Mother Earth Is Terminally ILL

IS CIRCULAR ECONOMY ENOUGH?

WORLD INTELLECTUAL FOUNDATION

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FOREWORD

When I look at what is going on—the heat waves, forest fires, droughts, floods and seismic events, 'Mother Earth' has clearly aged faster than we thought and is terminally ill. This decade is the start of an existential challenge for us. If we don't act now, our future will be much shorter than our history.

We are already too late and prevention is not enough. We need to push all engines and reverse the degradation as we are on the cliff and about to fall. It is a tough ask but humanity always rises to the challenge when pushed to the corner, and COVID-19 has proven this. Will circular economy based on the principle of sustainable consumption be enough to save us? Should we define the 'Optimum Ecosystem' for a sustainable planet? We cannot wait as we have limited time and choices on the issue of planetary sustainability. Also, India has just started its mega manufacturing plan (Make in India) to become self-reliant and it has a long way to go; will it be able to sustain the push for manufacturing and if it has to do so, what kind of 'development model' is needed so that we can be a responsible nation in all we undertake.

As I give final touches to this report, the temperature in Delhi is nearing 50 degrees Celsius. Microplastics have reached Antarctica, and space debris is falling on earth! If we continue this way, then we will never be able to enjoy the benefit of a developed nation; however, as a developing nation, India is paying the price for the irresponsibility of the developed nations and may have to compromise on its goal of becoming a developed nation given the environmental cost of development; thus, it is time for everyone to do beyond their bit. Given this backdrop I started this report, and my colleague Prithvi Dutt has done the heavy lifting to convert the idea and guidance into this wonderful document. We look forward to your views and more importantly actions to turn the clock back and reverse the planetary ageing. Remember, we are the last generation to make a difference.

Dr. Rajendra Pratap Gupta, PhD
Executive Chairman
World Intellectual Foundation

AGEING 'MOTHER EARTH' IS TERMINALLY ILL

> *'The farther we are moving away from nature, the faster we are moving towards our end.'*
>
> —Dr. Rajendra Pratap Gupta

The pre-industrial era had low-intensity mineral extraction and pollution levels, thus the net impact on the environment was minimal. As human population and greed increased, forests were removed to meet increasing cultivation demands, in some cases using the 'slash and burn cultivation' practises. Over time as the human population surged, the cultivation and agriculture community defined and modified the usage of the natural ecosystem; however, as the activities were related to the natural cycles of resources, exploitation was less intensive and hence sustainable. This sustainable system was disturbed with the beginning of the Industrial Revolution as nations grew dependent upon extraction of non-renewable resources in an uncensored way. The exploitation, depletion and pollution of natural resources was driven not only by industry but by inefficient fishing practices, agriculture and deforestation, causing overpressure on the natural stock of given resources and adversely affecting biodiversity.

> *'Human greed and growth without an intergenerational goal will lead to irreversible destruction.'*
>
> —Dr. Rajendra Pratap Gupta

QUANTITATIVE AND QUALITATIVE IMPACT: SUSTAINABILITY IS SECURITY

As the quantitative impact reduces the stocks, the qualitative impact degrades the natural resources, e.g., air and water pollution, followed by health hazards to the people residing in the 'impact zone', e.g., mounting outbreak of invasive pests and diseases. The economic and population growth exert uncensored pressure on the natural resources that leads to their degradation through growing urbanisation, industrialisation and intensive agricultural activities. Population growth further intensifies the need for shelter, food and material consumption. In other words, population size is linked to the environment for the following two reasons—pressure on natural resources due to the increasing consumption levels and the pollution caused at individual level. Similarly, increased demand and changing consumption patterns lead to economic growth that is currently based on resource extraction majorly. Since these natural resources are limited, either efficient resource utilisation can help reduce the biodiversity loss or a decrease in population can lead to a chain reaction to reduce expansion in industrialisation, urbanisation and agriculture.

One of the key factors contributing to the overpressure on the natural resources other than population growth is the structural paradigm shift in domestic and international demand. Ernst Engel proposed an economic theory in 1857 that suggests: At relatively low-income levels, a significant share of the income is spent on food and necessities. With rise in income, the share of food in the total expenditure tends to decline with a simultaneous rise in the spending share of manufactured and consumer goods. The manufacturing demand increases at a diminishing rate as the income rises; hence, the subsequent rise in income is spent on services. **The global middle income population increased from 899 million to 1.34 billion within a decade (2011–2019).**[1] This growing middle income class expands the scope for the manufacturing sector and hence the extraction of resources.

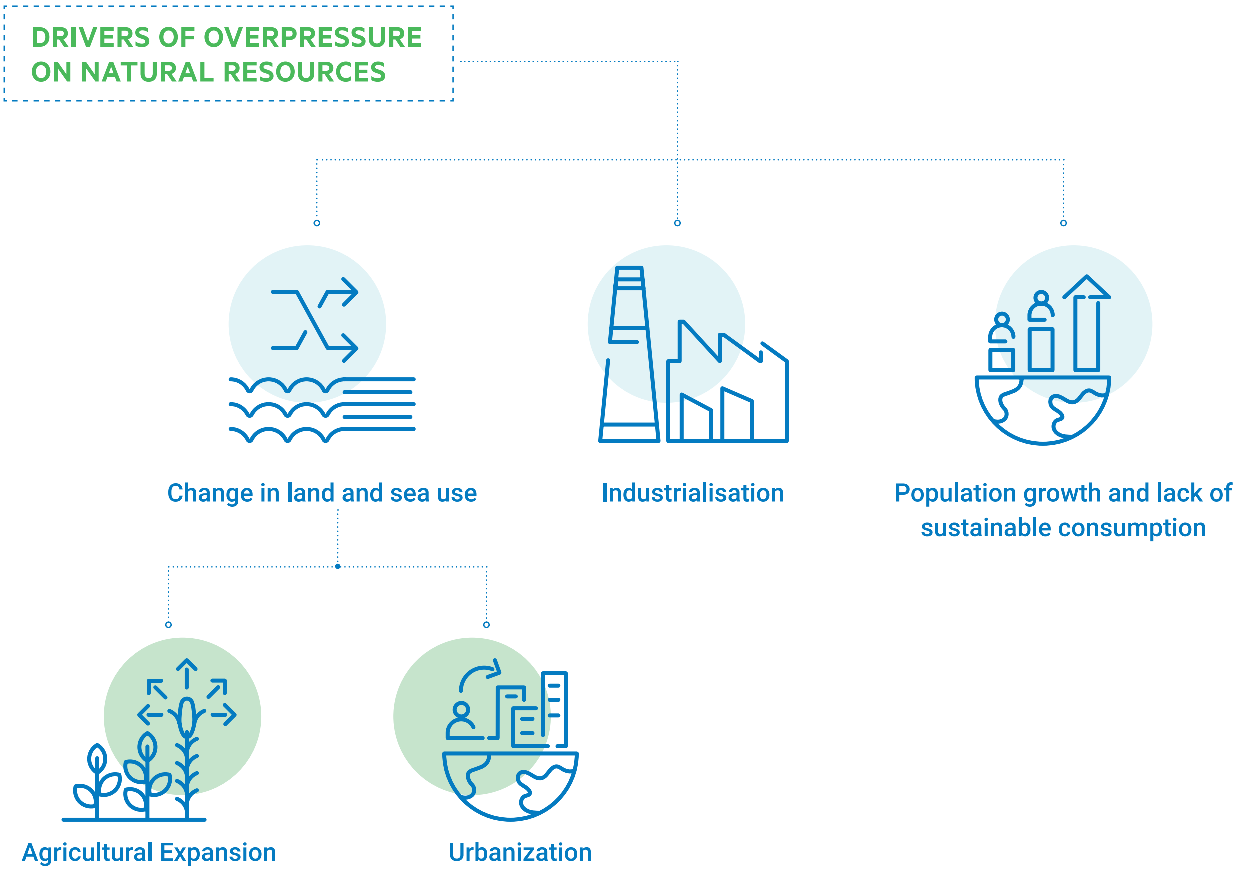
These expansions are at the cost of nature's ability to provide such services in the future. The consequences of uncensored linear processing are not just limited to depletion and degradation of natural resources but also adversely impact the natural ecosystems which act as filters for human pollution. For example, the 'carbon sinks' of Earth or the rain forests are being destroyed on a mass level and so is the high diversity of flora and fauna of which many are endangered or already extinct.

While the extraction of natural resources for economic gains contributes majorly to the upliftment of the local population economically, this does not always

[1] *World bank database.*

translate into betterment of the people given the severity of externalities. The Earth's natural cycles—both biochemicals and water—have been disturbed with the linear dependence upon resource extraction in the industries that determine the impacts of human activities in the biosphere. The over-dependence on natural resources to meet the increasing global demands have ignored the dependence of such resource-intensive industries on the natural minerals which will very soon deplete to a level that will exceed the ecosystem's capacity to replenish or repair the shortfall through the natural processes. The vast quantity of industrial and domestic waste generated in the process of this exploitation has negative impacts in terms of visible and invisible externalities. The toxic substances after being retained and hidden due to the Earth's natural cycles are now being accumulated in the biosphere as the garbage, waste and pollution surpass nature's capacity to repair the damage.

This highlights that innovative strategies and techniques to maintain a high recovery value chain are all neutralised by the simultaneous increase in extraction of raw materials, changing and shifting to higher levels of consumer demand, supported by subsidies. This calls for a collective shift from our current model of linear consumption towards circularity, enforced by social, business and regulative innovations and reforms. Circular economy intends to minimise waste production and carbon emissions through efficient resource utilisation. Standard economic accounting measures the economic growth in terms of output but dismisses the impact of linear processing on degradation of natural habitat, sanitation and increased health costs and problems.

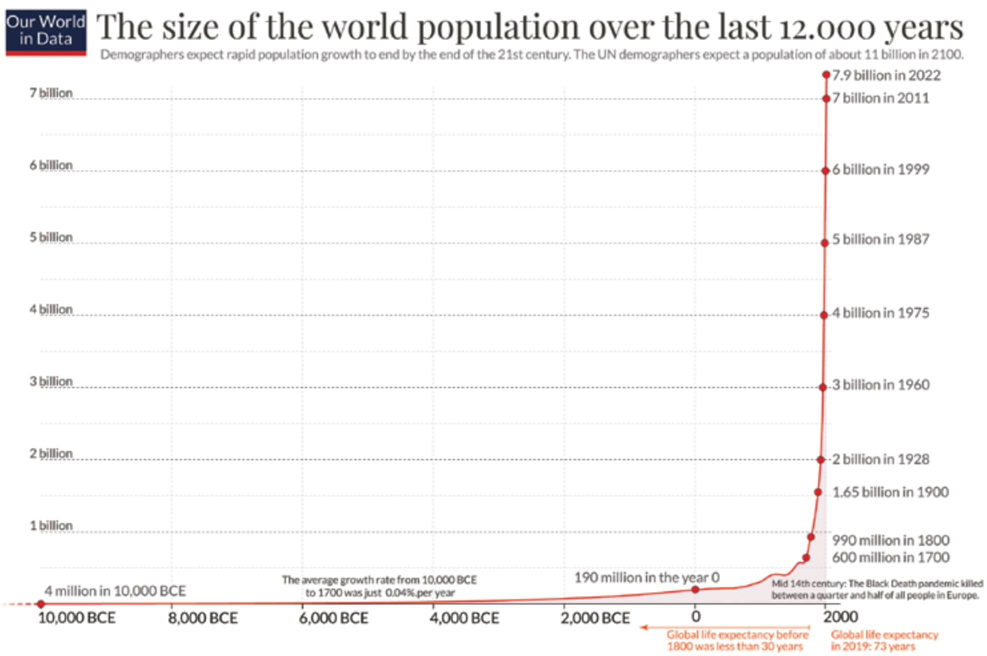


FROM RURAL TO URBAN: CHANGING HUMAN HABITS AND HABITAT

The current model of linear consumption has a dual fold impact as the loss of Biodiversity and surging levels of pollution in the biosphere. The underpinning national and international attention on climate change is the acknowledgment of the intensifying pressure on natural resources due to the drivers of change. Out of which, the population growth is assumed to be the most prominent and serves as the basis and the root cause for all other sub-drivers. Population explosion amplifies the already shifting consumer demands due to a better standard of living across the Globe as evident by the growing economic prosperity. (Birth rates and death rates determine the aggregate demand of an economy and hence, cyclical and structural factors attributing change to them are highly relevant for economic planning that indirectly put pressure on natural resources and the individual pollution contributions.)

Global population stands at 7.9 billion currently and is expected to grow by 2 billion in the upcoming 30 years, i.e., to 9.7 billion by the end of 2050.[2]

THE SIZE OF THE WORLD POPULATION OVER THE LAST 12,000 YEARS



Source: Based on estimates by the History Database of the Global Environment (HYDE) and the United Nations. This is a visualisation from OurWorldinData.org.

Technological advancement has led to an increase in the life expectancy years and a simultaneous decrease in the infant mortality and death rates. These changes combined with the fast-paced urbanisation, migration and fertility rate changes are largely reasoned for the rapid population explosion. Global population growth is projected to slow down as the income levels show a convergence, but nonetheless an OECD report estimates a **1.2X increase in the population by 2060**.[3] 1.2X does not sound enormous alone but would become problematic

[2] *UN Population Division.*

[3] *OECD, Global Material Resource Outlook to 2060 (Paris: OECD, 2019).*

if the multiplicative base is 7 billion. Simultaneously, global gross domestic product per capita is estimated to be at the current OECD levels, indicating a sign of **income convergence**. Income convergence, especially among developing countries, is linked to higher levels of economic prosperity driven by expanded infrastructure and investments which leads to higher material demand. Thus, exponential increase in the population and a simultaneous income convergence leading to higher GDP per capita drive the increased global demand for resources.

Human influence on land use varies with the changing soil quality, geographical conditions and climate. Estimated 40% of the deforestation in the tropics and subtropics has occurred due to commercial agriculture[4] and 33% by subsistence agriculture[5] Almost 50% of the world's total habitable land is used for agriculture and livestock,[6] and 16% of the total rice, wheat and maize production is lost due to invasive pests.[7] At least 50% of the ocean is covered by industrial fishing and 33% of fish stocks are overfished.[8] Anthropogenic impacts led to 1/3rd of the world's topsoil degradation, destruction of 50% of the world's coral reef system, and decline in the Amazon forest size by 17% in the past five decades.[9]

Out of the total land surface, 11% is under crop production, given almost 60% of the world's population depends upon agricultural activities that are highly linked to the rural areas. The rural population has increased slowly than the urban population to 3.4 billion in 2018; it is soon expected to reach its peak and decline to 3.1 billion by 2050. However, urban population has shown a steady increase with 30% urban residents in 1950 to 55% in 2018 and is projected to increase to 68% by 2050.[10] Rapid urbanisation is characterised by an alteration in the demographic and social structure as the dominant occupations, culture and lifestyle change. As urban areas serve as the centre for economic prosperity and technological innovation—with almost all necessities better available with an exceeding birth rate than the death rates, better sanitation and healthcare, quality water availability, they act as hubs for the drivers of pressure on the natural resources discussed above. To address the income impact on climate change, the richest 10% contributed with 31% of the carbon budget depletion where the poorest 50% only with 4%.[11]

Given the better living standards, the cities and urban areas are highly congested as UN urbanisation prospects, 2018, projected a 28% increase in the global population living in the medium-sized cities by 2030. The combined effects of increased population density with the emerging new middle class pave the way for growth in industrialisation and agricultural expansion to meet the growing demands of material and food consumption.

DIGITALISATION IS ADDING TO THE MESS

The proliferation of internet and internet-based technologies is increasing with each day passing. In as much as the life is becoming 'always connected', it has a negative impact on the environment through the carbon footprint. The below mentioned table gives us an idea of the carbon footprint of our daily digital routine.

[4] FAO, State of the World's Forests 2016. Forests and Agriculture—Land-Use Challenges and Opportunities (Rome: FAO, 2016).

[5] Noriko Hosonuma et al., 'An assessment of deforestation and forest degradation drivers in developing countries," Environmental Research 7, no. 4 (2012): 044009.

[6] IPBES, Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Bonn: IPBES, 2019).

[7] Centre for Agriculture and Bioscience International, Invasive Species: The Hidden Threat to Sustainable Development (Wallingford: Centre for Agriculture and Bioscience International, 2018).

[8] WWF, Living Planet Report (Gland: WWF, 2018).

[9] WEF, New Nature Economy Report (Cologny: WEF, 2020).

[10] United Nations, Department of Economic and Social Affairs, Population Division, World Urbanisation Prospects (New York: United Nations, 2018).

[11] Oxfam International & Stockholm Environmental Institute, Confronting Carbon Inequality (Oxfam International & Stockholm Environmental Institute, 2020).

The Carbon Footprint of[12]:

The use of an average-efficient laptop

10

CO_2e per hour

The use of a desktop computer with screen

50

CO_2e per hour

Use of phone one hour a day

63KG

CO_2e a year

A long email that takes 10 minutes to write and 3 minutes to read, sent from laptop to laptop

17G

CO_2e

5 minutes web browsing from a smartphone

5.6G

CO_2e

5 minutes web browsing from a laptop

8.2G CO_2e

A single text message

0.8G CO_2e

A Zoom call on an average efficient laptop

10G CO_2e

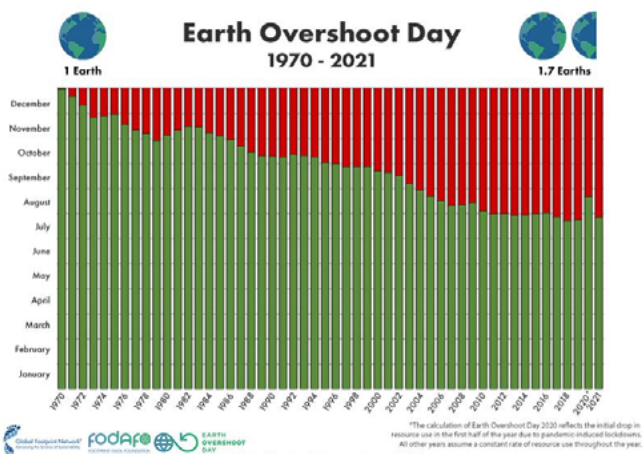
12

EARTH OVERSHOOT DAY

> ***'Earth Overshoot Day marks the date when human demand for ecological resources and services in a given year exceeds what earth can regenerate in that year. Last year, as chair of the Royal Academy Symposium, in my opening remarks, I mentioned how the Earth Overshoot Day has been hitting earlier with each year passing. It was August in 2020, and it was July in 2021. I looked at the historical dates. In 1970, our renewable resources lasted a whole year less than one day(December 30th). In 2000 it became September 22, meaning Earth Overshoot Day gets closer by a month with every decade passing. I guess in 2050; the overshoot day will move to April. By the end of the century, we will start the new year with Earth Overshoot Day!'***
>
> —Dr. Rajendra Pratap Gupta at London Climate Action Week 2021

Earth Overshoot Day represents the optimum natural resource usage in a year by indicating the date by which we will mark it; every day after the date means an exceeding extraction of the resources above the optimal level. By optimal, we mean nature's capacity to renew natural resources. 29th July is the overshoot day for 2021, the remaining 156 days will exploit nature's regenerative capacity. The anthropogenic unlimited wants and limited resources have led us to require approximately 1.7 Earths, which is not possible yet.

The USA, Canada, and Kuwait have their overshoot day on as near as March 14. If the world's population were to have the same lifestyle as them, the world would need 4.8 Earths.



Source: *National Footprint and Biocapacity Accounts Edition (data.footprintnetwork.org).*

Source: *National Footprint and Biocapacity Accounts, 2021 Edition (data.footprintnetwork.org).*

Highly nature intensive industries contribute to the gross value added as follows: construction ($4 trillion), agriculture ($2.5 trillion), food and beverages ($1.2 trillion); also, timber harvest has increased by 45%.[13] These industries require high extraction of resources directly from nature or from provisioning ecosystem services such as clean water, soil, etc. Since, the resources are limited (extracted for the given sectors), nature will lose it's capacity to support these industries which will lead to an existential crisis for life on Earth as the downfall for one element of the value chain leads to a downfall for all. Hence, this will have a ripple effect on biodiversity given the interlinkages of all the stakeholders.

> ***'If we don't act now, our future will be much shorter than our history'***
>
> —Dr. Rajendra Pratap Gupta
>
> Opening remarks of the Chair of the Frontiers of Development Symposium
> Hosted by the Royal Academy of Engineering on behalf of the Royal Society,
> The Academy of Medical Sciences, and the British Academy—11th November 2020

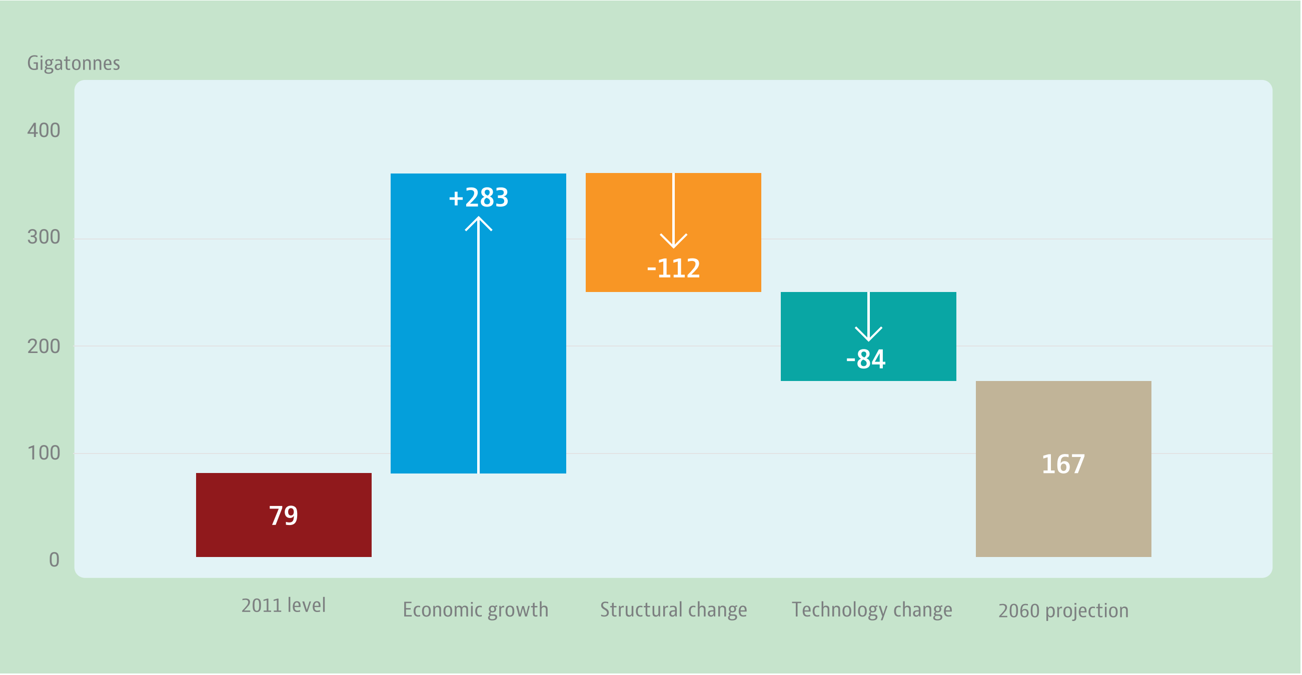
Some countervailing factors to the linkages of high economic growth and output productivity are the **structural shifts towards service sector** (less material intensive) from the agriculture and industrial sector as the developing economies converge to the developed income levels; these combined with the **factor augmenting effects of technological progress** might slow down the global material consumption growth rate. Thus, the material intensity might decrease by 1.3%[14] annually after 2025 to 2060 due to structural shifts to the service sector as economic convergence, digitisation and aging continues. However, in all scenarios with some uncertainty in the impact of technology and structural shift, the global material consumption is expected to rise, especially for construction and metals by 1.5% annually from 2011 to 2060. Thus, income convergence combined with the faster population growth have linkages to increased material demand.

[13] *WEF, New Nature Economy Report.*

[14] *OECD, Global Material Resource Outlook to 2060.*

CONSUMPTION EMERGENCY = CLIMATE EMERGENCY

GLOBAL MATERIAL CONSUMPTION TO DOUBLE BY 2060



Source: OECD, Global Material Resource Outlook to 2060 (Paris: OECD, 2019).

The rapid destruction of the environment has led to the implementation of various green policies intended to reduce the negative externalities of the overpressure and the pollution of natural resources. 2030 jurisdictions in 35 countries have declared a climate emergency covering over 1 billion citizens, and 23 national governments[15] have declared a climate emergency.[16] 92% of the citizens residing in Britain have their local authorities impose a climate emergency. The policies are designed to mitigate the destruction of limited natural resources due to inefficiencies and over-demand by establishing a circular flow of resources and inputs in the value chain. 196 countries signed the Paris Agreement in 2015, to keep global warming below 2 degree Celsius after the scientific consensus that exceeding this would lead to dangerous consequences for the planet.

IPCC 2021, Sixth Assessment Report (AR6), 'Climate Change 2021: The Physical Science Basis' presented the following key alarming highlights:

- Climate change mitigation via temperature control to 1.5 degrees Celsius is inevitable even in the best case scenario.
- The average surface temperature of the Earth will rise (pre-industrial levels) by 1.5 degrees Celsius in the next 20 years and 2 degrees Celsius by the mid-century.
- Decade 2011–2020 was the hottest since the last 1.25 lakh years.
- CO_2 emissions have been the highest in the last 2 million years with emissions due to anthropogenic activities being 2400 billion tonnes of CO_2, since the late 19th century.
- 86% of the global carbon budget[17] has been depleted.

[15] *EU is accounted as one jurisdiction.*

[16] *Climate energy declaration as on 7th October 2021, https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens/*

[17] *Bandwidth of carbon consumption that leaves the scope for mitigating climate change by limiting the warming up to 1.5 degrees Celsius.*

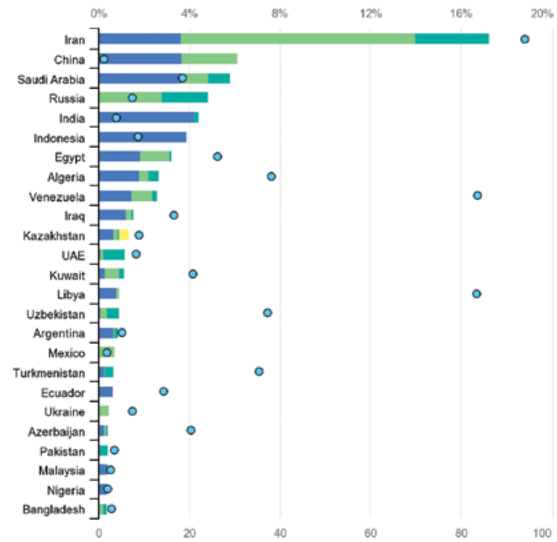
- Sea level rise was three times as of 1901–1971, Arctic ice has melted to the lowest level of the past 1,000 years, and 50% of the sea rise is attributed to thermal expansion.[18]
- The increasing temperature even by 0.5 degrees Celsius will lead to both hot and cold extremes that will have impacts also on the natural carbon sinks.

UN's Emissions Gap Report 2020 contemplated on how the current Nationally Determined Contributions (NDCs) are seriously inadequate for the global climate goals under the Paris Agreement and would increase the global temperature by at least 3 degrees Celsius by the end of the century (recent net-zero carbon emissions goals by European Union (EU) and others could reduce global temperature by 0.5 degrees Celsius given the policies are consistent). The report suggests a threefold increase in the current NDCs to achieve the 2 degrees Celsius target.

> ***'If temperatures continue to rise, it is indicative of "humanity" talking too much and doing too little to avert the disaster.'***
>
> —Dr. Rajendra Pratap Gupta

The Target 3 of Strategy A under the Aichi Biodiversity Targets, signed by 192 countries pledged for reducing or reforming the incentives, including subsidies harmful to biodiversity to minimise the negative impacts, latest by 2020. This transformation is extremely slow. In fact, before the pandemic, the incentives for high carbon-intensive infrastructure exceeded those of green technologies.

Value of fossil-fuel subsidies by fuel in the top 25 countries, 2019:



Total subsidies as % of GDP (MER) Oil Electricity Gas Coal

Source: International Energy Agency (IEA).

[18] *Water expands due to heating (here it is due to global warming), hence more space requirement for heated water leading the sea level rise.*

CIRCULAR ECONOMY IS SUSTAINABLE ECONOMY

The concept of the circular economy was first coined by Pearcer and Turner in 1990 in their book *Natural Resources and the Environment*, pointing out the relationship between the environment and economics. The linear model of processing is unsustainable and was built with no recycling or reuse tendency that treats the planet as a waste reservoir. They view the natural ecosystem as an input provider and waste receiver. This lines with the first law of thermodynamics that energy and matter remain constant in a closed process and hence equal to waste that ends up getting accumulated in the ecosystems. Analysing the problems of the current linear model of take-make-dispose and the relationship between economy and environment, the proposed solution was the closed loop of resources which they termed as circular economy. Extending their principle on the grounds of Kenneth Boulding's 1966 essay 'The Economics of Coming Spaceship Earth', they regard Earth as a closed economic system which requires different principles than the conventional open Earth or linear processing model. The essay contemplated Earth's waste accumulation and repair capacity with the focus on exhaustible or non-renewable resources. An excerpt from the essay reads as follows:

> *'Tile closed economy of the future might similarly be called the "spaceman" economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy. The difference between the two types of economy becomes most apparent in the attitude towards consumption.'*

This principle of circular economy is derived from the processes occurring in the biological sphere where each element is interdependent and a waste of one element is food for another. The **biological nutrients** in the ecosystem are designed to re-enter the biosphere holding the original value after the embodied utilisation, while the **technical nutrients** tend to remain in the loop of manufacture, reuse, repair, refurbish, recovery, recycle—ideally claiming an infinite life cycle of these nutrients. The circular model hence intends to reconcile the natural and economic prospects. The body of opinions that highlights the different significant aspects of drawing inspiration from nature for designing our industrial processes includes Laws of Ecology and Biomimicry[19] that connect the ecological and economical spheres by mimicking nature's process of value recovery; Industrial Ecology[20] as a study of maintaining a closed loop of resources where the waste of one production process remains in the value chain as an input for another one; and Permaculture that recalls the restorative and regenerative principle based techniques applied for soil fertility in agriculture (Julian Kirchherr, Denise Reike, Marko Hekkert).

> ***'Organizations, activities and practices should be based on natural ecosystem cycles like the carbon cycle and water cycle. There are no other cues for sustaining the planet.'***
>
> —Dr. Rajendra Pratap Gupta

VALUE RECOVERY MODEL

A study[21] conducted by gathering 114 definitions of circular economy across the scholar publications and encoding them into 17 dimensions found that circular economy is most frequently depicted as a combination of different strategies under the R's framework where 'Recycle' was given higher focus (79%) and was more policy oriented. Only 30% of the definitions highlighted the 'waste hierarchy' where the different 'R strategies' are arranged in order of the value recovery process. Ken Webster calls this misdirection and misinterpretation as an 'engineered pipework' that can lead to 'extractive economies adjusted under the circular economy concept'.[22]

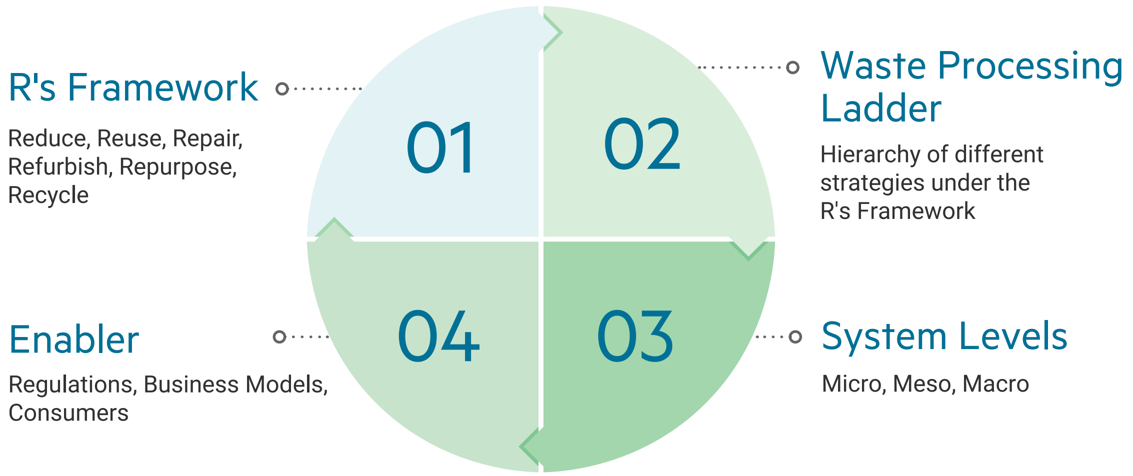
[19] *Janine Benyus, Biomimicry: Innovation Inspired by Nature (New York, NY: Harper Collins, 2002).*

[20] *Robert A. Frosch and Nicholas E. Gallopoulos, 'Strategies for manufacturing,' Scientific American, 261 (1989): 144–152.*

[21] *Julian Kirchherr, Denise Reike, and Marko Hekkert, 'Conceptualizing the circular economy: An analysis of 114 definitions,' Resource, Conservation and Recycling, 127 (2017): 221–232.*

[22] *Ken Webster, 'A circular economy is about the economy,' Circular Economy and Sustainability, 1 (2021): 115–126.*

The concept of circular economy is based on four pillars: R's framework with a given hierarchy and innovations enablers with decentralised yet integrated (via national norms and strategy) system levels. R's framework emphasises on the value recovery from the products through shredding/recycling only if they cannot be retained into their original state with the same value via reuse, refurbishing and repairing. This is enforced by following a 'waste processing ladder' that lists the sequential recovery methods where the recycling and complete reversal of products to their natural form is kept last; the frequency and the widened length of product usage should be increased. The circular economy strategy should be integrated at the three system levels, i.e., micro—individual firms/citizens, meso—group of firms and macro level with decentralised functions. The strategy is based on social, business and regulative innovations guiding the process for multi-systems.



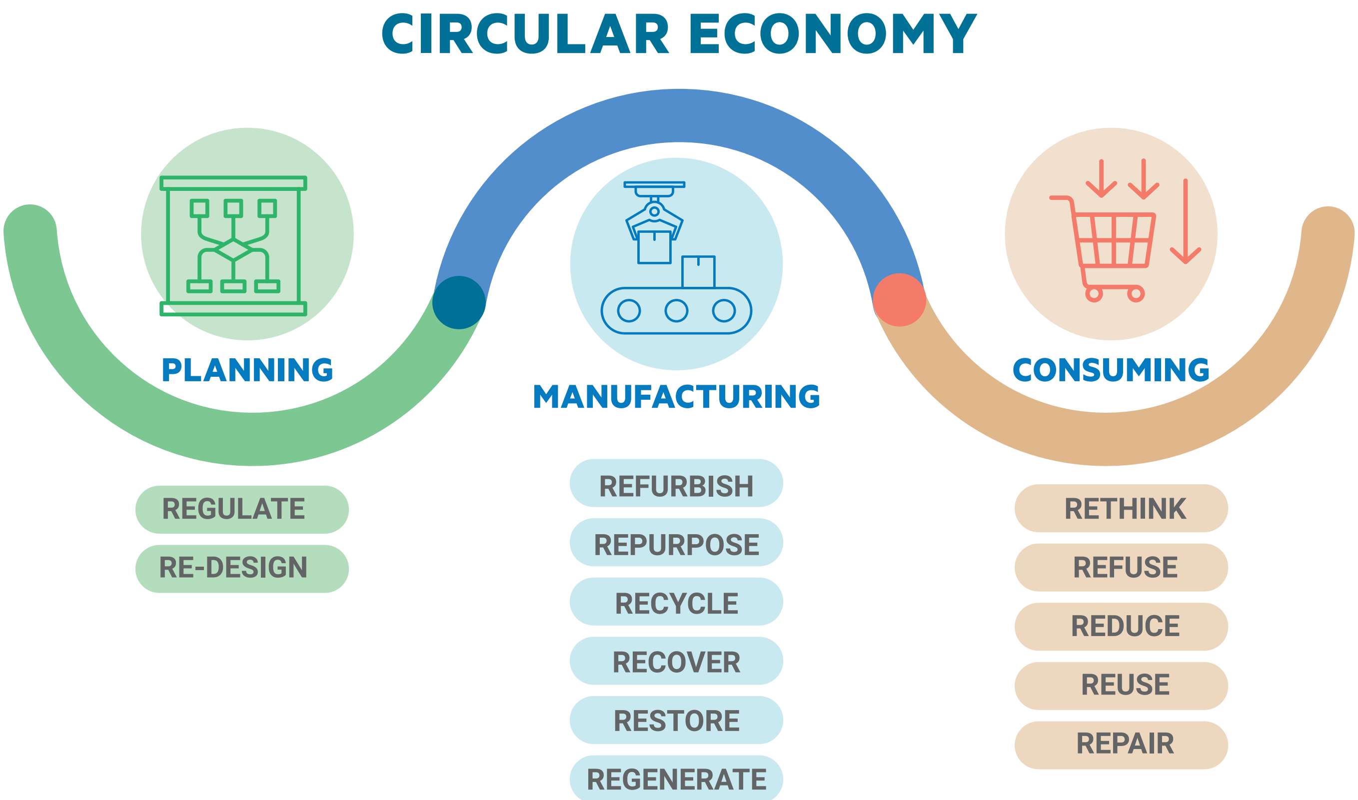
REGENERATIVE AND RESTORATIVE BY NATURE

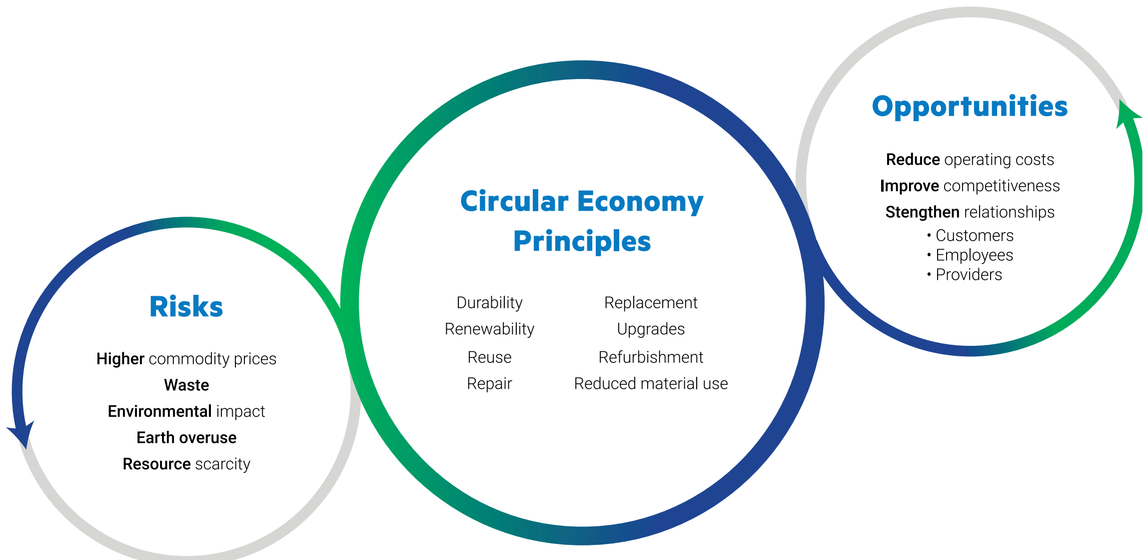
The material and energy which were initially embodied into an end product are valuable and can be restored if their current phase cannot be maintained or reused. The efforts should be to Repair, Refurbish, Remanufacture and if this is not possible, then Recycle. Industrial production procures two distinct types of materials namely, biological and technical. The material's original value is restored by the microbial process if the nutrient is 'biological', and requires human handling and interventions if 'technical'. The biological nutrients in the ecosystem are designed to re-enter the biosphere holding the original value after the embodied utilisation while the technical nutrients tend to remain in the loop of manufacture, reuse, repair, refurbish, recovery, recycle—ideally claiming an infinite life cycle under the circular perspective.

MOVING BEYOND RECYCLE

Conventional connotation of waste management and sustainability to mere 'recycling' could be problematic in the 21st century as it inadvertently shifts the focus from source reduction/management of waste to end treatment. A leakage of mere 10% on a short cycle between production and value recovery may lead to losing half the materials to the environment in a year and almost all in 20 months.[23] This disrupts the circular principles.

[23] *Walter R. Stahel, The Performance Economy (Berlin: Springer, 2010).*





Source: World Business Council for Sustainable Development, CEO Guide to Circular Economy (Geneva: World Business Council for Sustainable Development, 2017).

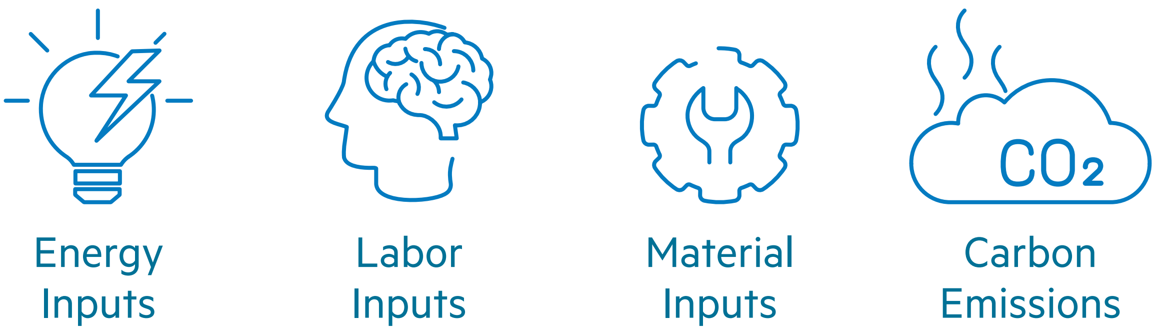
The three enablers of circular economy are Business through supply chains, Public through the waste minimisation and Government to facilitate and regulate the transformation from linear to circular model of economy. The principles, as depicted, follow the extension of the durability, increasing the frequency of use, minimising the waste and pollution, and regeneration and restoration of natural resources with sustainable recovery of value.

CIRCULAR ECONOMY INDICATORS

To ensure a successful transition to a circular economy, the ability to report on and measure the progress is required. Currently, there are three levels of indicators for measuring circular economy: macro, meso and micro.

MICRO AND MESO LEVELS

Micro level indicators support specific decision processes at business or local level and help in implementation of policies and decisions pertaining to energy efficiency and integrated waste management. Meso level indicators involve a more detailed tracking and analysis of information regarding material flows within the economy and distinguishing categories of materials including branches of production and consumption.[24]



Raw Material	• Proportion of primary material used • Proportion of secondary and recycled material used in the new products • Material losses while production • Proportion of environment friendly vs hazardous substances as raw materials • Proportion of easy to recycle material used • Total inputs required as a proportion of GDP (sector wise) • Are products made durable by design itself? • Total generated waste during manufacturing
Fuel	• Proportion of clean energy used in production • Clean energy as a proportion of total energy consumption • Greenhouse Gases (GHGs) emission

[24] Vercalsteren An, Christis Maarten, and Van Hoof Veronique, Indicators for a Circular Economy (CE CENTER Steunpunt Circulaire Economie). Department of Economy Science & Innovation.

Labour and Machinery	• Total usage for recycling • Time and cost for disassembly, recycling, refurbishing (sector wise)
Consumption	• Durability and longevity of selected products—consumer's point of view (sector wise) • Carbon footprint • Total generated waste due to consumption
Waste Management	• Total waste generated as a proportion of GDP (sector wise) • Recycling, refurbishing, disassembly rates (sector wise) • Quality comparison—recycled vs new • Waste collection efficiency rate • Proportion of extracted inputs from landfills • Pollution emitted

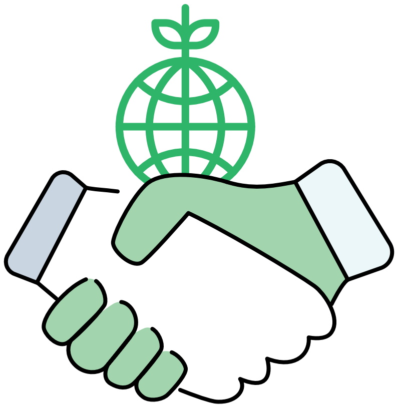
MACRO LEVEL

Macro level indicators provide inputs to formulate decision making in economic, trade, sustainable development strategies, national waste management and related policy matters. Putting a circular economy into practice in China, Feng Zhijun Æ Yan Nailing suggested that as circular economy is harmonised for social, ecological and economic dimensions, its assessment should include the following:

ECONOMIC GROWTH AND DEVELOPMENT | **GREEN DEVELOPMENT** | **HUMAN DEVELOPMENT**

Economic Growth	• Growth parameters like GDP per capita.
Green Development	1. **Reduction indicators** as a ratio of virgin material consumption and waste generation 2. **Reuse indicators** of natural resources, products and energy including sewage treatment 3. **Resource indices** of the utilisation ratios of generated waste.
Human Development	1. **Human habitation environment index** like air quality indicators, congestion, and per capita green space. 2. **Social index** including the social security coverage.

GLOBAL POLICIES: PIONEERS



'Green deal is the real survival deal'

—Dr. Rajendra Pratap Gupta

Rapid incidence of global deterioration of the environment has led many countries to adopt sustainable development strategies to negate the impacts of overpressure on the natural ecosystem. Several countries have introduced legislation and policies for circular economy emphasising the recycling principles. Germany, in 1996, was the first to launch the circular economy enactment law 'Closed Substance Cycle and Waste Management Act' focusing on the sustainable and compatible waste disposal system. Japan, in 2002, also established a basic law for moving ahead into a recycling-based society which consists of a comprehensive legal framework for action. It also enacted a Food Loss Reduction Promotion Bill and the food recycling rate is about 85%. This section attempts to draw a comparison between the next two countries/regions that have implemented comprehensive actions towards the circular economy at scale: China and EU.

'When the United Nations set "Sustainable Development Goals," clearly, we should have got our message, that "bright future" is out of sight, we need to just "sustain" what we have. Now, even that is slipping away.'

—Dr. Rajendra Pratap Gupta

CHINA

Circular economy was enacted under the Circular Economy Promotion Law in 2009 in China. Yet, the efforts were initiated in the early 2000s in the form of knowledge, research or early transformations revolving around the **Industrial parks** that are symbolic to the special economic zones but intended for the circular perspective to minimise and reuse the waste. China's current circular model is based on the following:

- Enhancing the circular processes in the industry,
- Increasing the recycling rates in the industry, and
- Green procurement by the government.

China and the EU signed a memorandum of understanding on Circular Economy Cooperation.

EUROPEAN UNION

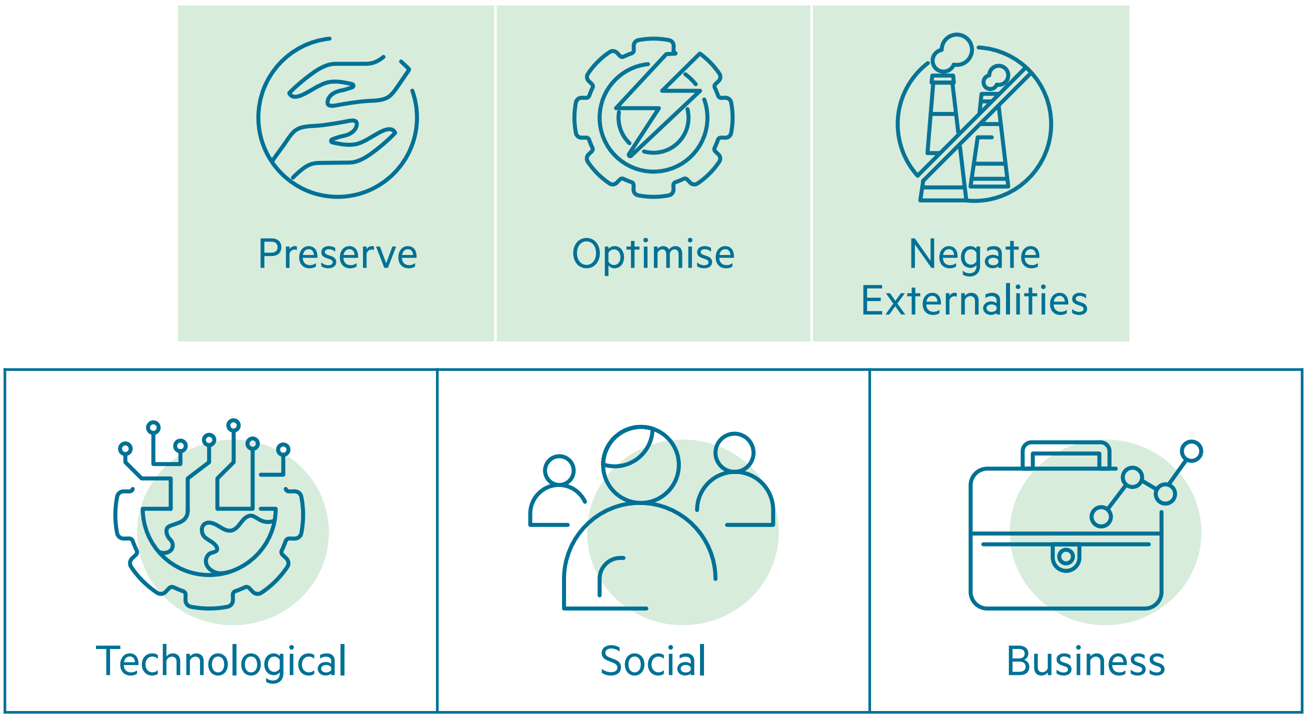
The EU in 2019, under the 'Green Deal', set up a target to be climate neutral by 2050 and proposed a new 'European Climate Law' in March 2020 for the same. European Commission (2012) had launched the European Resource Efficiency Platform (EREP)—Manifesto and Policy Recommendations that call labour, business, civil society and leaders to support the transition towards resource efficiency and regeneration. The efforts are to reduce the degradation and the preservation of scarce and exhaustible natural resources. European Union under the Green Deal has also adopted 'The Climate Pact' (December 2020) aiming to bring together the local authorities, industries, civil society and schools for social innovation and 'Circular Economy Action Plan' (March 2020) to decarbonise energy intensive industries and promote cleaner energy and resource utilisation. Some key features of the policy were as follows:

- Product environmental footprint
- EU monitoring framework for the circular economy
- EU strategy for plastics in a circular economy
- Policy targets and indicators oriented towards resources
- Focus on SMEs to achieve circularity

OTHER GREEN INITIATIVES AND MILESTONES

- Scotland has made a commitment and targeted to reduce food waste by 1/3 by 2025. France has a 'National Pact to Combat Food Waste' called 'Loi Garot'—the first national law against food waste particularly at the retail level.
- Sweden recycles 99% of the household waste from 38% in 1975. Major policy initiatives include creation of small scale and local treatment centres rather than large and **centralised** centres for waste treatment (no apartment or residence is located more than 300 m away from the centres). It has also introduced waste collection tax that is proportional to the waste amount and has proposed tax exemption on the repaired products, among others.

Reforms Needed



INDIAN PERSPECTIVE

India covers a land area of 3.28 million square kilometres—only 2.4% of the total land available and yet contributes 17% to the global population. According to the United Nations, the global population has reached approximately 7.9 billion out of which India alone contributes 1.38 billion. It was projected that India will surpass China as the most populous country by 2050.[25] But the current UN report[26] revised the year to as near as 2027. High fertility rates, lower migration rates and a growing older population are the major reported reasons for the expansion of projected rates. India has the second largest population globally, **with over 464.15 people per km^2** and **ranks third in the global carbon emissions** despite being only a quarter of US and EU's per capita emissions.

On the eve of independence in 1947, India's total population was approx. 34 crore and on average six children to each Indian woman. The population structure was very young and the illiteracy rate was as pervasive as 80%. Consequently, the population grew exponentially giving it early concerns of food security. It is of no doubt that reduced child mortality rates and death rates combined with increased life expectancy led to an increase in the population by three times during the period of 1951–2001. The decadal growth rates were irregular from 13% to 24% but food insecurity wasn't the only problem; the economic growth and population expansion also adversely impacted the ecology and environment.

The population growth has an alarmingly adverse effect on natural resources and biodiversity. Today, India owns 4 out of 34 global biodiversity hotspots with varied endemic species. The rapid economic growth with the current model of linear consumption, if not censored or managed efficiently, will lead to vast depletion of India's rich natural resource base.

- **70%** of India's water resources are contaminated.[27]
- **22** of the 30 **World's most air polluted** cities are in India.[28]

Other than the quantitative depletion, the major qualitative adverse effects are also becoming prominent in the Indian environment.

- According to a report by the National Statistical Office (NSO), there has been an increase in the average number of heatwave days in 2019 by **82.6%** year-on-year to 157 days.[29]
- Furthermore, **2019 reported the highest number of deaths** from acute respiratory disease in the last 6 years.
- A recent study conducted to study the forest fragmentation and land use changes in the Eastern Ghats over a period of 95 years (1920–2015) using historical maps and satellites detected an overall reduction in the **forest cover by 40%**, mining and urbanisation stated as the major contributing factors.[30]
- Between 1953 and 2017 (65 years), India suffered the following losses due to **floods**:[31]

[25] Brian O'Neill & Deborah Balk, World Population Futures, vol. 56, no. 3, Population Bulletin (Washington, DC: Population Reference Bureau, September 2001)

[26] United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019: Highlights (ST/ESA/SER.A/423, 2019).

[27] NITI AAYOG, Composite Water Management Index (New Delhi: NITI AAYOG, 2019).

[28] IQAir. World Air Quality Report: Region & City PM2.5 Ranking [online] (Switzerland: IQAir), https://www.iqair.com/world-most-polluted-cities/world-air-quality-report-2020-en.pdf.

[29] EnviStats 2020.

[30] Reshma M. Ramachandrana, et al., 'Long-term land use and land cover changes (1920–2015) in Eastern Ghats, India: Pattern of dynamics and challenges in plant species conservation,' Ecological Indicators, 85 (2018): 21–36.

[31] Central Water Commission, Flood Forecast Monitoring Directorate (No.3/38/2012-FFM/1067/1164).

8,07,17,993

houses destroyed with worth of

₹ 53,774.362

crore

1,07,535

lives lost

₹ 37,82,47,04,70,000

worth of damages

12,29,17,000

lives affected

- India **loses $9.8 billion every year** due to hazards as per the UN report 2015.[32]
- **79,732** people lost their lives and **108 crore** people were affected due to natural disasters between 2000 and 2019 (20 years).
- As per a report[33] published under IMF, GDP per capita loss to India will be approx. (with moderate level adaptation)
  1. **2.6%**, if the temperature were to be kept below 2 degrees Celsius.
  2. **9.9%**, if the temperature were to follow an unmitigated path, and can go up to 13.4%.

Currently, **India extracts 1,580 tons per acre of resources which is 351% higher than the world average of 450 tonnes per acre that too with a very low recycling rate**. Given India's transition towards the manufacturing sector, virgin materials and natural resource extraction will see a demand hike. Only 31% of India's population resides in urban locations, i.e., 377.1 million (Census of India, 2011). Despite that, India generates an enormous amount of 1,52,076.7 million tonnes (MT) municipal solid waste every day,[34] out of which only 37% is being treated currently. The urban population is projected to grow to 600 million by 2031 and so will the consumption demand and waste generation.[35] Currently, Indian waste generation accounts for 80% of total South Asian waste generation and 13% of the total global waste generation per year.[36] Draft National Resource Efficiency Policy 2019 is a step towards a sustainable future with the new Plastic Waste Amendment Rules, 2021. The new rules prohibit the single use plastic that constitutes 'low utility and high littering potential' by 2022.

To solve this waste generation and 'wastage of waste's value' will require a collaborative approach as supportive government policies create an easy-to-do business for private players along with the MSMEs, and business and social innovations.

WASTE TREATMENT STATUS

Municipal waste, industrial waste, bio-medical waste and electronic waste—all are governed by different laws and policies. In India, waste management practice depends upon actual waste generation, primary storage and collection, secondary collection and transportation, recycling activity, treatment and disposal.[37] Municipal authorities play an important role in collecting the general waste when **approximately 1.5 L TPD municipal solid waste is generated in India. The urban population (31.2% of the total population) contributes 65% of the GDP which is estimated to rise to 70% by 2030** and it will transition the Indian landscape economically, politically and socially.

The financial, environmental and social gain from waste management is untapped. For example,

- One tonne of recycled paper can save 17 trees (can absorb 250 pounds of CO_2 each year), 380 gallons of oil, 3 m^3 of landfill space, 4,000 KWh energy and 7,000 gallons of water, and hence, **64% energy savings and 58% water savings** as compared to virgin production.
- One tonne of steel scrap recycling saves 1.2 tonnes of iron ore, 0.5 tonnes of limestone, 0.7 tonnes of coal, 287 litres of fuel oil, 2.3 m^3 landfill space, i.e., 40% water savings and **58%** less CO_2 emissions as compared to virgin production.
- Creation of jobs in the labour-intensive value chain. The US scrapping industry generated 1.5 L direct and 3.23 L indirect jobs in 2015 as per the Institute of Scrap Recycling Industries (ISRI), USA.

The comprehensive solid waste management rules were passed in 2000, revised 16 years later in 2016. The National Environment Policy Act 1986 has revised or passed rules 17 times each handling different types of waste such as e-waste Rules 2011, Plastic Waste Rules 2011 and Batteries Rules 2011.

[32] *United Nations Office for Disaster Risk Reduction's (UNISDR), Global Assessment Report on Disaster Risk Reduction (GAR) (Geneva: United Nations Office for Disaster Risk Reduction (UNISDR), 2015).*

[33] *Matthew E. Kahn, et al., Long-Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis (IMF, 2019), 32.*

[34] *Central Pollution Control Board, Annual Report 2018-19 on Implementation of Solid Waste Management Rules (New Delhi: Central Pollution Control Board, 2019).*

[35] *Ministry of housing and Urban Affairs, Annual Report 2020–21 (New Delhi: Ministry of housing and Urban Affairs, 2021).*

[36] *World Bank Group, What a Waste 2.0 (Washington, DC: World Bank, 2018).*

[37] *Waste management initiatives in India for human well-being,' European Scientific Journal, 2015. 11, no. 10 (2015), https://eujournal.org/index.php/esj/article/view/5715*

The Solid Waste Management Rules, 2016, have the following key features:

- Mandate for all waste generators for waste segregation at source; bulk generators (any institution having more than 5,000 square feet area) to manage their own waste, although without penalty for non-compliance.
- Promotion and encouragement of an extended producer's responsibility to collect and reuse the product waste; setting up waste-to-energy plants; fertilizer producers to incorporate composting along with chemicals.
- Urban local bodies to levy charges for waste collection from the generators.

However, the current waste management value chain promotes waste creation to be *'easily solvable via dumping and burning'* instead of composting, reusing and recycling. The value chain involves a contractor responsible for door-to-door collection of waste, segregation of recyclable materials with market value and transporting the rest to landfills. The trucks usually have to wait two to three hours in queue for weighing and dumping, this creates two adverse incentives[38]:

- Without incentives—contractors will try to dump the collected waste on unscientific and illegal sites to save on transportation costs.
- Revenue proportional to the tonnes of waste dumped—this will encourage excess waste dumping than the landfill's capacity and hence open burning to create space.

The waste generators in India usually segregate the newspapers and cardboard blocks as they have a financial recyclable value that the middlemen create for them.

To incentivise the waste generators, collectors and managers should minimise generation and burning while maximising collection and treatments; following behavioural incentives could be incorporated to implement this:

- **Standard user fee** for waste generators (could be proportional to the waste generated to promote intelligent wastage) levied by the state would ensure efficient waste collection, dumping and accountability for regular service.
- Incorporation of **monetary penalties** for generators to segregate waste and collectors to collect only segregated waste and avoid illegal dumping by both.
- **Enforcing accountability** for the local bodies and other stakeholders along with the contractors for illegal dumping.
- For contractors—**landfills tax** for usage of landfills, incentives only for segregated tax at treatment centres based on targets.
- **Decentralised 'zonal' waste management** as this will enhance waste dumping due to reduction in the transportation cost and hence prevent illegal dumping. The waiting time of the trucks will also reduce significantly.
- **Standardising the waste treatment industry** to national norms as certified by the Central Pollution Control Board.
- **Institutionalisation of the recycling industry** to enhance standardised management, promotion and training of waste treatment. The unorganised ragpickers should be targeted for social transformation with the government's assistance to become the recyclers and be trained for safety and environmental norms.

The contaminated dump sites where waste is dumped unscientifically, violating the Solid Waste Management Rules, 2016, lead to the degradation of natural resources such as soil, water and air and pose environment and health threats to the people living in the 'impact zone' who tend to consume the toxic substances.

Waste management division of the Central Pollution Control Board conducts investigations of the contaminated sites followed by the remediation activities. A total of 112 such contaminated sites were

[38] *Mathangi Swaminathan, 'How can India's waste problem see a systemic change?', Economic Political Weekly, 53, no. 16 (2018).*

confirmed out of which remediation works have been initiated at 8 sites, namely Gujarat (2), Jharkhand (1), Maharashtra (1), Tamil Nadu (2) and Uttar Pradesh (2).[39] Though these efforts are to minimise the impact of waste on the environment and human health, a large potential lies ahead for social and business innovation for mitigation (aligning with the demographic projections for India in the next few decades). The solid waste generated includes different end-of-life products having combustible characteristics, such as non-recyclable packaging, soiled textiles and papers. This combustible fraction constitutes around 17%–20% of the total municipal solid waste generated.[40] This material can be further processed to make fuel called refuse derived fuel (RDF) and can be used for co-processing waste to energy plants.

LEGISLATION

1. The Solid Waste Management Rules, 2016, laid down mandates on using RDF in energy generation as follows:
   - All industrial units that use fuel and are located within 100 km from a solid waste-based RDF plant make arrangements within six months from the date of notification of these rules to replace at least 5% of their fuel requirement by RDF so produced.
   - Non-recyclable waste having a calorific value of 1,500 kcal/kg or more shall not be disposed of in landfills and shall only be utilised for generating energy either through RDF or by giving away as feedstock for preparing RDF. High calorific waste shall be used for co-processing in cement or thermal power plants.

   The current reported *thermal substitution rate* (TSR)[41] in the Indian cement industry is about 4% up from 1% a few years ago, and only 9% of the total authorised capacity is being utilised under cement processing. The cement industry aims at achieving 25% TSR by 2025 and 30% TSR by 2030. A TERI study provides tangible advantages of using RDF—15.5 MT of carbon reduction and 0.52 MT of fossil fuel like coal or petcock per annum can be replaced.
2. Hazardous Waste Management Rules are notified to ensure safe handling, generation, processing, treatment, packaging, storage, transportation, use, reprocessing, collection, conversion, and offering for sale, destruction and disposal of hazardous waste.[42] The rule 9 of the utilisation of hazardous waste calls for no trail runs for co-processing the waste in cement plants, which is currently 9% of the total capacity.

> ***'The gap between the waste collected and treated is glaring and utterly irresponsible.'***
>
> —Prithvi Dutt

[39] *Central Pollution Control Board, Status of Contaminated Sites in India (New Delhi: Central Pollution Control Board, 2020).*

[40] *Guidelines on Usage of RDF in various Industries (New Delhi: Ministry of Housing and Urban Affairs, 2018).*

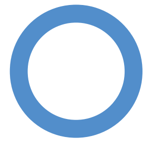
[41] *'The thermal substitution rate (TSR) refers to the percentage of sustainable alternative fuels used replacing fossil fuels.'*

[42] *Central Pollution Control Board.*

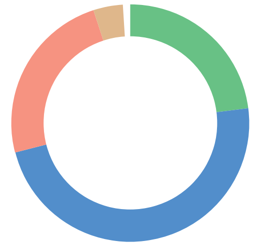
HAZARDOUS WASTE (2019-20)

152076.7 TPD
Solid Waste

COLLECTED - **98.4%**
TREATED - **36.6%**

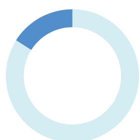


8782691 MT



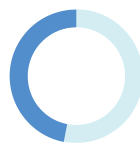
Recyclable 23%
Utilizable 48%
Landfillable 24%
Incinerable 4%

Utilization of hazardous waste (as percentage of their respective authorized capacities)

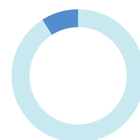


16.2%
Recycle

24.7%
Utilization under **Rule 9** of the Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016



47.5%
Captive Utilization



9%
Co-processing in Cement plants

		HAZARDOUS WASTE [43]		SOLID WASTE [44]		
	STATES	AUTHORISED UNITS	QUANTITY GENERATED (MT)	TOTAL GENERATED (TPD)[45]	COLLECTED (TPD)	TREATED
1	Andaman and Nicobar	2		120	117	54.25%
2	Andhra Pradesh	2,648	6,20,952	6,440	6,140	8%
3	Arunachal Pradesh			270.96	215	0%
4	Assam	183	52,394	1,293.663	1,119.37	
5	Bihar	166	7,630	2,272		
6	Chandigarh	1,363	2,125	470	458.32	31.9%
7	Chhattisgarh	413	1,72,438	1,650	1,396	77%
8	DD & DNH	410	4,631	98	94.5	5%
9	Delhi	1,912	2,683	10,817	10,614	52.8%

[43] *Source: Central Pollution Control Board, National Inventory on Hazardous Waste Generation 2019-20 (New Delhi: Central Pollution Control Board, 2021).*

[44] *Source: Central Pollution Control Board, Annual Report 2018-19 on Implementation of Solid Waste Management Rules.*

[45] *Tonnes per day.*

10	Goa	1,628	28,569	236.41	235.9	65.44%
11	Gujarat	19,662	24,85,317	22,238	11,119	5%
12	Haryana	4,845	2,00,606	4,635.79	4,430.25	17.6%
13	Himachal Pradesh	2,346	27,725	389	340	38.5%
14	J&K	238	1,213	1,530.53	1,452.86	
15	Jharkhand	566	4,09,761	2,205	2,043.4	37.9%
16	Karnataka			11,958	10,011	37.7%
17	Kerala	1,616	3,11,042		742.23	11%
18	Lakshadweep			35	18	51%
19	Madhya Pradesh	2,863	2,32,199	8,000	7,500	76.25%
20	Maharashtra	7,257	9,99,566	23,844.551	23,675.7	52.9%
21	Manipur	374	0	218.6	126.63	36.5%
22	Meghalaya	19	276	170.63	170.63	5.1%
23	Mizoram	40	20	251.42	213.06	11.6%
24	Nagaland	38	29	339.42	216.9	39.7%
25	Odisha	360	6,79,860	2,564.43	2,255.32	3%
26	Puducherry	131	34,907	599.25	505	4%
27	Punjab	3,263	1,22,167	4,634.48	4,574.93	19.7%
28	Rajasthan	2,094	5,87,554	6,625.56	6,475.39	11.7%
29	Sikkim	49	1,722	75.1	67.1	17.1%
30	Tamil Nadu	3,961	9,64,811	13,968	12,850	51.51%
31	Telangana	3,024	3,17,091	8,497	8,360	67.6%
32	Tripura			445.72	389.46	33.6%
33	Uttar Pradesh	2,597	3,62,114	17,377.3	17,329.4	26.5%
34	Uttarakhand	4,340	21,818	1,527.458	1,437.4	34.3%
35	West Bengal	809	1,31,412	14,613.3	13,064.63	6%
	TOTAL		**87,82,691**	**1,52,076.7**	**1,49,748.6**	

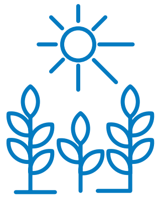
Arunachal Pradesh, Andhra Pradesh, Dadra and Nagar Haveli and Daman and Diu, Gujarat, Meghalaya, Odisha, Puducherry, West Bengal do not process even 10% of their municipal solid waste. There are about 8,400 municipal wards across states, with an efficacy rate of 98.4% of the collection of general waste. Transitioning towards a circular economy requires both the waste collection and management. **The very low treatment rate is due to lack of segregation at source and data of waste stream composition.**

Annual benefits of adopting a circular economy development path in India by 2050 as compared to the current development path[46]:

₹ 40 lakh crores
(30% of Current GDP)

44%
Redution in **GHG** emission

₹ 3.9 lakh crores

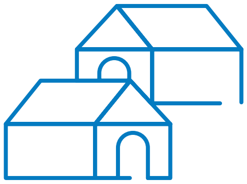


Agriculture

₹ 31 lakh crores

Mobility and Vehicle

₹ 4.9 lakh crores



Infrustructure and Building Stock

38%
Virgin Material consumption reduction

24% lower
Water Usage in construction sector

71% lower
Fertilizers & pesticides consumption

44% lower
GHG Emission

AGRICULTURE SECTOR

More than 42% of India's total employed population works in agriculture and allied activities that collectively contribute to only 16% of the GDP (2019). There is a huge disparity between the share of employment and the contribution to GDP. Climate change and under-stressed primary resources are challenging farmers' ability to cope with the wanted adaptations. Contemporary Indian agriculture presents numerous visible contradictions and conundrums. India's traditional crops face the food security–sustainability trade off. The areas and crops that were majorly targeted during the Green revolution have taken a turn towards excessive use of fertilisers. This, as a result, boosted India's crop yields, and transformed India into a net exporter of various crops from a net importer—over the past five decades, rice yield grew by 145% and wheat by 270%. And yet 194 million are left hungry daily. The cost of cultivation and the food waste and food loss rates are rising. Circular economy in agriculture would focus on resource regeneration and restoration, food wastage and reuse of the by-products.

FOOD WASTAGE IN INDIA

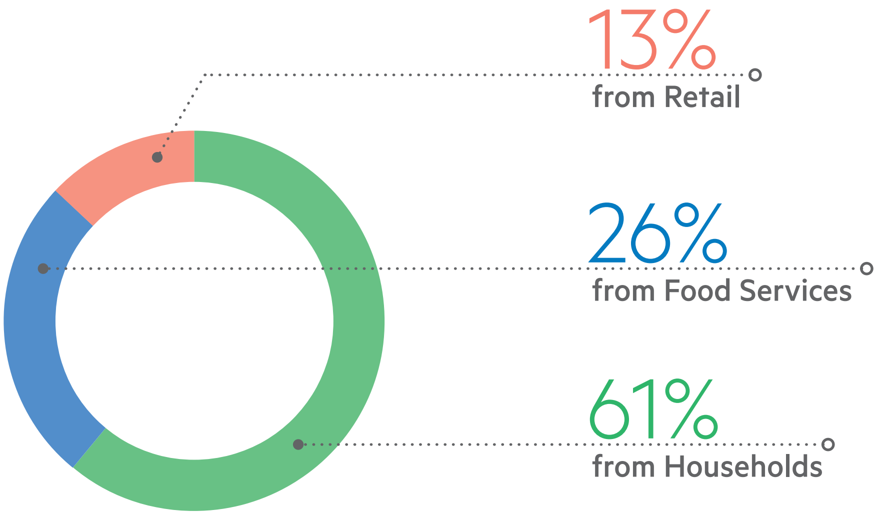
Food wastage is defined as the deterioration in the quality of food or the loss of quantity at the end of retailers, food service providers and consumers.[47] 40% of food produced in India is wasted (68,760,163 tonnes a year from households or 50 kg per capita per year).[48]

[46] *Ellen Macarthur Foundation, Circular Economy in India: Rethinking Growth for Long Term Prosperity (Cowes: Ellen Macarthur Foundation, 2016).*

[47] *Food and Agriculture Organization (FAO), Global Food Losses and Food Waste—Extent, Causes and Prevention (Stuttgart: FAO, 2011).*

[48] *United Nations Environment Programme, Food Waste Index Report (Kenya: United Nations Environment Programme, 2021).*

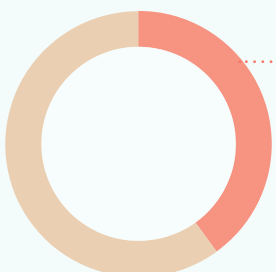
Who wastes food in India?



Source: United Nations Environment Programme, Food Waste Index Report (Kenya: United Nations Environment Programme, 2021).

As a country that ranks 101st out of 107 countries on the Global Hunger Index (2021), India is one of the worst performers, and this level of food wastage is severely problematic and mostly attributed to the inefficiencies and irresponsible outlook towards resource management.

67
million tonnes
food is wasted every year in India.



40% of total food produced in India is wasted

For context, it is estimated that this is equivalent to feeding all of Bihar for a year.

50kg
amount of food is wasted by each person in India, every year

Annual Cost of food security
with subsidised ration under the National Food Security programme.
₹ 1.5 lakh crores (approx.)

Annual loss due to food wastage
₹ 92,000 crores
Nearly two-thirds of what it costs the government to feed 600 million poor Indians.

25%
of fresh water used in production wasted

300 million barrels
of oil wasted

Food waste has substantial environmental, economic and social impacts. Given 1/3rd of the world's overall malnourished children reside in India,[49] the opportunity cost of wasting food rises even more, accounting for the GHGs emission, use of natural stock of resources and despite that millions sleeping hungry daily. Wasted food also implies wasted precious natural resources utilised in the entire food value chain. Sustainable Development Goal (SDG) target 12.3 aims at cutting the per-capita global food waste at the retail and consumer levels by half and reducing food losses along the production and supply chain.

FOOD LOSS IN INDIA

Food loss refers to the decrease in the quality or quantity of food resulting at the end of food suppliers in the chain, excluding retailers, food service providers and consumers.[50] Food contributes approximately 26% of the global GHG emissions, of which 8%–10% accounts for unconsumed food or losses that occurred before reaching the plate.

A report[51] released a scientific methodology to estimate post-harvest food losses in India. It calculated the following food loss statistics: paddy 5.2%, wheat 6%, maize 4.1%, cereals 4.65%–5.99%, pulses 6.36%–4.81% and oilseeds 3.08%–9.96%. Food loss due to storage for paddy, wheat and maize counted as 1.3%.

FACTORS AFFECTING POST HARVEST LOSS AT CRITICAL STAGES OF FOOD SUPPLY CHAIN

	FACTORS AFFECTING POSTHARVEST LOSSES (PHL)								
	(X_J)								
Critical Stages of Food Supply Chain (Si)	Moisture	Weather	Pests/Disease	Infrastructure	Size of Operation	Level of Mechanization	Quality of Management	Operator Characteristics	Access to Capital
Harvesting	x	x	x		x	x	x	x	x
Food storage	x	x	x	x	x	x	x	x	x
Processing	x	x	x	x	x	x	x	x	x
Packaging				x	x	x	x	x	x
Sales				x	x		x	x	x

Source: Jaspreet Aulakh and Anita Regmi, 'Post-harvest food losses estimation—development of consistent methodology,' in Selected Poster Prepared for Presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington DC, 2013.

[49] *Development Initiatives, Global Nutrition Report: Shining a Light to Spur Action on Nutrition (Bristol: Development Initiatives, 2018).*

[50] *FAO.org, 2021..*

[51] *S. N. Jha, et al. Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India (Ludhiana: CIPHET, 2016).*

Post-Harvest Losses

Proportion of food produce that the farmers are unable to sell in the market are 34%, 44.6%, and about 40% for fruits, vegetables, and fruits and vegetables combined in India as identified by a committee[52] on doubling farmers' income. With 86% small and marginal farmers, the post-harvest loss heavily impacts farmers given the already invested resources.

Food Loss at the Government Procurement System

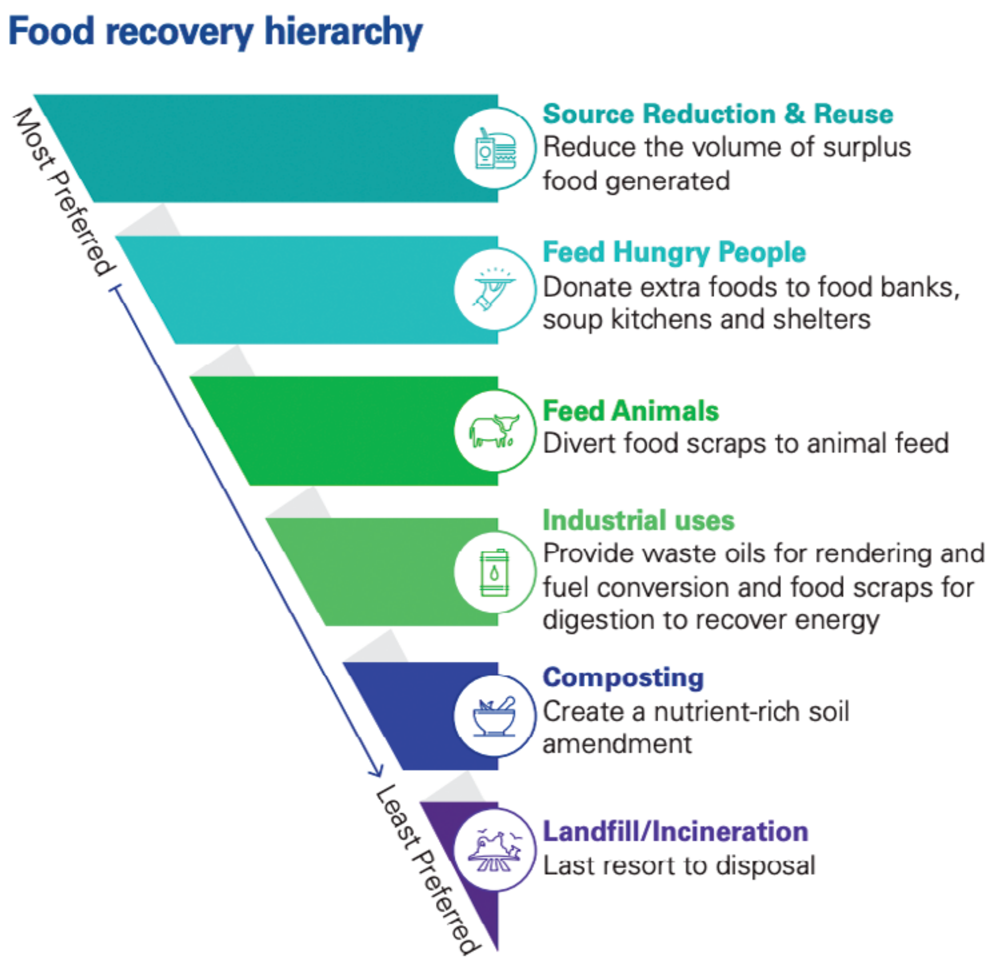
The Food Corporation of India (FCI) usually procures excess of its requirement and storage capacity. A report[53] by the Wire on 1 July 2020 highlighted that out of the 143.56 lakh tonnes of wheat stored in Covered and Plinth storage, 86.24 lakh tonnes of wheat was in Punjab alone. A total of 8.57 **lakh tonnes** of wheat had to be kept in **kutcha plinths**. The prolonged storage in FCI warehouses leads to damage and deterioration of some proportion of the grains which become non-issuable in the Public Distribution System. As per the FCI data, the storage losses have been brought down from 0.22% in 2012–2013 to 0.002% in 2019–2020. The transit loss (grain movement via rail, road, river) was 0.47% in 2012–2013 and 0.33% in 2019–2020. However, as per the RTI reply by the Ministry of Consumer Affairs, Food and Distribution, India has witnessed a 61,824 tonnes of food grain wastage between 2011–2012 and 2016–2017.[54] Efforts are being made to modernise the silos as they require only 1/3rd of land requirement by warehouse; as per the Farmers' Produce Trade and Commerce (Promotion and Facilitation) Act, 2020 (now repealed), storage of grains at silos will not attract any charges like market fee, effectively making it cheaper to store at silos. Expansion of silo capacity to 20 lakh tonnes was planned in 2012 but the goal was increased to 100 lakh tonnes capacity in 2015–2016 (as per the Shanta Kumar Committee). The expansion was planned in a phased manner, to be completed by 2019–2020. However, only 8.25 lakh tonnes of capacity has been built as of January 2021, land acquisition being the major impediment. Popularisation of drying-cum-storage facilities has also been recognised by FCI, acknowledging drying the moisture content as the top-most priority to mitigate food grain storage losses.

[52] *Kiran Pandey, 'Poor post-harvest storage, transportation facilities to cost farmers dearly', 2018.*

[53] *Siraj Hussain, 'Questions we should be asking about food wastage in the govt's procurement process', The Wire, 2021.*

[54] *News article by DNA India: https://www.dnaindia.com/india/report-62000-tonne-foodgrain-wasted-by-fci-2446621*

FOOD RECOVERY HIERARCHY



Source: KPMG, Fighting food waste Using the Circular Economy (Australia: KPMG, 2020).

The model mainly points out that the first priority should be extending the frequency of usage of a resource or reduction of waste at source. The least preferred is to send the waste to the landfills as any productive gain will be lost in addition to GHG emissions. This hierarchy is to attain the maximum value from the generated waste, following the fundamental principle of the circular economy.

Our ability to store, transport and trade are the backbone of this model for which logistics development should be enhanced. Promotion and encouragement of ecologically sustainable models includes the following circular loops:

- Nutrient and resource restoration
- Reuse and recycle as agricultural inputs
- Processing into by-products

All these loops are enhanced by social, market and regulatory innovations such as those listed below:

Asset/machinery sharing systems; agro-climatic and less resource-intensive cropping pushed by agricultural research; reuse and recycling of resources such as water and cow dung; sustainable packaging; efficient transportation and storage with minimal loss; reduced wastage at the consumer end with market innovations like technology-enabled efficient recovery, collection and segregation of waste.

AGRICULTURE AND THE NATURAL RESOURCES

Over the years, Indian agricultural policies were majorly focused on self-sufficiency in food. These policies were amplified by the damages caused due to the consecutive droughts in the early 1970s that created heavy food shortages and, thus, skyrocketing food prices. Thereby, the policy makers had the vision of India becoming a food secure nation. The idea was not to achieve sufficient food production by area expansion but by yield improvement. The productivity of crops was improved by the usage of fertilisers, pesticides and groundwater resources. The revolution increased the yield of wheat, rice, pulses, etc., but also destroyed the conventional diversified gene pool of the Indian cropping system. And as pointed out by the Report on Currency and Finance 2001–2002, government input-output price structure has been the reason for the distortion.

Given the government's emphasis on the production of subsidised high yielding hybrid crops, **India has lost more than 1,00,000 (approx.) varieties of indigenous rice** that took several centuries to evolve.[55] The Green Revolution began in the 1960s, which was initially limited to the Northern Indian states such as Punjab, Haryana and Western Uttar Pradesh and slowly reached the entire nation by the early 1980s.

The food security puzzle:[56]

Per capita production has been increasing since the Green Revolution and simultaneously the gap between productivity and availability, year after year. Availability refers to the productivity net change of stock and trade. The dichotomy here is of India becoming World's one of the largest exporters of food grains and yet the per capita availability of grains is still at the levels of the 1960s. The productivity has been rising since then but India still has 1/3rd of the world's malnourished children. The food puzzle is thus the coexistence of widespread undernourishment and rising food prices. This needs to be considered in the context of agro-climatic practices.

On the one hand, the overproduction of food and on the other the climate peculiarity and income inequality by themselves do not sufficiently explain the puzzle.

The World Bank Group explained this by connecting the inefficient agricultural practices to increased fertiliser dependency. Where, Minimum Support Price (MSP) and other input subsidies act as incentives for the inefficient agricultural practices, hence setting a vicious cycle in motion of MSP as the inefficiency in managing and utilising the chemicals and lack of crop rotation make the land infertile and lead to severe groundwater crisis in the long run. This demands higher compensation (via increased/adjusted MSP) for increased cost of cultivation to overcome the shortcomings following the non-agro climatic agricultural practices. The government procures in excess of its demand to clear the excess supply of highly subsidised crops and leads to food inflation and, hence, lesser consumption of conventionally cheaper sources of proteins.

Second, the imbalanced use of pesticides and fertilisers creates a widespread deficiency of secondary and micro nutrients such as sulphur (41%), iron (12%), zinc (48%) and manganese (5%) in the soil.[57] This is triggering data because the deficiency of zinc in food, in particular, results in the stunted growth and impaired development of infants, which could lead to malnutrition

[55] *Ann Raeboline Lincy Eliazer Nelson, Kavitha Ravichandran and Usha Antony, 'The impact of the Green Revolution on indigenous crops of India,' Journal of Ethnic Food 6, no. 8 (2019).*

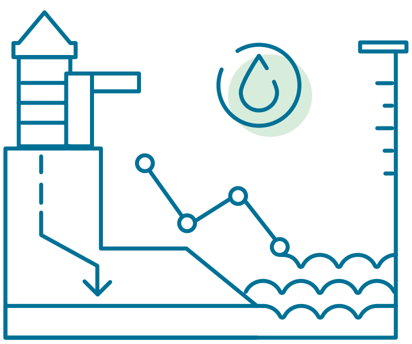
[56] *World Bank Group, Republic of India, Accelerating Agriculture Productivity Growth (Washington, DC: World Bank Group, 2014).*

[57] *FAO, National dialogue: Indian Agriculture towards 2030: Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food Systems (Rome: FAO, 2021).*

and deteriorative health of the posterity, impacting future productivity.

Third, excess nutrients released into aquatic systems flowing from the agricultural land from the use of N-fertilisers and burning of fossil fuels causes **eutrophication**,[58] a high growth environment for algal blooms and fish kills, and also polluting the air and soil with substantial consequences for biodiversity. Excess use of fertilisers in agriculture also contributes to GHG emissions. **India's fertiliser consumption per hectare of arable land was 175 kg, much higher than the global average of 136 kg.** It was observed that India lacks scientific analysis of soil fertility mainly required due to excessive use of fertilisers. Hence, the Soil Health Card Scheme was launched in 2015 to provide the farmers with relevant information regarding their soil. This project should be expanded. The soil health card is a good starting point but the government must invest more in research and development for agriculture.

WATER LEVEL



GROUNDWATER

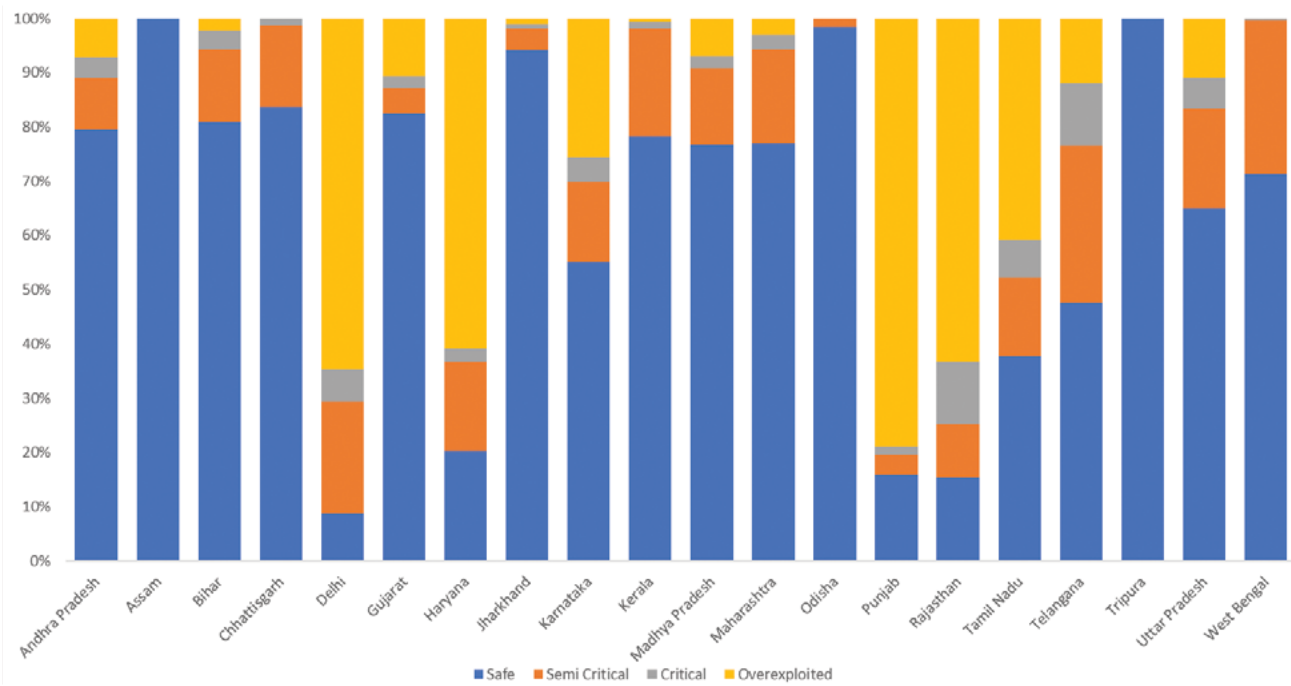
Given the binding land constraint, the agricultural and income growth depends upon the increase in the crops and livestock productivity. To enhance the crop or land productivity, using more inputs per hectare, technological advancements and an effective use of inputs can help. The groundwater level in India showed a decline by 61% between 2007 and 2017 and **89% of the extracted groundwater was used for irrigation.**[59]

However, agro-climatic farming appears to be less applied in contemporary Indian agriculture. For example, certain crops such as sugarcane and rice are suitable for relatively abundant water and a high moisture area. However, these crops have become more prominent in States like Maharashtra and Punjab which face high levels of water scarcity. Uncensored and highly subsidised electricity rates along with other government subsidies induce the crops to be dominant in areas that are not their natural habitat. This, as a result, increases the dependency on fertilisers and, hence, water overexploitation and soil degradation.

[58] 'The gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients in an aging aquatic ecosystem such as a lake.'

[59] Government of India, Ministry of Water Resources, River Development and Ganga Rejuvenation Minor Irrigation (Statistics) Wing, Fifth Minor Irrigation Census (New Delhi: Central Ground Water Board, 2017).

Groundwater level in India (2017)

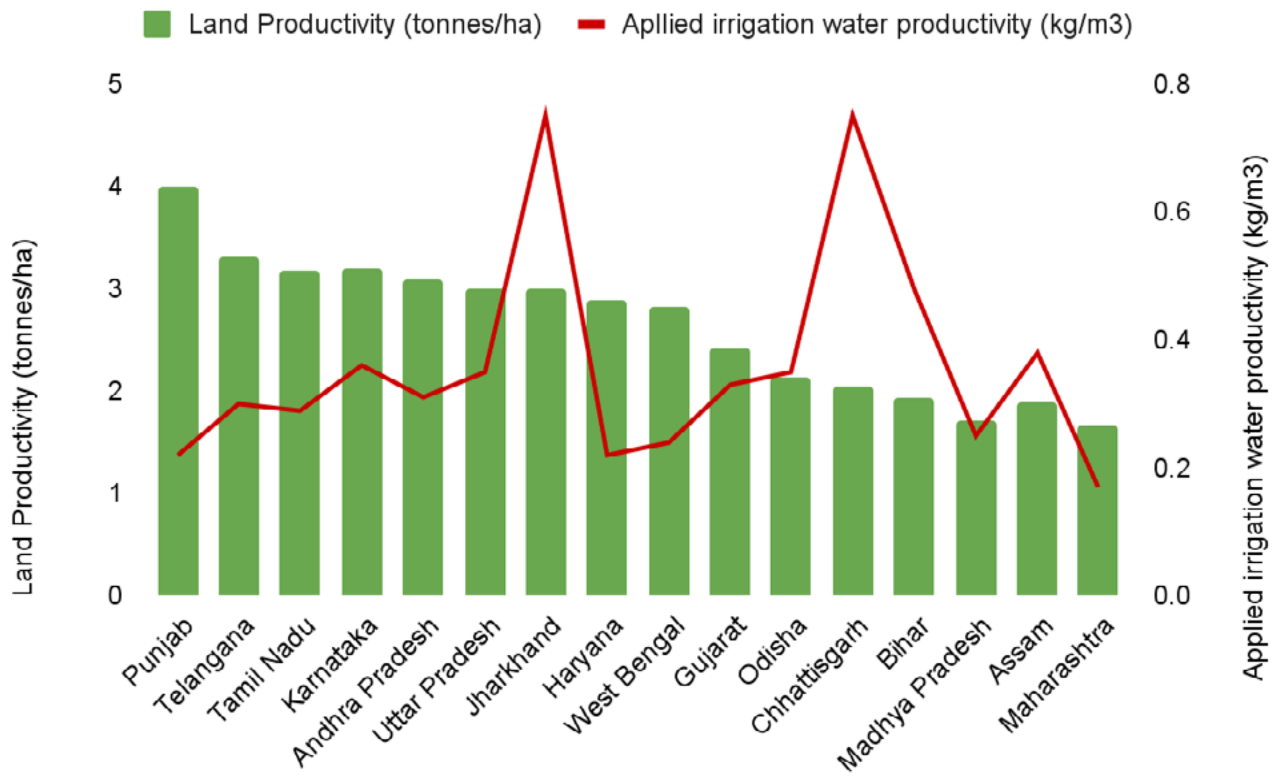


Source: Central Ground Water Board, Dynamic Ground Water Resource of India (Central Ground Water Board (Rice), 2017).

LAND PRODUCTIVITY VS THE EFFICIENT WATER UTILISATION

A report 'Water productivity mapping of major Indian cities' by NABARD and ICRIER analysed the irrigation efficiency using different metrics—irrigation water productivity (IWP), which is the crop output per unit of irrigation water used by the farmer; physical water productivity (PWP), which is the crop output per unit of water consumed; and economic water productivity (EWP), which is the value of the crop output per unit of water consumed by the crop, including from both rainfall and irrigation. All these metrics for 10 crops were then compared with their respective land productivity to determine if the current cropping patterns were hydrologically sustainable and agro-climatic.

For rice, it was found that states such as Punjab and Haryana had higher land productivity but the irrigation water productivity reported as low as 0.22 kg/m^3 despite having 100% irrigation. On the other hand, states such as Chhattisgarh and Jharkhand showed 0.68 kg/m^3 and 0.75 kg/m^3 of IWP despite lower irrigation coverage and lower land productivity.



Source: Bharat R. Sharma, et al., Water Productivity Mapping of Major Indian Cities (NABARD and ICRIER, 2018).

Sugarcane too reported a negative relationship between IWP and land productivity. Tropical belts of Uttarakhand, Uttar Pradesh (both with IWP of 10.22 kg/m^3) and Bihar (IWP 12.4 kg/m^3) report higher levels of IWP but lower levels of land productivity. At the same time, the subtropical belts of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu have high land productivity but lower levels of IWP values ranging between 3.55 and 4.48 kg/m^3.[60] Historically, sugarcane was majorly produced in Bihar and Eastern Uttar Pradesh (highest IWP) but the industry slowly shifted to Maharashtra, Karnataka and Tamil Nadu which are not naturally endowed with the suitable water requirements of Sugarcane.

Thus, this highlights a mismatch between rice and sugarcane cropping pattern and the IWP, majorly influenced by the fertilisers-induced increased land productivity across states. The correction is needed with adjusted incentives for the farmers based on hydrological sustainability.

[60] *Water Productivity Mapping of Major Indian Cities (NABARD and ICRIER).*

SUBSIDY AND SUBSISTENCE

IMPLICATIONS

The political economy of subsidies in India will have long-run negative effects of jeopardising the productivity and ecological sustainability:

- Uncensored electricity subsidies increased the yield per hectare of less diversified crops but also enabled over exploitation of the groundwater. A 10% reduction in the average electricity subsidy would reduce groundwater extraction by 6.7%.[61]
- MSPs have served as an inducing factor and a fall-back option for farmers to produce water-intensive, less diversified crops irrespective of the suitability to their respective climate conditions. This is amplified by excess use of fertilisers that sets a vicious cycle in motion and adversely affects the groundwater, and soil and crop productivity with a constant need of upgradation in the support prices, and, hence, increases the dependency over MSPs and the fertilisers in the longer run.

Contrary to the intended objectives of the policies, the distorted incentives acted against agro-climatic and efficient farming. For example, MSPs led to water-intensive crops in the Northern Western states which are now facing a severe groundwater crisis.

Farmers partly respond to the incentives created by MSP or subsidies or micro-irrigation facilities to fight the water crisis. Regulation of electricity subsidy will be a radical step and will require great leadership. Cases of electricity cuts have increased the uncertainty to farmers. Following steps need to be taken in the longer run:

- Regulation of electricity supply hours.
- Assurance and development on the reliability of the perfect supply of water during a given time.
- Focus on agro-climatic incentives to the farmers along with education about the threats of the current 'linear model' of farming to the future crops.

The Government of India and states have been deciding the date for paddy sowing since 2008, so that it matches the monsoon season and, hence, exerts less pressure on the groundwater. The government passed the Punjab Preservation of Sub Soil Water Act 2009 to enforce a given date restricting farmers' liberty to sow on any date after the wheat harvest, as earlier.

However, the shifting of the sowing date led to decreased margin between the soil preparation for the Rabi crops and harvesting Kharif crops. This acted as a driver for stubble burning, a by-product of paddy harvest. This has been discussed in the next section.

AIR AND SOIL

Burning of wheat and rice straw and other agricultural residue after harvest has contributed significantly to the loss of soil fertility along with air pollution.

- According to a 2014 study by the Indian Agricultural Research Institute (IARI), in 2008–2009 the **country generated 620 MT of crop residue**, of which close to 16% was burnt on farms. **60% was paddy straw** while wheat accounted for just 22%.
- It is estimated that **Punjab alone produces 19–20 MT of paddy straw** and about 20 MT of wheat straw. **About 85%–90% of this paddy straw is burnt in the field**.
- To address the mounting air pollution and subsidised technology to manage crop residue, the Department of Agriculture and Farmers Welfare implemented a special Central Sector scheme in the states of Haryana, Punjab, Uttar Pradesh and NCT Delhi for the period of 2018–2019 to 2020–2021. The Ministry of Environment, Forest and Climate Change reported **a 44.5% increase in the stubble burning cases in Punjab** in 2020–2021 despite the state being allotted 46% funds of the scheme.

The major direct and Indirect impacts of this include-

- According to a study by SpringerBriefs in Environmental Science, 2014, one year of crop

[61] *World Bank Group, Republic of India, Accelerating Agriculture Productivity Growth.*

residue in Punjab contains about 6 MT of carbon that on burning could produce about 22 MT of CO_2 in a mere 15–20 days.[62]

- A study by the Institute for Social and Economic Change, Bengaluru, has estimated that rural Punjab population spend approximately 7.6 crores annually for health ailments caused due to stubble burning.
- Burning stubble lets the heat transmit to the soil (1 cm) that kills the crucial bacteria and fungus required for soil fertility.[63]
- Living in areas with intense stubble burning increases the risk of acute respiratory diseases by threefold, as evident from observing the satellite images for 5 months. With an estimated cost of $1.5 billion over five years, stubble burning and firecrackers together cost 1.7% of the Indian GDP.[64]
- The **monetary cost** of stubble burning to Punjab farmers is estimated to be around **Rs 800–2,000** crore every year in terms of nutritional loss and increased cost of cultivation and Rs 500–1,500 crore in the form of government subsidies on fertilisers.

The Indian government launched the National Policy for Management of Crop Residue in 2014. Despite this and technological advancements like Happy Seeder, the burning rates have remained approximately constant. Machine sharing and subsidised inputs for residue management should be emphasised rather than penalised. For example, the National Thermal Power Corporation (NTPC) was directed to utilise 10% of the crop residue in coal production.

In conclusion, the contemporary Indian agriculture, given the input and output price structure and superior yields of a particular number of crops mainly wheat and rice, has turned agriculture into a monoculture of two to three crops in some parts of the country. **This cobweb model revolving around less diversified crops has led to over exploitation of groundwater resources, non-agro-climatic cropping patterns, excess use of fertilisers and hence resource degradation.** Crop residue management has come to the forefront as the health and environmental impacts have increased. Subsidies are perceived to have higher economic impact, but the ecologically unsustainable cropping patterns lead to a flow in motion of increased cost of cultivation that depresses them economically.

A comprehensive food value strategy starting from production to food processing to retail should be enhanced through sustainable investment. The role of the private sector should be recognised in infrastructure development investment in developing technologies with best practices required for resilient food systems with soared efficiency and sustainability.

[62] *'India's burning issue of crop burning takes a new turn,' Down to Earth, 2017, https://www.downtoearth.org.in/blog/agriculture/stubble-burning-a-problem-for-the-environment-agriculture-and-humans-64912*

[63] *'Burning of soil residue—how does it affect the soil health,' Just Agriculture, 1, no. 1 (2020): 67.*

[64] 'Risk of acute respiratory infection from crop burning in India,' International Journal of Epidemiology, 48, no. 4 (August 2019): 1113–1124.

POLICY SUGGESTIONS

1. Adequate agricultural research and innovation expenditure

The spending on agricultural research is inadequate and should be increased. The need is to increase private and public initiatives on investment and research in resource management and sustainable solutions either through social or business innovations for the current productivity–sustainability trade off. The committee on doubling farmer's income highlighted that **Indian expenditure on agricultural research has remained around 0.3%–0.4%** of the agriculture GDP since 2001 except in 2011.[65] The report compared the Indian expenditure with other comparable developing countries and observed that the share of agricultural research in agriculture GDP is much higher in Brazil (1.8%), Mexico (1.05%), Malaysia (0.99%), and China (0.62%). The high-income countries spent around 3.01% of the agriculture GDP on agricultural research and innovation. Also, the focus has been on infrastructural maintenance and capital tech, and very less has been diverted to farmers' education.

Allocation to major heads of expenditure under the Department of Agricultural Research and Education in 2021–2022 (Rs crore):

	2019–2020	2020–2021 (Budgeted)	2020–2021 (Actual)	% CHANGE (Budget vs Actual 2020–2021)	2021–2022 (Budgeted)
Indian Council of Agricultural Research (ICAR) headquarters	4,869	5,138	4,997	−0.03	5,322
Crop sciences	859	965	836	−0.15	968
Agricultural education	688	740	529	−0.40	613
Animal sciences	452	486	420	−0.16	462
Management of natural resources	205	226	223	−0.01	250

Source: Ministry of Agriculture and Farmers' Welfare, demand no. 2.

2. Rationalised input subsidies

The subsidies from the Government of India on an average are Rs. 70,000 crores towards fertilisers, Rs. 20,000 crores towards farm credit, Rs. 6,500 crores towards crop insurance and Rs. 24,000 crores towards MSP, totalling Rs. 120,500 crores. And a similar support from state governments are of Rs. 90,000 crores towards electricity power subsidies, Rs. 17,500 crores towards irrigation subsidies, and Rs. 6,500 crores towards crop insurance subsidies, totalling Rs. 1,14,000 crores. The opposite directional relationship with the similar magnitude of order in the MSP (negative due to increasing cost of cultivation) and input subsidies (positive), approximately offset each other as a support to farmers.

[65] Ministry of Agriculture and Farmers Welfare, Science for Doubling Farmers' Income, Report of the Committee on Doubling Farmers' Income (New Delhi: Ministry of Agriculture and Farmers Welfare, 2018).

However, the distortions they create in the Indian economy do not cancel each other. As discussed above, subsidies, though rightly intended, often lead to market distortion and ecological inefficiencies; hence, they need to be rationalised. More emphasis should be laid upon information, education and communication about the new technology rather than continuously enlarging the subsidy loop.

3. Broadening direct cash transfers to the farmers

A shift from the price policy approach of heavily subsidising the inputs towards an income-based approach by directly transferring the subsidy or a fixed amount per cropping season per hectare basis is required. Policies such as 'Pradhan Mantri Kisan Samman Nidhi' at the All-India level for 9.5 crores farmer beneficiary families (8th instalment as of May 2021) and state policies like 'Rythu Bandhu scheme' have been initiated. This approach, if substitutes for electricity and chemical fertilizer subsidies, will help in overcoming the severe groundwater crisis and excess fertilizer usage which causes soil degradation problems in Northwestern states.

4. Marketing system

Essential information regarding the consumer demand should be directed to the farmers so they can channelise the resources into productive and remunerative market streams. Thus, the market linkages are necessary to address deferred and uncertain returns. Mitigation of food loss, integration, provision of vital information to the farmers, and logistics are the necessities.

5. Encouraging innovation for sustainable productivity growth with climate change mitigation and adaptation being made available to the farmers

Market Innovation: Examples of market innovation include easily accessible and facilitative market reforms for farmers like E-NAM and less barriered entry for the private sector for infrastructure development. The **average income of a farmer's household in India is Rs.6,427/month against a monthly expenditure of Rs.6,223.**[66] And the spread of benefits such as MSP and efficient market procurement are limited to fewer states.

- Survival of business operations depends upon the ability of the business to earn net positive return, save, invest and expand. However, this does not seem to be happening in this case. Foreign trade restrictions should be eased out, reviewing the process of MSP setting in relation to the cultivation costs and incentives to reduce it, also to ensure that MSP doesn't exceed the international pricing benchmarks leading to trade leakages of inefficient import–export parities to trade.
- For better remuneration for their produce and market connectivity, infrastructure is endogenously related. Logistics—transportation and cold chain storage facilities should choose the time of the transaction; processing mills locally available should increase the value of raw materials. These aspects have been discussed in the prior sections.
- States such as West Bengal and Uttar Pradesh contribute a substantial proportion to the overall rice production in the country. These states also reported higher IWP than the other large rice producing states like Punjab and Haryana. However, they counted lower EWP due to absent and inefficient market procurement systems. Allowing farmers to realise higher EWP in these states with higher IWP will lead to hydrological efficiency.

Technological Innovation: Examples of technological innovation include increased research intensity in the agriculture sector and leveraged efforts on strengthened 'zero budget natural farming' with appropriate chemical usage. For example, IFFCO recently launched the world's first Nano liquid urea which holds the substitutability of chemical fertilisers at least by 50%.

[66] *National Sample Survey Office, Situation Assessment Survey of Agricultural Household (New Delhi: NSS, 2013).*

AUTOMOBILE AND TRANSPORTATION

India was the fifth-largest auto market in 2020 with 3.49 million vehicles sold in the passenger and commercial vehicle category and sixth largest manufacturer. Domestic automobiles showed a 2.36% Compound Annual Growth Rate (CAGR) (2016–2020) and domestic sales at 1.29% CAGR (21.55 million) during the same period. The growing middle class and a younger population drives the growing demand for the two wheelers; this in turn boosted the demand for Electronic Vehicle (EV) with a growth rate of 20%. India's EV finance industry is expected to reach Rs.3.7 lakh crores in 2030.[67] A report by India Energy Storage Alliance estimates a CAGR of 36% for the EV market in India by 2026.[68]

A McKinsey study estimated supply-side disruptions to occur every 3.7 years across industries, to tackle which the review of their product portfolio is required.[69] The reduced automobile product variants and design complexity will increase the operational resilience. This can reduce the part counts by 20%–30% and materials costs by 6%–8%.[70] The emerging trend towards autonomous driving, connected cars, electric vehicles and shared traveling will significantly change the automobile industry.

Also, aligning automobile production to the Bharat Stage (BS) VI (emission regulation to limit the output of air pollutants from internal combustion engines) norms will shoot up the prices as the production costs go up. India is the only country to leapfrog from Euro IV equivalent standards directly to Euro VI and the deadline was set up in April 2020 (that manufacturer will only sell the BS VI vehicles). This has a threefold goal—emission control, fuel efficiency and re-designing engines. The ambitious goal of this leapfrog within a period of less than four years seemed impossible; however, India has been able to achieve this on time except for some unprecedented circumstances created by the pandemic that needed an extending window. The BS VI reduces the sulphur content to 10 parts per million (ppm) from 50 ppm, which was enforced by a timely shift and supply of ultra-low sulphur fuel in the refineries and hence to their other backward-forward linkages. State owned refineries spent around Rs.35,000 crores to switch to ultra-low sulphur fuel along with Rs.60,000 crores spent on previous such transformations. The domestic automakers also co-operated, some complying and launching the vehicles at substantial amounts of time before the deadline. The reduction in emissions through BS VI combined with the scrappage policy will lead to the realisation of the full potential of the policy. An IIT Bombay study, on emissions from the Indian transport sector with on road fleet composition and traffic volume, estimated that only 45% of the pre-2005 vehicles were responsible for 70% of the total emissions.[71] Policies regarding the old vehicles have been formulated for phasing out 15 and 10 years old and 'unfit' vehicles. As per the estimations, India had more than 87 lakh end-of-life-vehicles in 2015 and will have 2 crores such vehicles by 2025. The Corporate Average Fuel Efficiency Phase 1 was launched in April 2017 by the government to reduce the carbon emission from vehicles via minimising the dependence on carbon-intensive fuel and technologies, shifting towards more fuel-efficient vehicles such as EVs and hybrids.

The growth rate of Indian automobile production and consumption has been substantially high. During 2001–2011, the registered motor vehicles witnessed a three times growth rate of the road network (Ministry of Statistics and Programme Implementation, MoSPI). Over a longer time period, the registered motor vehicles increased from 0.3 million in 1951 to 142 million in 2011. The production of automobiles in 2011 was 3.8

[67] NITI Aayog and Rocky Mountain Institute, Mobilising Finance for EVs in India: A Toolkit of Solutions to Mitigate Risks and Address Market Barriers (NITI Aayog and Rocky Mountain Institute, January 2021).

[68] India Energy Storage Alliance, India Electric Vehicle Market Overview Report 2019–2026 (India Energy Storage Alliance, 2019).

[69] Mckinsey Global Institute, Risk, Resilience, and Rebalancing in Global Value Chain (Mckinsey Global Institute, 2020)

[70] Brajesh Chhibber and Nitesh Gupta, The Indian Automobile Industry—from Resilience to Resurgence? (Mckinsey Insights, 2021).

[71] Apoorva Pandey and Chandra Venkataraman, 'Estimating emissions from the Indian transport sector with on road fleet composition and traffic volume,' Atmospheric Environment, 98(December 2014): 123–133.

times that of 2001 levels. India's automobile industry produced 26 million vehicles in 2020 with a $118 billion market value and is expected to grow to $300 billion as the world's third largest automobile industry in terms of volume. This tremendous growth in the industry has led to resource extraction, domestically or by importing. The sector accounts for 8% of total R&D spending and there is scope for increasing the material intensity and resource efficiency. Influx of motor vehicles is driving India's population away from using public transport. The percentage of people still using public transport is high, but the growth is declining. The future dimensions of mobility based upon the vehicle type and model will determine the future resource outlook. A shift towards a more sustainable approach of adopting public transport should be encouraged.

STEEL

The steel industry employs 25 lakh people directly or indirectly and is expected to grow to 36 lakh jobs as per the National Steel Policy (NSP) 2017 and a capacity expansion to 300 MT by 2030, of which 68% will be through the blast furnace route that requires coking coal. Substantial demands for coking coal are fulfilled via imports from Australia. According to the NSP 2017, only 60%–65% of the coking coal will be imported and rest will be domestically procured; for that Jharia district that has abundant coal reserves has to be developed and the other social issues of the area need to be addressed to overcome the price volatility in raw materials.

Steel has been a major raw material for the automotive industry due to structural dimensions. However, the mass adoption and rising demand for EVs has significantly reduced the share of iron and steel in vehicle manufacturing. However, the aggregate steel demand is expected to remain flat as the per vehicle steel requirement decrease is offset by a simultaneous increase in the volume of EV production.[72] EVs are expected to become the centre stage given the policy incentives, rising incomes and technological advancements. This will surge up the demand for aluminium and plastic due to their lower weight.

The underlying shortage of scrap for manufacturing steel from scrap is evident as in 2017 the deficit was to the tune of 7 MT, imported at the cost of more than Rs. 24,500 crore (approx.) in 2017–2018.[73] There lies a huge potential of recovering steel from the old and scrapped vehicles which tend to increase as per the new norms for 'fitness certificates' in the country. The policy is founded on two main incentives—charges for those sticking to the old and less energy-efficient vehicles and relaxation for those opting for scrapping. India imported 7.05 MT of steel scrap in 2019, and expects to reduce it to only 1 MT by 2024–2025 as heavy reliance would be on the local content, enforced by the flagship National Recycling Policy. Recycling steel can not only reduce the resource intensity (as it is 100% recyclable without the loss of quality) on the natural capacity of the planet but also the externalities associated:

- 1 tonne of steel scrap saves an estimated 1,030 kg of iron ore, 580 kg of coal and 50 kg of limestone.[74]
- According to the Institute of Scrap Recycling Industries, recycling one car can save around 1,000 kg of iron ore, 560 kg of coal and 48 kg of limestone.[75]
- The use of every tonne of scrap saves 1.1 tonnes of iron ore, 630 kg of coking coal and 55 kg of limestone.[76]

ALUMINIUM

The demand of aluminium is bound to increase in India as the EVs take the centre stage and aluminium is considered to be crucial for their production. Innovation is expected to raise the average use of aluminium per vehicle from 29 kg currently to the global standards of 250 kg per vehicle predicted for the future.

[72] *Robert Stall, How Advancing Mobility Will Impact the Mining and Metal Sector (EY, 2020).*

[73] *Indian Bureau of Mines, Mineral Policy and legislation, Indian Minerals yearbook 2019 (Nagpur: Indian Bureau of Mines, 2021s).*

[74] MD Fenton, 'Iron and steel recycling in the United States in 1998,' in Flow Studies for Recycling Metal Commodities in the United States, ed. Scott F. Sibley (Reston, VA: US Geological Survey, 2006), G1–G8.

[75] Institute of Scrap Recycling Industries, Iron and Steel Fact Sheet (Washington, DC: Institute of Scrap Recycling Industries, 2014).

[76] Indian Bureau of Mines, Mineral Policy and legislation, Indian Minerals yearbook 2019.

India witnessed a 327% increase in the aluminium scrap imports from the US in 2020 as compared to 2015. This has been ignited by China's National Sword Policy to cut down the scrap imports with stringent scrap standards, tariffs and incentives. Making India world's largest importer of the aluminium scrap, the entire value chain has shifted to unorganised (now formalised in one sector with the registered vehicle scrapping facility) imported scrap management despite India's own capacity and the vehicle scrappage policy. Recycling Aluminium can be environmentally beneficial as it is 100% recyclable multiple times without losing its quality. One tonne of recycled aluminium saves 95% of energy, 1 square metre of land use, 24 barrels of crude oil, 15 tonnes of water use, and cuts approximately 9 tonnes of CO_2 emissions and 2.5 tonnes of solid waste.[77]

Legislations

- 'Older vehicles pollute the environment 10 to 12 times more than fit vehicles and pose a risk to road safety'—Minster, Road transport and highways while introducing the new vehicle scrapping policy. The policy aims at phasing out unfit and polluting old vehicles with issuance of a voluntary 'fitness certificate'; vehicles to be de-registered if failed to secure the certificate after 15 years for commercial and 20 years for passenger vehicles. Emissions, brakes, safety among many other criteria should be focused upon as per the Central Motor Vehicles Rules, 1989. Only BS VI standardised vehicles would be on road and majorly the BS IV will go through this check. The vehicles that fail to get certified will have to forego the following incentives along with the prospective imposition of 'green taxes':
  1. The state governments may offer off road tax rebates to the 'fit vehicles' ranging from 15% to 20%.
  2. Vehicle manufacturers might allow a discount of 5%-6% for the purchase of a new vehicle against the scrapping certificate along with the waving off the registration fees.
- The Ministry of Road Transport and Highways will promote the setting up of Registered Vehicle Scrapping Facilities (RVSF) across the nation. The ministry will also encourage PPP and integrated scrapping facilities across India. It is being planned to develop a highly specialised centre for scrapping in Alang, Gujarat. The efforts are to synergise the scrapping facilities and technologies across the value chains; the environment norms compliance will be monitored at the scrapping facilities.
- The Steel Scrapping Recycling Policy, 2019 (issued via Gazette notification dated 7.11.19) has been issued to promote formal, scientific and standardised collection, segregation and dematerialisation processes of the treatment phase for the end-of-life products with the high value of recoverable resources, leading to resource and energy conservation. The industry needs to be trained for environment friendly processes and safety norms.
- National Mobility Plan Mission, 2020, aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. It encompasses the following incentives:
  1. Demand side—facilitation to acquire EVs, such as tax cut on the loan amount taken to purchase EVs, GST reduction from 28% (with cess) to 12% (no cess) to 5%.
  2. Sale of electricity as 'service'—Delhi government's Electric Vehicle Policy 2020 aims at switching 25% of the new vehicle registrations towards battery and electricity by 2024. To facilitate this, the Delhi government aims to establish 500 EV charging points at 100 locations and the newly constructed spaces are required to have 20% of their parking spaces ready for electric vehicle.
  3. Faster Adoption and Manufacturing of (Hybrid) and Electric Vehicles India (FAME India) to promote the manufacturing of EVs in India—total fuel expected to be saved was 52,700 L CO_2

[77] The Aluminium Association. North American Aluminium Industry Sustainability Report (Arlington County, VA: The Aluminium Association, 2011).

reduction by 1.3 Lakh kg/day.[78] Phase 2 of the FAME policy was launched in 2019 with a funding of INR 10,000 crores.

4. Other incentives include retro fitment of on-road tools (hybrid kits), promoting charging infrastructure, and R&D enhancement.

CONSTRUCTION AND INFRASTRUCTURE SECTOR

India Energy Outlook: World Energy Outlook Special Report 2015 estimates that three-quarters of the anticipated 2040 building stock, in India, is yet to be constructed. Integrated techniques and innovation of net zero energy and waste in future developments from the inception phase minimises the long-term costs, builds climate resilient and environmental mitigating future projects. The Government of India has been laying a massive emphasis on infrastructure development, with 100 smart cities, modernisation of 500 cities, affordable housing for all by 2022, cement concrete of national highways, provision of sanitation facilities, dedicated freight corridors, Clean India Mission, Ultra Mega Power Projects, connectivity improvement including water transport, which will bring the required boost in infrastructure and housing sectors. These development projects that are in the pipeline would be the main drivers of growth of the Indian construction sector.

However, building stock and infrastructure is a highly resource-intensive process with an alarming degradation and depletion of natural resources. Since buildings are necessary and given their high natural resource dependence, the consumption should be intelligent and wisely inclined towards sustainability. Some solutions include incorporation of recycled inputs in the process and reusing and extending the life size with a circular loop in motion. Though the resource-intensity level depends on the type of building, our efforts here are to synthesise the status reports on the various resources that are majorly impacted by the construction phase of a building stock and perspective of circularity. According to an estimate, India generates 150 MT of Construction and Demolition (C&D) waste annually of which concrete contributes 23% to 35%.[79] The recycling capacity is merely 6,500 MT/day, just 1%. Centre for Science and Environment (CSE) has carried out a detailed and comprehensive analysis of the C&D waste management in India with focus on the critical impediments to the implementation of the rules. The use of C&D aggregate instead of natural aggregate leads to a 40% reduction in CO_2 emissions. As per the estimated 1.1 billion tonnes per annum demand of concrete and road laying, C&D waste replacement can potentially reduce 8 MT of CO_2 emissions per annum.[80] For example, the alternative to natural sand called m-sand produced using granite and other stones could be made using C&D. Also, the projected effects such as congestion and pollution will make the life of a city dweller tougher without a sustainable approach.

CEMENT

The Working Group on Cement Industry constituted by the Planning Commission for the 12th Five-Year Plan period has projected a demand growth at the rate of 10.75% per annum during the plan period at an expected 9% GDP growth rate (pre-COVID-19).

- India currently operates at a **545 MT** installed capacity; the Working Group expects that the installed capacity requirement would be **1,035.3 MT** by 2027 that is **substantially higher than the current level**.
- The production in the cement industry is expected to be 800 MT by 2030.[81]

Recovery of wastes and substitution of coal has only recently been practised in India's cement industry. The TSR is estimated to average 4 per cent up from 1% a few years ago. 90 cement plants are utilising hazardous waste in their production for energy recovery. The quantity authorised for co-processing is 1,87,79,127 MT and about 17,87,042 MT hazardous waste has been co-processed during 2019–2020.[82]

[78] https://fame2.heavyindustries.gov.in/content/english/15_1_FAMEI.aspxs

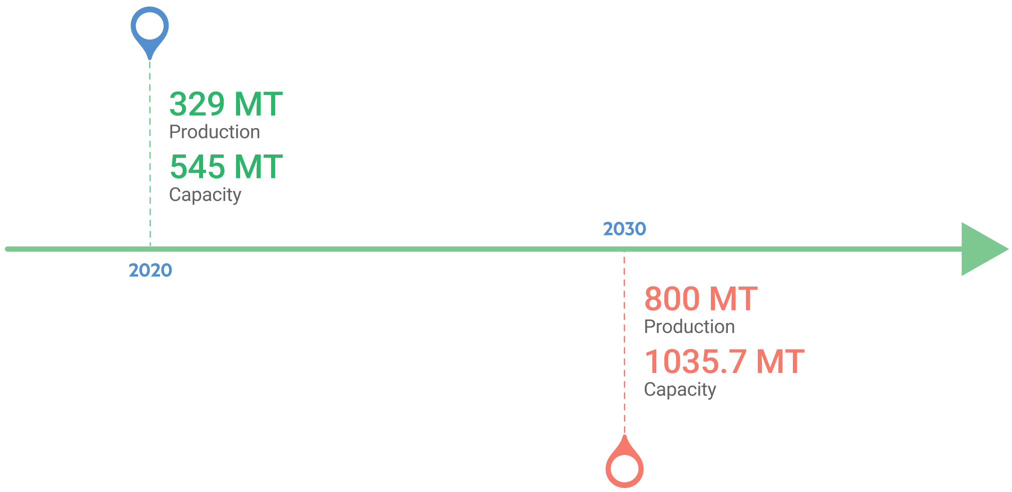
[79] Building Material Promotion Council, 2020.

[80] USEPA, Background Document for Life-Cycle Greenhouse Gas Emission Factors for Clay Brick Reuse and Concrete Recycling (Washington, DC: Environmental Protection Agency, 2003).

[81] Bureau of Energy Efficiency, Govt. of India.

[82] Central Pollution Control Board, National Inventory on Hazardous Waste Generation 2019-20.

Production and Installed Capacity Projections in Cement Industry



> *'We will have the potential to consume 12 MT of plastic waste in our kilns annually by 2025, resulting in conservation of conventional fuels such as coal to the extent of 10 per cent.'*
>
> —CMA President Dr Shailendra Chouksey

LIMESTONE

Limestone is abundantly available in the country with 100% self-sufficiency as per the Annual Report on Minerals and Metal 2020–2021. However, mineable reserves are limited to 13 states. A total of 97% of the annual limestone production is consumed by the cement industry.[83] The used limestone in cement production cannot be recovered directly or reused in the original form but can have indirect usage in the aggregate form, recovered from the C&D waste. It is projected that India will have reserves for limestone only for the next 35–41 years.[84] Limestone mining contributes 0.0021 kg of CO_2 per kg of limestone mined.[85] Thus, alternatives to limestone should be researched with minimum waste and emissions.

Fly ash, a waste generated from the thermal power plants of coal, can be utilised up to 45% in high-volume fly ash cement. The Swachhta Action Plan enhanced fly ash utilisation by activating the 40% low quality fly ash through mechanical and chemical routes.[86]

STONES AND IRON & STEEL

The demand for stones is likely to remain high in the construction sector as the concrete will be one of the primary resources utilised. The Union Ministry of Housing and Urban Poverty Alleviation stated in Rajya Sabha (2012) about the scarce construction material, especially aggregates and stones, given the environmental concerns and hence limitations on mining. The Bureau of Indian Standards has permitted the use of concrete made from the aggregates and C&D recycled and processed waste. Despite this, potential buyers appear 'risk averse' towards using recycled materials and prefer conventional resources.[87] The missing confidence could be built by the governments' initial encouragement

[83] Indian Bureau of Mines, Mineral Policy and legislation, Indian Minerals yearbook 2019.

[84] Ministry of Commerce and Industry. Report of the Working Group on Cement Industry for XII Five Year Plan (2012-2017) (New Delhi: Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, 2011).

[85] Source: Ecoinvent Database of SIMAPRO software.

[86] Indian Bureau of Mines, Mineral Policy and legislation, Indian Minerals yearbook 2019.

[87] Avikal Somvanshi and Anurag Verma. Another Brick off the Wall (New Delhi: CSE, 2020).

via green procurement; for example, the Ministry of Housing and Urban Affairs fixed targets for 13 Central and Delhi government departments and MCD for using 16 LMT of C&D recycled waste in the projects of 2019–2020. Studies have been conducted to investigate the relevance of using stone aggregate waste produced during the processing and recycling phase, as to reuse to utilise the resources and minimise the negative environmental effects. Natural stone waste can be used as soil stabilisers (adding natural or human made products to the soil to enhance its properties), along with other industrial wastes such as fly ash and blast furnace slag.[88]

The use of steel will remain mainstay given its strength; it has been discussed comprehensively in the above section.

Legislations

- The Construction and Demolition Waste Management Rules, 2016, notified by The Ministry of Environment, Forest and Climate Change focuses on waste utilisation and pollution mitigation.
    1. Large generators (generating 20 tonnes or more in a day) shall segregate the waste, submit environmental plans to the local authority to get approved and shall pay the given waste management charges.
    2. To institutionalise the C&D waste management, local authorities should be responsible for managing the waste under their jurisdiction. The local authorities shall procure and utilise 10%–20% C&D waste into municipal and local contracts.
    3. The Central Pollution Control Board shall grant the authorisation to treatment plants, standardising the norms at national level. But, out of the 53 cities to establish recycling facilities by 2017, only 13 have done so by 2020.[89] As per the Swachh Survekshan 2019, only Gujarat had 7 Urban Local Bodies (ULBs) that processed 70% of the C&D waste as per the rules 2016. The criteria for ranking cities was changed in 2020, instead of ranking only on the proportion of C&D waste processed or recycled; it also included minimum facilitative infrastructure for recycling as the criteria. This is in line with the development and establishment of bare minimums and then focusing on the outcomes.
    4. Service providers (in the line of extending producer's responsibility) shall submit a comprehensive waste management plan.
- Steel Scrap Recycling Policy, 2019, promotes scientific and formal collection, dismantling and treatment of recyclable scraps. This will also enhance the compliance under Hazardous and Other Wastes (Management & Transboundary Movement) Rules, 2016, issued by Ministry of Environment, Forest and Climate Change for hazardous waste by creating a mechanism that involves all stakeholders and is environment friendly and safe.
- Promotion of fly ash[90] vide a notification, S.O. 763 (E) 1999 mandated the use of fly ash in building materials for construction projects operating within the 100 km radius of coal or thermal power plants. The central and state agencies are supposed to help create an environment of ease for recyclers of fly ash by assisting them in land and resources. The thermal plants also provide 20% of dry fly ash free of charge for bricks producing units.
- In addition to the notification, 50% of fly ash by weight is used in fly ash bricks, blocks, etc., and at least 25% of fly ash in clay bricks. Around 10% of the total fly ash generated is used in producing bricks/tiles/blocks.[91]

[88] Osman Sivrikaya, Koray R. Kıyıldı and Zeki Karaca, 'Recycling waste from natural stone processing plants to stabilise clayey soil,' Environmental Earth Sciences, 71 (2014): 4397–4407.
[89] Somvanshi and Verma. Another Brick off the Wall.
[90] 'Fly ash is a fine powder recovered from gases created by coal-fired electric power generation. When mixed with lime and water, the fly ash forms a cementitious compound with properties very similar to portland cement.'
[91] Central Electricity Authority, 2019.

SMART CITIES: AN ENVIRONMENTAL PERSPECTIVE

The emergence of information and communication technologies, Internet of things (IoT), and technology innovation has led to new ways of addressing and planning smart cities. The smart cities mission in India is the first of its kind project to incorporate the scientific and technological innovations for sustainability in the urban sector.[92] Since the mission embarks the journey towards future 'sustainable cities', the indicators of resource and energy efficiency should be planned, executed, monitored and rectified over the period of time from the very initial phase itself. However, the environment protection has been least prioritised among the three pillars of smart cities development, i.e., Social, Economic, Environment.[93] Data suggests the more densely populated cities have lower carbon footprints as compared to less densely populated ones, since they hold potential for more public utilities usage including transport.

- The green indicators of sustainability developed by the Sustainable cities Initiatives reduced the 13 indicators of environment sustainability under six headings—green spaces, energy efficiency, mobility, quality water availability, air quality and recovery through waste management hierarchy.[94]
- The Green City Index series from the Economist Intelligence Unit emphasised the eight categories—CO_2, energy, buildings, transport, water, waste and land use, air quality, environment governance.
- The sustainability index for smart cities mission in India, after various stages of analysis, emphasised on the four broad domains—solid waste management, water supply management, sewage and sanitation and ambient environment conditions.[95]
- European Green Capital Award, EU, recognises and awards the local efforts on 12 indicators that include climate change adaptation and mitigation, urban mobility, sustainable land use, green growth and eco innovation, air quality, waste, water, noise and governance.

Resource Efficiency

- Standardised waste management planning, evenly spread out centres, proper incentive mechanism with 'ease of doing business'.
- Community engagement programmes that recognise and reward the local efforts to drive behavioural changes in the residents, e.g., Swachh Survekshan Surveys held to rank the clean cities and contests and competitions for the goodwill factor inclusion.
- Promotion of resource-efficient 'green buildings' with incentives.
- Use of IoT and technological innovations in buildings for better management of resources by generating direct relevance to the target audience.
- The plan should have clarity in design, pragmatic costs, high quality relevance as suggested by the World Bank Environment Department (WBED).

Energy Efficiency

- Availability of choices for energy and shift as per the preferences and affordability.
- Enabled neighbourhood supply of energy instead of broadcasting model; this will enhance the management of energy generation based on the demand, for example, using technology to track the consumer's demand based on past levels of consumptions.

[92] Shruti Shruti, Prabhat Kumar Singh, Anurag Ohri, 'Evaluating the environmental sustainability of smart cities in India: The design and application of the Indian Smart City Environmental Sustainability Index. Sustainability, 13, no. 1 (2021): 327.

[93] Gunjan Yadav, Tushar N. Desai , 'A fuzzy AHP approach to prioritize the barriers of integrated Lean Six Sigma,' International Journal of Quality & Reliability Management, 34, no. 8 (2017): 1167–1185.

[94] Sustainable Cities International. Indicators for Sustainability: How Cities are Monitoring and Evaluating Their Success (New Delhi :Sustainable Cities International, 2012).

[95] Aman Randhawa and Ashwani Kumar, 'Exploring sustainability of smart development initiatives in India,' International Journal of Sustainable Built Environment, 6, no. 2 (2017): 701–710.

- Use of IoT for optimisation and efficiency by controlling, sensing, scheduling, programming, etc., at buildings.
- Localisation and generalisation of renewable energy sources and increased efficiency in cost, for example, mapping of solar panels on the rooftop through programming to estimate the potential, better coordination in planning and generation of energy.

GREEN BUILDINGS

The concept of green buildings vary country to country and region to region. A green building, too, uses natural resources during its manufacturing and operational phase. However, the objective should be to optimise the resource consumption–sustainability trade off, increase energy and resource efficiency, reduce resource extraction, minimise waste generation and maximise reuse and treatment of waste and resources. The green building conceptualisation and execution should start from the designing phase such that the site is sustainability planned, water use is efficient, etc. In short, a green building should be economically, socially and ecologically sustainable.

The five principles of green buildings are as follows[96]:

- Sustainable planning of the site to optimise the resource utilisation and minimise the ecological footprint.
- Water efficiency in terms of proper and smart usage and extraction of water with a substantial harvesting, reuse rate and recycling rate via wastewater treatments. However, achieving sustainability and efficient management of water would not be possible without measurement of embodied water consumption.
- Energy efficiency as the demand of energy will increase over time. Commercial buildings accounted for 1,400 million square metres and consumed 71 billion units of electricity annually (commercial building stock energy modelling). Since the construction sector is going to peak, it is of high concern to systematically design, execute and monitor the energy-efficient methods to maintain the carbon emissions below 2 degrees Celsius.
- Optimised building material with minimised waste, easy-to-dispose and extractive waste with an intelligent designing, use of waste as inputs.
- Healthy indoor environment quality with maintained ventilation, moisture, day lighting, etc.

BENCHMARK FOR GREEN BUILDINGS

The green building system is designed considering the demographics and requirements of the country, for example, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan 2001, Hong Kong Building Environmental Assessment in 1996, and Leadership in Energy and Environmental Design (LEED) in the US 1998.

The Ministry of New and Renewable Energy has adopted a national rating system for India—GRIHA, developed by The Energy and Resources Institute (TERI). This system considers the provisions of the National Building Code 2005 and the Energy Conservation Building Code 2007 announced by BEE and other IS codes. These were developed for non-air or partially air conditioned buildings; GRIHA rates commercial, institutional and residential buildings in India. It has been developed considering the climate variations and attempts to strike a balance between national and international technologies and practices. The Indian Green Building Council (IGBC), constituted in 2001 also conducts IGBC ratings.

However, the following aspects should be addressed in the green buildings[97]:

- **Refuse**—intelligently adopt international trends, materials, technologies, products, etc., and should be suitable to the local requirements.
- **Reduce**—resource- intensive consumption and processing.

[96] Adapted from Samreen S. Makandar and Nadeem A. Sanadi, ‘Limitations of green building rating systems—a case of LEED and GRIHA,’ IRJET, 6, no. 5 (2019): 6798–6803.

[97] Ministry of New and Renewable Energy, GoI and ADaRSH (Association for Development and Research of Sustainable Habitats), “The National Rating System for Green Buildings,” The Little Book of GRIHA rating (New Delhi: Ministry of New and Renewable Energy, GoI, 2012).

- **Reuse**—resources and waste material so as to decrease the dependence on natural resources for virgin extraction and the costs associated. Circular economy should function from the designing phase itself.
- **Recycle**—all of C&D waste.
- **Reinvent**—increase the intensity of research and innovation along with a facilitative entrepreneurial environment.

Green buildings should have an integrated design approach, harness local site habitat's natural environment and traditional architectural practises, be inclusive of locally available material and processes, calculate precise energy and resource requirements, reduce intensity of consumption and adopt efficient technology and market innovation.

However, the GRIHA ratings as a 'green building' benchmark lacks on two aspects:

- Its benefits for large buildings outweigh those for the medium and small ones. To worsen the situation, the registration fees and the charges to acquire the ratings are exorbitantly high for medium-size buildings (relatively lower if only applied to large complexes).
- This is designed for either newly built or in construction buildings. There is a neglect of large scale operational buildings which have high maintenance consumption.

Thus, the cost-benefits of applying this rating will generate inefficient results for small scale construction ratings. Thus, green building rating systems should be made efficient for small scale construction (e.g., IGBC Affordable Housing) as well. Rational players usually care about the cost and benefit in monetary terms; incentives like natural resource conservation inherit **collective responsibility** and, thus, it would require monetary incentives or strict legislation for some improvement towards individual responsibilities. To achieve this, the Union government and the state governments follow different incentivising policies with the three—IGBC, GRIHA and LEED—being recognised by different states.

Incentives for Green Rated Buildings[98]:

GOVERNMENT	DEPARTMENT	INCENTIVES
Union Government	Ministry of Environment, Forest and Climate Change	Fast track environment clearance for IGBC-certified green buildings.
	Small Industries Development Bank of India, 2015	All IGBC-certified MSME green projects are eligible for financial assistance at concessional rates.
	Sunref—Affordable Green Housing India programme	Targeted to Primary Lending Institutions (PLIs) meant for project developers of residential projects (targeting EWS, LIG, MIG income groups) which achieve Gold or Platinum under IGBC Green Homes & IGBC Affordable housing Rating.
Punjab Government	Dept. of Local Government (Town Planning Wing), 2016	Offers an additional 5% floor area ratio less fee to rated gold or above.
	Dept. of Housing and Urban Development, 2020	Offers additional 5%, 7.5% and 10% FAR free of charge with 100 % exemption of building scrutiny fee to silver, gold and platinum rated.
Rajasthan Government	Dept. of Urban Development, 2009	Offers additional 0.075, 0.10 and 0.15 FAR free of charge to silver, gold and platinum, respectively.
	Rajasthan Investment Promotion Scheme, 2019	Investment subsidy of 50% (up to Rs. 50 lakhs) to green projects with minimum floor area of 2,000 square meters.
West Bengal Government	Dept. of Municipal Affairs, 2015 and New Kolkata Development Authority, 2016	Offers additional 10% FAR free of charge for gold or above rated by IGBC or GREHA.
Uttar Pradesh Government	Housing and Urban Planning Dept, 2015, and Greater Noida Industrial Development Authority, 2016	Offers additional 5% FAR free of charge to gold or above rated.

[98] Website, Indian Green Council Building.

Andhra Pradesh Government	Industries and Commerce Dept.	25% investment subsidy (up to Rs. 50 crore) for MSMEs.
	Municipal administration and urban development	20% reduction on permit fees, one-time reduction of 20% on duty on transfer of property (if sold within 3 years) on the submission of occupancy certificate issued by the local authority.
Maharashtra Government	Urban Development Dept, Pune MC and PMRDA	Offers an additional FAR of 3%, 5% and 7% for green buildings rated as silver, gold and platinum, respectively
Gujarat Government	Gujarat Tourism Policy, 2021–2025	Offers 50% repayment (up to Rs.10 lakhs) of certification fees to hotels, wellness centres if rated green.
	Industries Commissionerate, Industries and Mines Dept.	Offers 50% consultation charges (up to Rs. 2.5 lakhs) for industrial projects.

Moreover, green bonds/loanable funds are issued through banks at lower rates for ecologically viable projects that get certified as ‘green’. This should be accompanied by intensive digital marketing and knowledge sharing or supporting with viable tax credits for certified ‘green homes’.

SUGGESTIONS FOR CONSTRUCTION AND AUTOMOBILE SECTOR

- **Raw material recovery and designing out waste**

  Reuse and redesign can reduce the resource cost—both monetary and environmental. An example of this could be the comprehensive plan for demolition and waste recovery and disposal, designed by Germany, Austria, and Switzerland. Several alternative materials are being tested in place of the conventional resources for brick making, e.g., pond ash and marble sludge. Toyota Europe makes products at least 85% recyclable and 95% recoverable along with easy dismantling of the parts.

- **Strategical tracking of resource extraction and waste**

  Lack of tracking affects the research and development and management of the resources negatively. This also undermines the valorisation potential; hence, the proper tracking of the resource should be enhanced for transparency. For example, Telangana and Andhra Pradesh track the rendering of sand, Maharashtra uses the Sand Mining Approval and Tracking Systems (SMATS) through which order could be placed on the mobile phones.

- **Integrated and local waste treatment**

  The management of material flow—C&D waste, automobile parts, scraps—should be integrated with the national norms and policies but managed by the urban local bodies locally. This is to make sure an environmentally safe and sound management system. The Registered Vehicle Scrapping Policy helps in transparency in mapping, analysing and comparing the potential of technologies and waste value recovery. An integrated policy for the 'end of life products' should be enforced.

- **Design improvement with accessible technologies**

  The technologies for value recovery should be available and accessible by removing the knowledge gap between manufactures and the service providers. New methods and techniques should be identified for reusing and recovering from the waste streams more efficiently. For example, Honda collected and recycled approximately 200,000 end-of-life oil filters and approximately 180,000 end-of-life bumpers in 2015. The recycled bumpers were then utilised by Honda Freed's splash guards and other components. Technologies should not discourage entrepreneurs from engaging in waste treatment and should ease the process.

RECOMMENDATIONS: ACTION POINTS

'If we cannot manage the earth we live in, we have no right to screw up other planets. So, let us not talk of plan B. It is time to redefine and quantify the R's framework where the acceptable "Recycle" percentage should be defined and similarly, we need to define the "Waste hierarchy" and the value recovery process to avoid extractive and exploitative economies. A new level of design thinking with an intergenerational goal is the need of the hour.'

—Dr. Rajendra Pratap Gupta

- Economic growth must be replaced by sustainable consumption-based model of development.
- We need to redefine the 'standard of living', 'urban lifestyle' and 'quality of life' given the demands on the planet.
- Environmental, Social and Governance principles should be defined for every organisation.
- Products and processes with negative carbon footprint needs to be reoriented to become neutral or be phased out in a time-bound manner.
- Waste management should be a part of the action at the household level. Waste collected should be treated or incinerated and used.
- Electric subsidies which are depleting groundwater should be reconsidered and alternatives must be explored.
- We need to invest in agricultural research to ensure nature-friendly agricultural practices.
- Children in school should be educated about the issue through short 10–15 minute documentaries and the same should be done for general masses.
- Public transport should be subsidised and incentivised.

CIRCULAR ECONOMY INDICATORS

Indicators should be incorporated in the national accounts as the precedent principles proposed under the 'System of Environment and Economic Accounting' framework, adopted by the UN Statistical Commission in 2012. India's participation in the project 'Natural Capital Accounting and Valuation of Ecosystem Services (2017)' has helped MoSPI launch Environment Accounts under this framework as an annual report namely EnviStats from 2018. Another tool that the project will help India commence is 'India-EVL Tool' to draw upon the value of ecosystem services in different states. These combined efforts under the project will lead India to advance upon ecosystem accounting.[99] However, as these records account for the physical and monetary changes in the natural stock, broader CE indicators should be integrated with the Natural Capital Accounts. **Businesses face problems in implementing CE principles due to unavailability of formal CE indicators and targets to assess the alternatives for economic benefits. We need to redefine the existing metrics and standardise them into easily understood and applied concepts.**

- Implementation at the national level via legislation or policies should be accompanied by work at the meso and micro level through municipal authorities, and business or the public innovations.
- **Green procurement should be enhanced by the government** to ensure environmental aspects are included in the government procurement process. A

[99] Ecosystem accounting can act as a lookup tool to produce information on the extent of ecosystems and their services and their condition based on selected indicators.

strategy should be formulated for the same, e.g., enhanced loan facilities for green investments. Mandating the federal government institutions to include the element of 'circularity' as an input in the future projects should be encouraged.

- **Green tax** should be applied on the usage of 'non-renewable' resources (proportionally), where labour is a renewable source. This will promote intelligent demand and reduce the wastage of resources with an incentive to move to other alternatives. Thus, tax incentives for green products and services should be enhanced and subsidies for brown products reduced.
- **Circular economy** should be included **in education** via courses at university levels or inclusion in the school curriculum. The learning should be practical that sets up the circular economy in ACTION.
- Enhanced research and development should be promoted with **dedicated institutes/departments** implementing circular concept, product and design innovation.
- A comprehensive **Process Reduction Policy** should be formulated, as per the needs, suitability and requirements of India.
- Standardisation of policy formulation and implementation for the circular economy requires a **legitimate institution** (as an umbrella body under the government's environment ministry) with sector-specific sub-divisions.
- States with higher population and waste generation worsened with low collection/treatment rates should be prioritised for urgent circular economy in action; recycling rates should be increased, fusing industries with circular principles.

It appears that we have little time left and the challenge grows every second and is moving the earth closer to extinction. I am not sure if circular economic model is the is the only solution, but certainly, it is a step in the right direction.

Don't read this report and get worried; please take one step very day to save 'Mother Earth'.

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The World Intellectual Foundation (WIF) is a global not-for-profit and a non-partisan think tank headquartered in Delhi and works on diverse topics and themes to promote global Peace, Prosperity, and Sustainability.

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