambient conditions and its skin turns black on day two due to moisture loss, thus making the product unfit for consumption.

Uflex conducted trials under 10° Celsius using the FlexfreshTM 60*40 liners inside the reusable plastic crates. The fruits were packed both in bunches and also in punnet for retail sales. The trials were conducted with different transmission values and their initial observations were done after 3 and 7 days with the first and second set of samples respectively. The fruit was then left in ambient environment of around 28°C for a period of 48 hours to see their shelf life. It was observed that the weight loss after 7 days was below 0.5% and the quality was intact due

to no moisture loss. It came as a surprise to the customer that even with exposure to ambient conditions for 48 hours, the product was still in good condition with weight loss of around 5%.

Flexfresh™ made it possible for the producers to offer Rambutan to distant location under refrigerated conditions with excellent shelf life and very low weight loss. The producers are now looking at options of exporting the product to other countries as this has open up a completely new opportunity in offering the products internationally, where the profitability could easily recover their additional investments.

Cold Chain

As already mentioned, fruit and vegetable suffers significant post-harvest losses due to their perishable nature and sensitivity to handling damages. Development of cold chain infrastructure is one of the possible solutions for reducing such losses and it could even help in increasing product value by enabling sales out of season and in far-away markets. The below mentioned study deals with the cold chain business model for kinnow fruit which is supplied from Punjab in North India to Bangalore in South India.

India's Kinnow Cold Chain Study (Munjal Institute for Global Manufacturing-ISB, 2016)

Kinnow is a citrus fruit rich in micronutrients and is commonly grown in the Punjab region of India and Pakistan. Kinnow is only available for a period of 3-4 months per year and it is a highly perishable product which is best when kept at 4-5 °C and a relative humidity of around 85-90%.

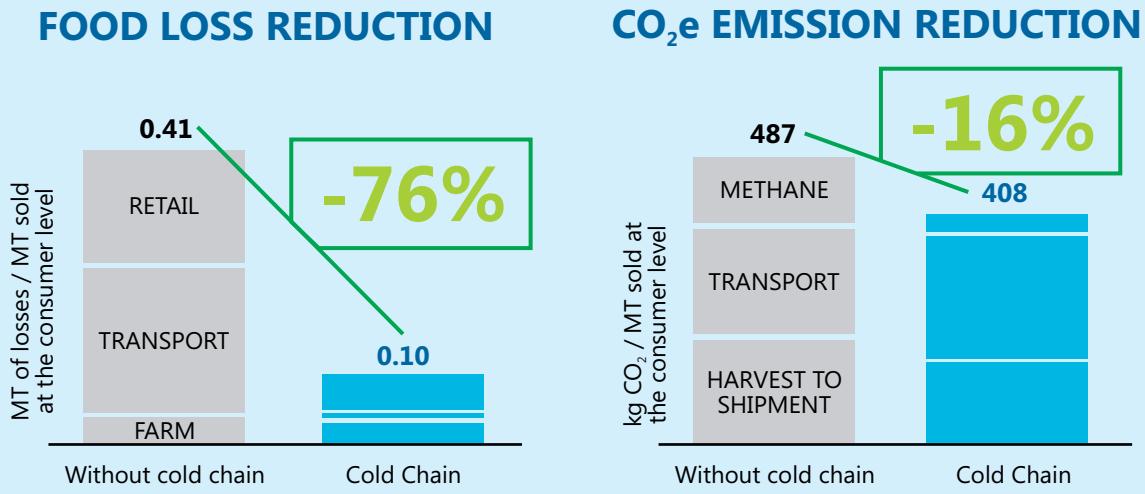
The study measured the effects of cold storage and refrigerated transport from Abohar, in north India to Bangalore, in the southern region of the country, which is roughly a distance of 2500 kms and requires 4-5 days of travel time by truck. The following post-harvest process is followed by Balaji Cold Store to supply the Kinnow fruit from Punjab to Bangalore –

Picking of fruit from the orchard in Abohar; packaging of fruit in Abohar pack-house after grading/sorting and waxing; pre-cooling and cold storage in Abohar pack-house; transportation of fruits in refrigerated trucks to Bangalore; distribution and retails in Bangalore

Profitability and Payback:

- Profit for aggregator using cold storage and refrigerated trucks post season i.e. during March was around INR 8,179 per tonne. The payback period for investment of INR 40 lakh in pre-cooling equipment was 2.3 years while investment of INR 4 crore in cold storage was 9 years (subject to cold storage becoming part of the kinnow cold chain using reefers and pre-cooling)
- Assuming two trips a month between Punjab and Bangalore, transporter would make an annual profit of INR 12.5 lakhs on an investment of INR 29.5 lakhs. It would give a payback period of about four years
- In case of distributor, the revenues would increase to INR 40,000 per metric tonnes of kinnow shipped thus increasing profits to INR 1,537 per metric tonne
- Retailer's revenue would increase to INR 100,000 per metric tonne of kinnow sold thus increasing the profit margin to INR 7,895 per metric tonne.
- It was also estimated that with the investment in cold chain especially in pre-cooling and transportation refrigeration equipment, food losses got reduced by 76% and a 16% reduction in CO_2 emissions was registered.

Figure 27: Food Loss and Carbon Emission reduction through Cold Chain support for Kinnow



The use of cold chain systems not only helped in reduction of losses but it also helped the aggregator in increasing their geographical reach nationally (Bangalore) and internationally (Russia, Dubai and Bangladesh).

Food Waste Utilization

Due to high consumption and industrial processing of edible parts of fruit and vegetables, thousands of tons of waste are being produced, mostly in the form of peels and seeds. Thus, fruit and vegetable waste has become one of the major sources of solid wastes and imposes a great threat to environment. At present, majority of the food processors follow the conventional method of accumulating waste in pits and landfills. However, inappropriate management of these landfills creates environmental nuisance such as emissions of methane and carbon dioxide, the risk of leachate seeping into the groundwater and bad odour in the vicinity of the landfills. Also, there is a theoretical economic loss because the untapped potential of the fruit waste remains exploited. Therefore, there is an urgent need of transformation from current to sustainable practices.

Organic waste Bio-methanation and biogas utilisation for power production (Jain Irrigation Systems Limited, 2017)

Jain Irrigation, India's largest fruit and vegetable processor and the world's largest Mango fruit processor has adopted a uniquely sustainable method of bio-methanation to handle the huge waste generated at their facility in Jalgaon, Maharashtra. Their facility handles up to 800 MT/day of fruit during the peak season (May-July) and 300 MT/day during the remaining months, thus generating significant amount of solid waste with an average 50:50 yield to waste ratio.

The bio-methanation technology used by Jain Irrigation treats approximately 198 TPD of waste i.e. waste from fruit processing and onion dehydration at their own unit, MSW, puff puree and press mud cake waste from nearby industries. It generates 1.7 MW of electricity which is used for captive consumption. Apart from generating electricity, waste heat coming from the flue gases of biogas engines (approx. 500 °C) is converted to over 400 tonnes of refrigeration using vapour absorption machine, which is used in cold storages at the onion processing plant and the photovoltaic building.

The excess digested slurry is further utilized for making organic soil conditioners since they still retain useful plant nutrients such as Nitrogen, Phosphorus and Potassium. The project is successfully running since more than 5 years now. In year 2016-17, it has generated 1,225,875 m^3 biogas which further resulted in production of 2,060.4 MWh electricity during the period.

Stakeholders Insight

“ We, at Jain Irrigation Systems Ltd, strongly believe that enhancing output of Indian agricultural fields will create new opportunities for farmers, thus opening up new dimensions for the food processing industries. Jain Irrigation is the second largest Micro-Irrigation company in the world and has successfully converted 2 million farmers, including 1 million women farmers from traditional surface irrigation to micro irrigation methods. Use of micro-irrigation with fertigation ensures efficient use of fertiliser and increase in crop yield by over 50 to 300 %.

Farm Fresh Foods Limited, one of our subsidiary companies, is India’s largest fruit and vegetable processor. This company produces dehydrated onions, mango puree, banana paste, pomegranate juice and mango & strawberry IQF of very high quality and international standards for exports and domestic market. The unit has a state-of-the-art bio-methanation technology using which agricultural and fruit processing waste is converted into biogas to generate power of 1.6 MW capacity along with waste heat for refrigeration and pre-heating.

While working with small farmers and realizing the high cost of compliance with international supply chain standards of Global G.A.P, the company has developed and mainstreamed Jain G.A.P as an intermediate cost-effective standard to improve farm yield and quality, adopt climate-smart agriculture practices and increase hygiene and sanitation on farms.

Keeping in line with our visionary founder and leader Late Padamshri Bhavar H Jain, path and policies of Jain irrigation Systems Ltd has always been farmer centric with the belief that farmers should always be kept at the heart of the circular economy. Each stage of our value chain feeds to the next to extract maximum value from farm produce, which finally gets passed on to the farmers. ”

Surender Makhija
Jain Irrigation Systems Limited

Section IV

Realizing opportunities in circular economy for businesses in India

Section IV

Circular economy models amongst businesses

Assessing circularity at a company level

Given the attractiveness of the circular economy, researchers and other stakeholders (IMSA; Circle Economy, 2013), have developed initiatives to assess circularity in recent years. Some of the important ones include:

- **Circle Economy** (Circle Economy & PGGM, 2015)
- **VBDO** (VBDO, 2015)
- **The Ellen MacArthur Foundation (EMF)** (Ellen MacArthur Foundation; Granta Design; 2015)
- **Viktoria Swedish ICT** (Viktoria Swedish ICT, 2015)

These proposals have different approaches, as well as levels of development, targets and goals, but all have the aim of assessing circularity at the company level (as shown in Table 9 below):

Table 9: Comparative analysis of different approaches assessing circularity

Dimension	Circle Economy	VBDO	EMF	Viktoria ICT
Purpose	Evaluating organizations based on their ability to implement policies supporting circular economy principles	To measure to what extent a company is taking concrete steps towards a circular business	Developing a methodology to design more circular products, and the overall material circularity of the company	To help companies progress along a path towards CE. Assesses costs and benefits associated with different degrees of circularity

Dimension	Circle Economy	VBDO	EMF	Viktoria ICT
Scale	Organization/ system	Organization/ system	Product/ Organization	Business Model/ Product offerings
Aspects	Materials, energy and labor: Renewability, recyclability, criticality, geopolitical risk, locality, competition.	Strategy and governance: targets for improving resource efficiency and accountability.	Inputs: virgin, re-used or recycled	Materials: LCA or MFA are tools relevant to assess material use and environmental impacts.
	Activities: smart, efficiency, modular, extended lifetime, degradability, hazardousness, precaution.	Implementation: revenues from circular products and services, product design and procurement.	Use: length and intensity	Costs: cost savings due to reduction of material costs
	Practices: transparency, collaboration, integrity	Innovation: circular business models, innovation budget and strategic partnerships.	End-of-life: landfill, re-use, recycle	Value retained: portion of added value that comes back to the company
	Impact: global impact on land, water, atmosphere and society	Communication and engagement regarding circular economy customer, stakeholders, raising awareness	Complementary indicators for assessment: Energy use, CO_2, water use, cost, price variation, toxicity	Recirculation: costs of input coming from reuse, recycle, remanufacturing

Source: Adapted from Camacho-Otero, Juana & Ordoñez, Isabel. (2017).

Given the focus of this study, let us look at the indicators assessing the circularity of the products and businesses. Circularity of a product is assessed on the basis of following parameters: (as shown in figure 28):

- **Input in the production process:** How much input is coming from virgin and recycled materials and reused components?
- **Utility during use phase**: How long and intensely is the product used compared to an industry average product of similar type? This takes into account increased durability of products, but also repair/ maintenance and shared consumption business models.
- **Destination after use**: How much material goes into landfill (or resource recovery), how much is collected for recycling, which components are collected for reuse?
- **Efficiency of recycling**: How efficient are the recycling processes used to produce recycled input and to recycle material after use?

The diagram below shows the material flows taken into account to arrive at the Material Circularity Indicator of a product. The MCI gives a value between 0 and 1, where higher values indicate a higher circularity. These Material Circularity Indicators are then complemented with risk and

impact indicators to provide further insights into potential risks in relation to business priorities. Examples for complementary risk indicators include material price variation, material supply chain risks, material scarcity and toxicity. Complementary impact indicators can include, for example, energy usage and CO_2 emissions (Ellen MacArthur Foundation, & GRANTA, 2015).

Figure 28: Material Circularity Indicator of a product

Source: Ellen MacArthur Foundation, & GRANTA. (2015)

The **company-level Material Circularity Indicator** is calculated based on the hypothesis that the material circularity of a company can be built up from the material circularity of the company's products. That is, to determine the MCI for a company one needs to know the MCI for all product types of that company, which are then aggregated by a suitable weighing factor. Given practical computational challenges, MCI assessment for every single product is not feasible, and hence MCI can be computed for a list of reference products. The MCI of a company is then obtained by taking a weighted average of reference product MCIs using either mass or revenue as a normalizing factor.

The reference products in particular should exhibit:

- Similar material composition, in terms of the type of material and the their relative masses
- Similar levels of recycled and reused content in the feedstock
- Similar levels of recycling and reuse at the end of the use phase
- Similar productivity function characteristics

For assessing sustainability performance and managing progress, following objectives may be considered (figure 1):

- **Adoption of circular supply chains**: Efforts towards greening the supply chain in manufacturing remains at the cutting edge of technological development and sustaining product design. This includes a crucial role in the rapid transition to renewable energy (RE), the substitution of hazardous chemicals and the greater use of recycled materials vis-à-vis virgin material. Moreover for sustainability criteria's to percolate to Tier 2, Tier 3 and Tier 4 companies should disclose the list of suppliers they use to make their products, including what the supplier does and where it is located. Manufacturers should also disclose information about these facilities, including amount and type of energy used in the manufacture of a brand's products, the amount and type of GHG emissions generated, and the chemicals used in these facilities. Regular public reporting of these metrics will help to drive improvement over time. The global economy depends on the preservation of natural resources. Yet the majority of businesses have not traditionally placed a high enough financial value on natural capital – the products and services they derive from nature. Monetary valuation of a company's environmental impacts would enable businesses to determine how much their business costs the environment and assess the impact of natural capital risks on profitability.

- **Extensions of product life**: Legacy design approaches around 'single use' can restrict the potential for end-of-life products to be separated into recoverable components and materials. The short lifespans of products takes a toll on the planet's finite resources and contributes to the overall GHG emissions. By extending the useful life of a product, the negative environmental impacts created in the manufacture and disposal of it are spread out over time, helping to reduce the sector's overall impact. There is a greater need to design products that are easy to repair and contain standard parts that can be replaced without the need to replace the whole device thereby extending the useful life of the product. It is imperative to have a design for products which is receptive to using recycled/ secondary raw material which also reduces chances of down-cycling. Standard operating procedures manual, software extend and availability of spare parts would facilitate repairs and upgrades.

- **Enabling greater use of products as a service and the use of sharing platforms**: While the idea of Product as a service and use of sharing platform has been predominantly prevalent in the consumer context, these have now started gain more traction within the upstream business operations. Business efforts geared towards reducing costs and environmental impact from fixed assets are encouraging a shift from privatized equipment ownership to shared equipment access. At the same digital platforms are enabling improved product connectivity and contributing to improved utility through monitoring and predictive maintenance.

- **Improvements in recovery and recycling rates**: Finally to close the loop, producer take-back, is an increasingly popular waste policy that is radically different from traditional recycling practices. This is because Extended Producer Responsibility makes the producer of the product responsible for the financial and/or physical responsibility for product recycling. Policy requiring Individual producers to provide a tack back facility for their products would encourage competition between companies on how to manage the end-of-life phase of

their products and in turn drives innovation, such as in business models, take- back logistics and design changes, to reduce the environmental impact of products at the end of their life. In a collective system where products of all brands gets recycled and processed by a common facility there is no incentive to design products to be easier to recycle. That is because producers would simply be paying a proportion of the total cost based on their market share.

Table 9 below lists the indicators under each category against which company's performance can assessed:

Table 9: Company-level Material Circularity Framework

Objectives	Indicators	Sub-weights	Category score	Weights	Total Score
Making Supply chain Circular	Use of recycled material vis-à-vis virgin material	0.2		0.25	
	Elimination of hazardous materials and greater use of biodegradable materials	0.2			
	Efforts to reduce Supply Chain GHG Emissions and Transition to Renew-able Energy	0.2			
	Greater Transparency to disclose the list of suppliers making their products, including what the supplier does and where it is located.	0.2			
	Natural capital valuation (monetary valuation of company's environmental impact eg placing a price on carbon, water etc.)	0.2			
Product life extension	Design for reusability, reparability and recycling	0.33		0.25	
	Manuals and Spare parts available for repairs and upgrades	0.33			
	Certification of refurbished and recycled products	0.33			
Products as a service, asset sharing and use of sharing platforms	Consumer demand for company's product utility rather than ownership	0.25		0.25	
	Intra and inter organization sharing of idle or underutilized assets (shared services availed vis-à-vis owning the equipment)	0.25			
	Internet of things facilitating sus-tained utility through monitoring and predictive maintenance	0.25			
	Product Standardization-improving the viability of extended service programmes	0.25			

Objectives	Indicators	Sub-weights	Category score	Weights	Total Score
Recovery and Recycling	Take back systems	0.33		0.25	
	Recovery and Recycling rates	0.33			
	How much material goes into the landfill?	0.33			

Source: Developed by the authors

The above aggregated index was designed to allow businesses to track the progress of their individual products towards a circular economy as it helps in identifying strong or weak areas. It could be used internally to focus business strategies, calculating potential cost savings, as well as to benchmark and compare companies and products to encourage race to the top.

In order to assist the proactive organizations, a supporting ecosystem would include enabling policy frameworks and mobilization of finance

Enabling policy framework for Circular Economy in India

The importance of resource efficiency in achieving sustainable development has increasingly been reflected in different policies that have been adopted across various sectors over the years. The different stakeholders have also reciprocated positively to the changing policy landscape and in certain situations taken the lead in taking the agenda forward in the absence of any guiding policy or legislative framework.

However, potential opportunities of enhancement in existing policy frameworks to support transition to circular economy include:

Table 10: Policy actions needed to enhance resource efficiency across lifecycle stages

Policy/Regulations	Enabling policy framework for Circular Economy
Policies related to mining	
Enabling efficient mining practices	While resource efficiency in this sector means improved mining practices, thereby minimizing wastage and augmenting resources in the system, issues related to co-production of by-products or absence of directives of extraction of secondary minor metals from the mined ores often lead to wastages. This needs appropriate attention and coverage in the mining policy of the Government. Transparency with regard to sharing of mining plans by the Ministry has been raised quite often, which calls for possible revisiting of the relevant policies. Further the issue of illegal mining is often ignored during policy formulations. Uncontrolled illegal mining will invariably result in wastages and have serious resource inefficiency consequences. Better use of information technology for governance will be key to addressing many of these challenges. The draft new Mineral Policy has proposed ways to address some of these issues.

Policy/Regulations	Enabling policy framework for Circular Economy
Policies related to design stage	
Supporting product design that are resource efficient	Product designs are a key to achieving sustainable consumption and production. This calls for developing standards that will enhance product life as well as ensure increased recyclability potential of the materials. There is a requirement for promoting R&D related to waste management as well as enhance funding for resource efficiency and Secondary Raw Materials (SRM) related research. Further, there is a need to promote voluntary standards, like Green Reporting Initiative and ISO 14062:200212 to develop and strengthen design initiatives for improving resource efficiency and promoting use of secondary raw materials across sectors (MoEF&CC, BMUB, 2017).
Policies related to Manufacturing	
Strengthening resource efficiency at the manufacturing	Industrial and sectoral policies and programs at the cluster level need to promote industrial symbiosis (where waste from one industry is raw material for another), process efficiency programs and use of recycled materials in manufacturing (MSME, 2017). Circular economy strategy can only be successful in the presence of appropriate measurable indicators and the Government can develop these indicators and mandate public disclosure based on mutual discussion with the industry.
Policies related to consumption	
Mechanisms of improved labelling and supporting informed decision making by consumers	While MoEFCC has introduced eco-labelling scheme, its impact has been limited (Singh et.al 2012). This calls for inclusion of provisions for preferential procurement of eco-labelled products through sustainable Procurement strategies / policies. In addition, incentives need to be explored through tax sops for such products that would encourage consumers to purchase those products, based on informed decision choices. Further awareness is required among consumers and across various product categories.
Policies related to waste management and recycling (end of life)	
Sustainable and viable end of life management of products	In case of end-of-life stage policies, while there are rules for addressing various waste streams like municipal solid waste, construction and demolition (C&D) waste, plastic waste, e-waste and hazardous wastes, enforcement has been rather limited due to lack of support for business models that lead to better implementation (MoEF&CC 2016). There is a need to mobilize funding or cost of treatment for waste through Extended Producer Responsibility (EPR) and Polluter Pays Principle. Also, there is a need for a unifying framework that brings together these different sources of secondary raw materials for effective closed-loop recycling. To effectively manage the dispersed waste streams, there is also a need to involve the informal sector by providing them with technical capacity building and financial support.

Table 11: Examples of policy instruments to support circular economy

Categories of policy measures	Examples of policy measures
Regulatory instruments	• Regulations (e.g. on waste recycling, identifying stakeholders responsibility across the value chain, ecodesign, take-back systems, etc.) • Quality and other mandatory targets (e.g. recycling and recovery) • Codes, standards, certification for products, recycled material content, packaging, emissions, as well as the ones triggering
Economic instruments	Fiscal/financial instruments and incentives, including, advance recycling fees, landfill tax, subsidies and tax reliefs, pay as you throw • Direct investment/funding (e.g. infrastructure, programme, etc.) • Demand pull instruments, including public procurement • Market based instruments, etc.
Research, development and deployment	Funding for R&D for developing products with sustainable design and ensuring their pre-commercial procurement • Innovation vouchers schemes for SME on CE related innovations • Support to innovation incubators focusing on CE related areas • Support R&D Infrastructure incentives for R&D personnel
Information, capacity building and networking support	Advisory services & information provision (to companies, start-ups, customers, technology adopters, etc.) • Professional training and qualification and skills enhancement courses, i.e. in material chain management • Support matchmaking via waste exchange and technology sharing platforms
Voluntary measures	Performance label for products and services • Guarantee for product durability, repair,

Source: Doranova and Gigli 2014

Financial innovations for supporting circular economy models in India

India's ambitious targets under the Paris Agreement and the quest to achieve the SDGs has resulted in significant investment opportunities in some of the major sectors concerning the Indian economy. Incidentally the low carbon growth trajectory positively impacts the circular economy principles leading to creation of innovative business models. The country indeed has the potential to achieve its development goals by adopting a circular economic model of growth.

Recent report by International Finance Corporation titled 'Climate Investment Opportunities in South Asia' identifies investment potential in 7 key sector as indicated below in the table 12:

Table 12: Investment potential across sectors

Sector	Investment potential (in $)
Transport Infrastructure	USD 250 billion
Green Buildings	USD 1.4 trillion
Renewable Energy	USD 448 billion
Agriculture	USD 194 billion
Urban water	USD 128 billion
Waste	USD 11 billion
Electric Vehicles	USD 667 billion

To mobilize the quantum of finance needed for making transition towards these sustainable sectors, orchestrated efforts from all the stakeholders is paramount. While public finance will continue to be the central driving force in achieving sustainable development in emerging economies like India, what is more important is the role of public finance in accelerating private investments in driving this transition.

Some of the innovative financial instruments fueling investments in the emerging sectors will include:

Table 13: Innovative financial instruments

Green Bonds	Green bonds in India have emerged as a key financing mechanism for financing sustainable sector mainly renewable energy. However, proceeds from green bonds can be utilized to finance other sectors like waste and water management
SDG aligned Bonds	In lieu of the global goals adopted in 2015, innovative financial instruments to finance the SDGs will be instrumental in achieving the SDGs and involving greater participation from private sector organizations. World Bank in 2017 launched the first-ever bond linked to SDGs. Similar bonds will mobilize finances towards circular economy business models at national level
Municipal Bonds	Municipal bonds have the potential to empower urban local bodies to deal with problems related to linear economy models at a large scale. India currently has a large untapped market with issuance totaling USD 250 million. There have been recent developments like in the case of Pune Municipal Corporation raising capital for the smart city project. Similarly other municipalities should come forward to tackle massive problems particularly related urban water and waste management
Sovereign Bonds	The world has seen innovative utilization of sovereign bonds to raise funds for sustainable development sectors like in the case of Poland, first nation to come out with world's first Green Sovereign Bond to finance projects in renewable energy, clean transportation, sustainable agricultural operations, afforestation, national parks and reclamation of heaps. There is definitely a strong business case for India to employ such sovereign mechanisms towards achieving the imperatives of circular economy
Blended finance instruments	Blended finance instruments involve leveraging development finance through grants, concessional financing, credit guarantees, or other supporting mechanisms to mobilize private capital flows towards development related projects. Such innovations assist pooling of funds by private sector by taking care of perceived risks and uncertainties

Aggregation and Securitization mechanisms	Typically circular economy business models may lack scale, hampering the bankability of such projects. Aggregation and securitization schemes aimed towards pooling circular economy projects in order to aggregate value and promote risk diversification will minimize transaction costs and facilitate the participation of institutional investors
Impact investing	Impact investing is becoming increasingly popular amongst investors. According to a JP Morgan research, demand for impact investing strategies could reach USD 1 trillion by 2020. Through impact investing, institutional equity investors can invest capital as part of the equity for companies that have environmental and social factors at the heart of their business strategies. Organizations committed to implement circular economy models can approach such investors to mobilize initial seed funds to start their business
Risk Guarantee schemes	Banks and financial institutions may perceive higher risks involved in circular economy business models, especially if the proposed model does not have a proven past record of successful implementation. In order to promote energy efficiency amongst the industry, there are Government backed schemes such as Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) to provide 50% guarantee and Partial Risk Sharing Facility (PRSF) of SIDBI to provide 75% guarantee. Through such schemes more involvement of private sector can be encouraged in financing circular economy business models

Platforms for business engagement, collaboration and experimentation

Engaging with the relevant stakeholders helps to gain insights which create the necessary buy-in and the conditions for effective collaboration, while fostering new habits and processes. Collaboration with suppliers, distributors, retailers, waste managers, customers and others is needed to keep used products, components and materials in circulation. Circular businesses engage both internally and externally. With organization they look to tap into expertise, resources and networks, and to foster support and externally they engage across value chains and sectors to help build systems to repurpose or reprocess technological, mineral and biological elements.

Using the circularity indicators identified earlier, following Table 14 lists external stakeholders to engagement at each stage:

Table 14: Stakeholder engagement

Circularity Indicator	Stakeholders
Making Supply chain Circular	Suppliers
Product life extension	Customers, Suppliers, retailers and distributers
Product as a service, asset sharing and use of sharing platforms	Suppliers, Customers, Insurers and Government
Recovery and Recycling	Regulators, Recycling facilities, landfill operators and haulers

To accelerate transition towards Circular Economy World Economic Forum has collaborated with the Ellen MacArthur Foundation for a number of projects to scale business driven circular economy innovations. Building on this work, the Platform for Accelerating the Circular Economy (PACE) was launched in 2017 as public-private collaboration.

PACE aims to create systems change at speed and scale by enabling partners to:

1. Develop blended financing models for circular economy projects, in particular in developing and emerging economies. Applying mixed funding approaches to de-risk private investments would help identify strategies for national governments to scale private sector Circular Economy activities such as secondary materials recovery systems and reorient their larger-scale investments to integrate Circular Economy design/principles. The Platform will help scale existing activities by brokering partnerships and test collaborative funding approaches through the network of private, public sector and institutional partners.

2. Help create and adjust enabling policy frameworks to address specific barriers to advancing the circular economy. Policies and regulation often surfaced as both key barrier but also enabler for scaling up Circular Economy efforts – including trade policies, waste regulations, public procurement policies, resource pricing etc. These crosscutting systemic policy issues need to be addressed from both global and national perspectives. Further solutions need to be designed collaboratively by integrating the views of government, business and the civil society. The Platform will bring key stakeholders to the table to collaboratively design public policy reforms from both a global perspective through the leaders' network, and a local view through the projects (World Economic Forum, 2017).

Similarly The Ontario Circular Economy Lab (CEL) brings together private and public sector leaders and innovators from across Ontario to generate, test and implement circular economy solutions. It provides a platform for ongoing experimentation, innovation and collaboration leading to tangible breakthroughs that can accelerate Ontario's transition to a circular economy.

Convened by The Natural Step, lab's first program (Oct - Dec 2016) has brought together twenty-five influential leaders from different sectors and value chains to develop a shared vision for the future of paper and packaging materials in a circular economy (Circular Economy Lab).

References

1. Agriculture in India: Information about Indian Agriculture & its Importance. India Brand Equity Foundation. Retrieved from https://www.ibef.org/industry/agriculture-india.aspx.
2. Akolkar, A. B., Sharma, M., Puri, M., Chaturvedi, B., Mehra, G., Bhardwaj, S., Mutz D, Arora R and Saluja M. (2015). The Story of Dying Car in India. Part II. Report prepared on behalf of GIZ, CPCB and Chintan. New Delhi: CPCB. Retrieved from: http://cpcb.nic.in/upload/Latest/Latest_113_Draft_ Guidelines_ELV-1_.pdf.
3. Arora, N., Kapur, S. and Bhattacharjya, S. (2017). "Designing a business model for Sustainable management of End of Life vehicles in India". Policy brief. The Energy and Resources Institute, New Delhi.
4. Associated Chambers of Commerce and Industry of India (ASSOCHAM). (2017). Up to half of milk, fruits & veggies produced in India goes waste due to poor cold chain infra: Study. Retrieved from https://assocham.org/newsdetail. php?id=6547.
5. Biomass Power/ Cogen. Ministry of New and Renwable Energy. Retrieved from http://mnre. gov.in/schemes/grid-connected/biomass-powercogen/.
6. Bisen, N. and Rahangdale, C. P. (2017). Crop residues management option for sustainable soil health in rice-wheat system: A review. International Journal of Chemical Studies.
7. Bosch Sustainability Retrieved from: https://www.bosch.com/sustainability/environment/.
8. Bureau of Energy Efficiency. (2015). "Perform, Achieve and Trade (PAT) 2012", 'Retrieved from https://beeindia.gov.in/content/pat-3.
9. Bureau of Energy Efficiency. (2017). "About Standards & Labelling Program", Retrieved from https://www.beestarlabel.com/.
10. Bureau of Indian Standards. (2016). "Operation of Eco Mark Scheme", Retrieved from http://www. bis.org.in/cert/echo_mark_scheme.htm.
11. Camacho-Otero, Juana & Ordoñez, Isabel. (2017). Circularity assessment in companies: conceptual elements for developing assessment tools.
12. Central Pollution Control Board (CPCB). (2016). CPCB Guidelines for environmentally sound management of end-of-Life vehicles (ELVs) 2016. Retrieved from http://cpcb.nic.in/Final_Report_on_ELV_Guidelines_December_2016.pdf.
13. Centre for Science and Environment. (2016). "Not in my backyard" Down to Earth Magazine. New Delhi.
14. Charissa Rujanavech, J. L. (2016). Retrieved from www.apple.com: https://www. apple.com/environment/pdf/Liam_white_paper_Sept2016.pdf.
15. Chatterjee, D. S. (2011). Elecytonic waste and India. New Delhi: MEITY.
16. Circle Economy, & PGGM. (2014). Circularity Assessment for Organizations : Draft Indicators.
17. Circular Economy lab. (2014). Retrieved from http://circulareconomylab.com/.
18. Confederation of Indian Industry. (2014). "Innovation Ecosystem in India", Retrieved from https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-innovation-ecosystem-of-india-noexp.pdf.
19. Danish Government. (2015). "Denmark without waste II: A waste prevention strategy".
20. De Medina, H. V. (2006). Eco-design for materials selection in automobile industry. In Proceeding of the comunicação técnica elaborada para o 13th CIRP Internacional Conference on Life Cycle Engineering, LCE (pp. 299-304).
21. Department of Heavy Industry. (2012), "National Electric Mobility Mission Plan 2020", Retrieved from http://dhi.nic.in/UserView/index?mid=1347.
22. Department of Industrial Policy and Promotion. (2017). "National Design Policy" Retrieved from http://dipp.nic.in/sites/default/files/national_design_policy%20%20%20eng%201.pdf.
23. Department of Science and Technology. (2013). "Science, Technology and Innovation Policy, 2013", Retrieved from http://www.dst.gov.in/sites/default/files/STI%20Policy%202013-English. Pdf.
24. Dhawan, V. (2017). Water and Agriculture in India: Background paper for the South Asia expert panel during the

Global Forum for Food and Agriculture (GFFA). Federal Ministry of Food and Agriculture. Retrieved from https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf.

25. Dittrich, M. (2012). Global Material Flows database. Retrieved from: www.materialflows.net
26. DNA. (2016). Mumbai gets its 1st e-waste collection centre.
27. Doranova, A., Gigli, M. (2014). "Circular Economy Policy Guidance."
28. Effizienz-Agentur NRW (EFA). (2017). Protect Resources. Strengthen The Economy. (2017). Retrieved on 28.12. 2017, from Effizienz-Agentur NRW (EFA) : http://www.ressourceneffizienz.de/en/ressourceneffizienz/startpage-en.html.
29. Electronics.ca Publication. (2014, 03 19). Global Electronic Equipment Production Outlook and Forecast Report. Retrieved 01 04, 2018, from Electronics.ca Publication: https://www. electronics.ca/global-electronic-equipment-production-outlook-and-forecast-report.html.
30. Elizabeth, G. C. (2017). Guide to greener electronics. Washington D.C.: Green Peace.
31. Ellen MacArthur Foundation & GRANTA. (2015). Project Overview: An Approach to Measuring Circularity. Ellen MacArthur Foundation, 12. https://doi.org/10.1016/j.giq.2006.04.004.
32. Ellen MacArthur Foundation. (2016). "Circular Economy in India: Rethinking growth for long-term prosperity". Retrieved from: http://www.ellenmacarthurfoundation.org/publications/
33. Ellen Macarthur Foundation. (2016). "Money makes the world go round", Retrieved from https:// www.ellenmacarthurfoundation.org/assets/downloads/ce100/FinanCE.pdf.
34. Ellen McArthur. (2015). "Towards a Circular economy: Business rationale for accelerated transition". Retrieved from: https://www.ellenmacarthurfoundation.org/assets/downloads/ TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf.
35. Ernst & Young (EY) and Federation of Indian. Chambers of Commerce and Industry (FICCI). (2015). Study on Indian electronics and consumer durables segment.
36. Federal Office for the Environment. (2017). Retrieved from www.bafu.admin. ch: https://www.bafu.admin.ch/bafu/en/home/topics/waste/guide-to-waste-a-z/electrical-and-electronic-equipment.html.
37. Ford Sustainability Report 2016/17. (2017). Creating a Future Where Everyone Moves Better. Ford Motor Company, United States.
38. Ghosh, A. (2016). Is water our weakest link? Inflexion points. Business standard. Retrieved from https://www.pressreader.com/india/business-standard/20161025/281960312292111.
39. GIZ and Development Alternatives. (2017). "Resource Efficiency & Sustainable Management of Secondary Raw Materials in Construction Sector". New Delhi.
40. GIZ. (2015b). Resource Efficiency in the Indian Construction Sector: Market Evaluation of the Use of Secondary Raw Materials from Construction and Demolition Waste. New Delhi: GIZ.
41. Grimes, Sue, Donaldson, John and Gomez, Gabriel Cebrian. (2008). Report on the Environmental Benefits of Recycling. London: Bureau of International Recycling.
42. Grimes. S, Donaldson. J and Gomez. G.C. (2008). Report on the Environmental Benefits of Recycling. London: Bureau of International Recycling.
43. Gupta, Sumit, Dangayach, G. S., Singh, Amit Kumar. (2015). "Key Determinants of Sustainable Product Design and Manufacturing', Procedia CIRP 26 (2015). 99 – 102. Retrieved from, www. sciencedirect.com.
44. Gurauskienë. I and Varþinskas. V. (2006). "Eco-design Methodology for Electrical and Electronic Equipment Industry".
45. Hãloiu, A., & Iosif, D. (2013). Bio-Source Composite Materials Used In Automotive Industry. University of Pitešti, Pitešti, Romania.
46. IGEP. 2013. India's Future Needs for Resources. Dimensions, Challenges and Possible Solutions: Retrieved from: http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e48745/ e50194/e58089/ResourceEfficiency_Report_Final.pdf.
47. IMSA, & Circle Economy. (2013). Unleashing the power of the Circular Economy, 98.https:// doi.org/10.1089/ind.2013.1564.
48. ING (2015), _Rethinking finance in a circular economy- Rethinking ¬finance in a circular economy', Retrieved from https://www.ing.nl/media/ING_EZB_Financing-the-Circular-Economy_ tcm162-84762.pdf.

49. Jadhav, J. R., Mantha, S. S., & Rane, S. B. (2015). Roadmap for Lean implementation in Indian automotive component manufacturing industry: comparative study of UNIDO Model and ISM Model. Journal of Industrial Engineering International, 11(2), 179-198.

50. Jain Irrigation Systems Limited. (2017). Power Generation from Fruit and Agro Waste at Jain Food Park, 2017. Jain Irrigation Systems Limited.

51. Kapur, S. and Arora, N. (2017). "Financial solutions for promoting recycling". The Business Standard. Retrieved from : http://www.business-standard.com/article/current-affairs/financial-solutions-for-promoting-recycling-117111800839_1.html.

52. Kluijver. J. (2016). "Closing the loop: The garbage collectors of mobile Industry" Retrieved from: https://www.fairphone.com/en/2016/07/14/closing-the-loop-the-garbage-collectors-of-the-mobile-industry/.

53. Kumar, P. (2016). Energy Generation by Use of Crop Stubble in Punjab. In: Nautiyal S., Schaldach R., Raju K., Kaechele H., Pritchard B. and Rao K. (eds) Climate Change Challenge (3C) and Social-Economic-Ecological Interface-Building. Environmental Science and Engineering. Springer, Cham.

54. Kumar, S. and Sharma, A. (2016). Agricultural Value Chains in India: Prospects and Challenges. Retreived from http://www.cuts-citee.org/pdf/Agricultural_Value_Chains_in_India_Prospects_ and_Challenges.pdf.

55. LC^3 project supported and implemented by a consortium of École Polytechnique Fédérale de Lausanne (Switzerland), IIT-Delhi, IIT-Madras, Technology and Action for Rural Advancement and CIDem (Cuba) and supported by Swiss Agency for Development and Corporation (SDC).

56. Li Tong Group. (2014). Retrieved from www.litong.com: http://www.litong.com/enUS/ overview.html.

57. Maher MJ (1991). Science and Cultivation of Edible Fungi. Rotterdam: AA Balkema.

58. MAIT. (2016). Salient Features of the E-Waste (Management) Rules, 2016 and its likely implication. Retrieved from: http://www.mait.com/assets/india-weee-rev---salient-features. Pdf.

59. International Financial Corporation. 2017. Making Agriculture Climate – Smart.

60. Maruti Suzuki Sustainability Report for 2014-15. (2015). Serving with Commitment. Maruti Suzuki India Limited. New Delhi.

61. Ministry of Electronics & Information Technology. (2017). "National Policy on Electronics – 2012", Retrieved from http://meity.gov.in/writereaddata/files/NPE_Notification.pdf.

62. Ministry of Environment and Forest & Climate Change & German Ministry of Environment. (2017). "Recommendations for an Indian Resource Efficiency Programme (IREP), A Guiding Document for Policy Makers by the Indian Resource Panel,' Retrieved from http://re.urban-industrial.in/live/hrdpmp/hrdpmaster/igep/content/e64918/e64922/e67075/e67084/DMS_ GIZ_IREP_PolicyBrief.pdf.

63. Ministry of Environment and Forest & Climate Change (2016), "Waste Management Rules", Retrieved from http://envfor.nic.in/sites/default/files/Waste%20Management%20Rules,%20 2016.pdf.

64. Ministry of Environment and Forest & Climate Change. (1992). "Policy Statement for Abatement Of Pollution", Retrieved from http://www.envfor.nic.in/divisions/cpoll/psap.pdf.

65. Ministry of Environment and Forest & Climate Change. (1999). "The Fly Ash Notification, 1999". Retrieved from http://envfor.nic.in/legis/hsm/flyash.html.

66. Ministry of Environment and Forest & Climate Change. (2006), "National Environment Policy 2006", Retrieved from http://www.moef.gov.in/sites/default/files/introduction-nep2006e. pdf.

67. Ministry of Environment and Forest & Climate Change. (2006). "National Environment Policy 2006'. Retrieved from http://www.moef.gov.in/sites/default/files/introduction-nep2006e.pdf.

68. Ministry of Environment and Forest & Climate Change. (2010). "Batteries (Management and Handling) Amendment Rules 2010", Retrieved from http://envfor.nic.in/legis/hsm/SO1002.pdf.

69. Ministry of Environment and Forest & Climate Change. (2011). "Sustainable Development in India: Stocktaking in the run up to Rio+20", Retrieved from http://unpan1.un.org/intradoc/ groups/public/documents/cgg/unpan047509.pdf.

70. Ministry of Environment and Forest & Climate Change. (2016). "Waste Management Rules", Retrieved from http://envfor.nic.in/sites/default/files/Waste%20Management%20Rules,%20 2016.pdf.

71. Ministry of Environment and Forest (2003), _Charter on —Corporate Responsibility for Environmental Protection (CREP)', Retrieved from http://cpcb.nic.in/displaypdf. php?id=Q1JFUF9UYW5uZXJ5LnBkZg.

72. Ministry of Environment, Forest and Climate Change. (2016, March 23). www.moef.gov.in. Retrieved 12 29, 2017,

from Ministry of Environment, Forest and Climate Change: http:// www.moef.gov.in/sites/default/files/EWM%20Rules%202016%20english%2023.03.2016.pdf.

73. Ministry of Micro, Small and Medium Enterprises. (2017). "National Manufacturing Competitiveness Programme", Retrieved from http://www.dcmsme.gov.in/schemes/nmcp_scm.htm.
74. Ministry of Micro, Small and Medium Enterprises. (2017). "National Manufacturing Competitiveness Programme", Retrieved from http://www.dcmsme.gov.in/schemes/nmcp_scm.Htm.
75. Ministry of Mines. (2017). "Sustainable Development Framework for the Mining Sector", Retrieved from https://mines.gov.in/writereaddata/UploadFile/SDF_Overview_more.pdf.
76. Ministry of Mines. (2017). "The Mines and Minerals (Development And Regulation) Amendment Act, 2016", Retrieved from http://www.indiacode.nic.in/acts-in-pdf/2016/201625. Pdf.
77. Ministry of New and Renewable Energy. (2009). "National Policy on Biofuels", Retrieved from http://mnre.gov.in/schemes/new-technologies/biofuels/.
78. Ministry of Petroleum and Natural Gas. (2015). "National Auto Fuel Policy" Retrieved from http://164.100.47.193/lsscommittee/Petroleum%20&%20Natural%20Gas/16_Petroleum_ And_Natural_Gas_5.pdf.
79. Ministry of Steel (2018). "National Steel Policy 2017", Retrieved from http://steel.gov.in/sites/ default/files/NATIONAL_STEEL_POLICY_2017.pdf.
80. Ministry of Steel. (2018). "National Mineral Policy 2008', Retrieved from http://steel.gov.in/sites/ default/files/88753b05_NMP2008%5B1%5D.pdf.
81. Ministry of Environment, Forest and Climate Change (MOEFCC). (2015). Fly Ash notification, retrieved from: http://cbrienvis.nic.in/flyashnotification. Pdf.
82. Munjal Institute for Global Manufacturing-ISB. (2016). Cold Chain Development for Fruits & Vegetables in India: Kinnow Cold Chain Study. Retrieved from http://www.nccd.gov.in/PDF/ Kinnow-PILOT-Report.pdf.
83. NEW_InnoNet. (2016). Report summarising the results of the analysis of Electronics Value. New_InnoNet.
84. NITI Aayog. (2016). Make in India Strategy for Electronic Products. Government of India.
85. NRDC-ASCI. (2012). Constructing Change: Accelerating Energy Efficiency in India's Buildings Market. Natural Resources Defense Council and Administrative Staff College of India. Retrieved from: https://www.nrdc.org/sites/default/files/india-constructing-change-report.pdf.
86. Nussholz, J. and Milios, L. (2017). "Applying circular economy principles to building materials: Front-running companies' business model innovation in the value chain for buildings".
87. Olivier, J. G., Janssens-Maenhout , G., Muntean, M., and Peters, J. A.H.W. (2016). Trends in global CO2 emissions; 2016 Report. The Hague: PBL Netherlands Environmental Assessment Agency, Ispra: European Commission, Joint Research Centre.
88. Pandit, V. (2016). India's e-waste growing at 30% annually. The Hindu Business Line.
89. Perfotec. (2016). Extending the shelf life of fresh fruit and vegetables through customised packaging. Retrieved from http://perfotec.com.
90. Press Information Bureau. (2011). "National Manufacturing Policy 2011", Retrieved from http:// pib.nic.in/newsite/PrintRelease.aspx?relid=76843.
91. PWC. (2015). Low Carbon Economy Index 2015. Retrieved from: http://www.pwc.co.uk/services/sustainability-climate-change/insights/low-carbon-economyindex- 2015-download-section.html.
92. PWC. (2017). Championing change in the Indian appliance and consumerelectronics Industry Rujanavech. C, Lessard. J, Chandler. S, Shannon. S, Dahmus. J, Guzzo.R (2016) —Liam – An Innovation Story" retrieved from https://www.apple.com/environment/pdf/Liam_white_ paper_Sept2016.pdf.
93. Ramkumar. S (n.d.). "Making Sense of the Circular Economy - The 7 Key Elements Circle-Economy". Retrieved from: https://www.circle-economy.com/the-7-key-elements-of-the-circular-economy.
94. Ranasingh. N, Mohanty. S and Behera. S. (2010). Oyster Mushroom Cultivation: A Profitable Enterprise - A Case Study. Orrisa Review.
95. Renewable Energy Certificate Registry of India. (2010). "Renewable Energy Certification (RECs) 2010", Retrieved from https://recregistryindia.nic.in/index.php/general/publics/index.
96. Sandhar Automotives (2009). Case Study #4: Sandhar Automotives, Dhumaspur. Gurugram, Haryana, India: Sandhar Automotives -Dhumaspur.

97. Schluep. M (2014). Case Study: E- waste management. Retrieved from: http://www.global-chemicals-waste-platform.net/fileadmin/files/doc/casestudy_EMPA.pdf.

98. Sevea Association Loi 1901. (2013). Husk Power System Power to Empower. Retrieved from http:// www.seveaconsulting.com/wp-content/uploads/2016/02/Case_study_HPS.pdf.

99. Singh, A. P., Raman, N. S. and Waghe, U. P. (2012). "Ecomark Scheme in India", International Journal of Pharma Medicine and Biological Sciences. 2012. Vol. 1, No. 2, October 2012.

100. Sohail, Sadia. (2015). Retrieved from http://www.downtoearth.org.in: http://www. downtoearth.org.in/blog/e-waste-disposal-what-india-can-learn-from-norway-48398.

101. Tata Motors Limited. (2017). Tata motors, Sustainability report 2016-17. Retrieved from http://corp-content.tatamotors. com.s3-ap-southeast-1.amazonaws.com/wp-content/uploads/2015/10/15092832/tml-sustainability-report-2016-2017.pdf.

102. Technology Information, Forecasting and Assessment Council (TIFAC). (2001). Utilisation of Waste from Construction Industry. New Delhi: Technology Information, Forecasting and Assessment Council.

103. TERI-GIZ-DA. (2016). "Material Consumption Patterns in India: A Baseline study of the automotive and construction sectors" Published by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

104. TERI-GIZ-DA. (2016). Material Consumption Patterns in India: A Baseline Study of the Automotive and Construction Sectors. Retrieved from: https://www.international-climateinitiative.com/fileadmin/Dokumente/2016/GIZBaselineReportSummary_SinglePages.pdf.

105. The Danish Government. (2015). Denmark without waste II. The Danish Government.

106. The data blog. The World Bank. Retrieved from https://blogs.worldbank.org/opendata/ chart-globally-70-freshwater-used-agriculture.

107. The World Factbook. Central Intelligence Agency. Retrieved from https://www.cia.gov/ library/publications/the-world-factbook/geos/in.html.

108. Toyota Motor Corporation. (2014). Vehicle Recycling. Toyota Motor Corporation. Tokyo, Japan.

109. Uflex. (2016). Uflex presents shelf life extension for exotic fruits.. Retrieved from http://www. uflexltd.com/blog/uflex-presentsshelf-life-extension-forexotic-fruits/.

110. UL Environment. (2014). https://www.ul.com/newsroom/pressreleases/ul-environment-awards-first-closed-loop-validation-to-dell/.

111. UNEP-IRP. (2016). Global Material Flows and Resource Productivity. United Nations Environment Programme – International Resource Panel. Retrieved from: http://unep.org/ documents/irp/16-00169_LW _ GlobalMaterialFlowsUNEReport_FINAL_160701.pdf.

112. VBDO. (2015). Company Assessment Criteria Theme: Circular Economy.

113. Viktoria Swedish ICT. (2015). Measuring business model circularity as a means to promote resource productivity.

114. Waste to Energy: A case Study of Rice Husk Power Plant, Bihar. Retrieved from http://www. devalt.org/knowledgebase/pdf/Case%20Study-3.pdf.

115. WBCSD & IEA. (2013). Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry. World Business Council on Sustainable Development and International Energy Agency.

116. World Economic Forum. (2013). From linear to circular—Accelerating a proven concept. Retrieved 12 29, 2017, from reports. weforum: http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/from-linear-to-circular-accelerating-a-proven-concept/?doing_wp_cron=1514530425.6549520492553710 937500#view/fn-11.

117. World Economic Forum. (2015). Which countries waste the most food? https://www.weforum.org/agenda/2015/08/which-countries-waste-the-most-food/.

118. World Economic Forum. (2017). "Platform for Accelerating the Circular Economy". Retrieved from: https://maritim.go.id/konten/unggahan/2017/09/Basic_PACE_Desc_Susan.pdf.

119. Wuest, P. J., Rose, D. J. and Beelman, R. B. (1987). Cultivating Edible Fungi. Elsevier. Amsterdam.

120. Annual Report 2016-17 and India Nivesh coverage of Ganesha Ecosphere Ltd. (dated 4th Dec 2017)

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