

# TerraGreen

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VOLUME 15 | ISSUE 7 | October 2022

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## Solar Energy for India's Energy Security

Reducing Variability and Achieving Stability

Understanding Sustainability through Gandhi

### SPECIAL HIGHLIGHTS

Environment-Friendly Festival Chhath  
Model Farm School

### TERRA YOUTH

### IN CONVERSATION

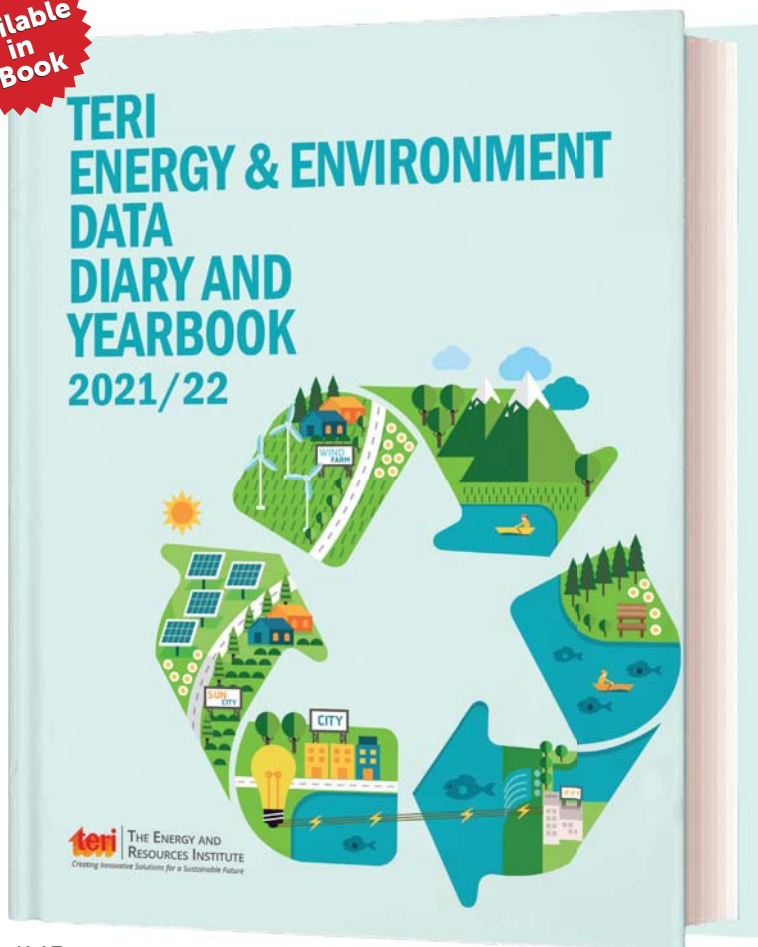
Mahesh Palashikar,  
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# EDITORIAL



“ The energy landscape around the world, and in India in particular, has changed dramatically over the last decade, especially in light of efforts to strengthen policies to combat the threat of climate change. ”

India will prioritize a phased transition to cleaner fuels and slashing household consumption to achieve net zero emissions by 2070, according to a national report released on November 14, 2022 at the 27th United Nations Climate Change Conference (COP27) in Sharm El-Sheikh, Egypt. The long-term plan now builds on the 2070 goal with elements such as increasing renewables and strengthening the grid; exploring a greater role for nuclear energy and enhancing support for R&D into future technologies such as green hydrogen; appropriate demand-side measures such as energy efficiency improvements; rational utilization of fossil fuel resources; enabling a focused transition towards low carbon development; and optimum energy mix supplementing national development scenarios.

Bringing the focus on solar energy for India's energy security, our cover story for this issue highlights India's commitment to renewable energy, which reflects its synergistic efforts to accelerate solar growth and provide energy access to all. The energy landscape around the world, and in India in particular, has changed dramatically over the last decade, especially in light of efforts to strengthen policies to combat the threat of climate change. The growing number of net-zero emissions pledges by countries and companies reflect the increasing sense of urgency and momentum behind the clean energy transition. Statistics have shown a highly impressive growth in India's renewable energy sector, where the country will lead the world in areas such as solar power and batteries in the coming decades.

Although India is one of the fastest growing solar energy countries in the world, where access to and use of energy has expanded across the length and breadth, there are still challenges to overcome. To achieve consistent development in the solar sector, it is important to guarantee that the renewable energy sector infrastructure is strong and modern. Issues related to land acquisition in renewable energy development, integrating a greater share of renewables into the power grid, providing financing for larger solar deployment targets, long-term international financing, developing an appropriate risk mitigation mechanism, fostering entrepreneurial innovation and a manufacturing ecosystem, improving renewable energy penetration in hard-to-decarbonize sectors are some of the major challenges that need to be urgently addressed if the country's energy needs and the government's sustainable growth agenda are to be met.

I sincerely hope that this issue of *TerraGreen* will strike a chord among our readers and that you shall come back with your thoughts and invaluable inputs for this publication to keep growing from strength to strength.

A handwritten signature in black ink that reads "Vibha Dhawan".

**Vibha Dhawan**  
Director-General, TERI



I read the September 2022 issue of *TerraGreen* online and found the articles very thought-provoking and concise. The feature article on “Making India a Sustainable Superpower” is a must read. Sustainability and a circular economy was the fulcrum of Indian culture. I second author’s views that in India, most people eat food with their hand, they believe that each of the five fingers represent the five elements of the earth energy, and when brought together aid digestion. These cultural practices help save the planet from the use of plastic knives, spoons, and forks including the cutting down of trees to make dining tables. In ancient India, hygiene practices were also sustainable. People brushed their teeth with tree twigs of medicinal value thus saving the planet from the disposal of plastic toothbrushes. Bathing was with herbal shampoo and soap.

Dishes were scrubbed with coconut husk. Natural cleaning agents were used to wash floors, utensils or clothing. Water systems were never polluted with chemicals. In short, sustainable development was a bottom-up rather than a top-down approach. The carbon footprint of individuals in ancient India was significantly lower compared to the modern man.

**D P Chatterjee**  
Kolkata, West Bengal

The article on role of women in Indian agriculture published in the September issue of your magazine is very apt as women constitute over 42 per cent of agricultural labour in the country but own less than two per cent of farmland, which could be attributed to several social norms and rights-related issues. This is an alarming figure and raises several questions on the land rights and social inequalities persisting in rural India. Authors are correct when they say that women are not given their share of recognition in the Indian farm sector and, therefore, have limited entitlements. While recognition is a key issue, another crucial matter of concern is that of control. Even if a woman owns the land, she does not have control over it; instead, it will be in the hands of a male.

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# Contents

VOLUME 15 • ISSUE 7 • OCTOBER 2022

4 **NEWS**

8 **TERI ANALYSIS**  
Cleaning Musi River  
(Concluding Part)

10 **ENVIRONMENTAL RESEARCH**  
Carbon Emissions from Green  
Energy Facilities

12 **FEATURE**  
Environment-Friendly Festival  
Chhath

18 **IN CONVERSATION**  
Mahesh Palashikar,  
President - General Electric (GE)  
South Asia

22 **COVER STORY**  
Solar Energy for India's Energy  
Security

30 **SPECIAL REPORT**  
Model Farm School

34 **GREEN CHALLENGES**  
Sacred Groves (Part 2)

37 **TERRA YOUTH**

46 **WILDLIFE**  
Rescuing Joymala

50 **PIONEER**

53 **BREAKTHROUGH**

56 **GREEN EVENTS**

12  
FEATURE



30  
SPECIAL REPORT



10 ENVIRONMENTAL  
RESEARCH



37 TERRA YOUTH



22  
COVER STORY



## Migratory Birds from Different Countries Arrive at Harike Wetland in Punjab

Migratory birds from different countries have started arriving at Punjab's Harike wetland, with around 40,000 winged visitors reaching the northern India's largest wetland so far. More than 90,000 migratory birds of over 90 different species from different countries, including Siberia, Mongolia, Kazakhstan, Uzbekistan, Russia and other parts of the world arrive at the Harike wetland every year after water bodies get frozen in their native places in winter. Harike wetland, spread over 86 square kilometres in Tarn Taran, Ferozepur, and Kapurthala districts, serves as a home to rare species of migratory water birds during the winter season. The wetland is situated on the confluence of Sutlej and Beas rivers.

Source: <https://www.thehindu.com/>

## India, France Adopt Roadmap for Development of Green Hydrogen

India and France have adopted an ambitious roadmap for the development of green hydrogen as part of the efforts to promote clean energy transitions and meet carbon neutrality targets. The French embassy said the roadmap aims at bringing the French and Indian hydrogen ecosystems together in order to establish a reliable and sustainable value chain for decarbonized hydrogen. It said the roadmap was adopted by French Minister of State for Development and International Partnerships Ms Chrysoula Zacharopoulou and Shri R K Singh, Hon'ble Minister of Power and New & Renewable Energy, Government of India.

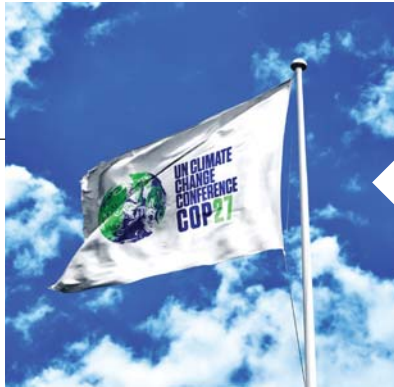
Source: <https://economictimes.indiatimes.com/>



## MNRE Issues Draft National Repowering Policy for Wind Power Projects, 2022

The Ministry of New and Renewable Energy (MNRE), Government of India, recently issued the revised draft of the National Repowering Policy for Wind Power Projects, 2022, as the majority of old wind power projects with sub megawatt scale wind turbines are yet to be repowered. "The objectives of the Repowering Policy are optimum utilization of wind energy resources by maximizing energy yield per sq. km of the project area and utilizing the latest onshore wind turbine technologies," said the ministry circular. It added that the revised policy has been drafted taking into account representations received from various stakeholders and subsequent deliberations. The Ministry had issued the earlier policy in 2016 to create a facilitative framework for repowering.

Source: <https://energy.economictimes.indiatimes.com/>



## COP27 Inclusion of Sustainable Lifestyle Key for India

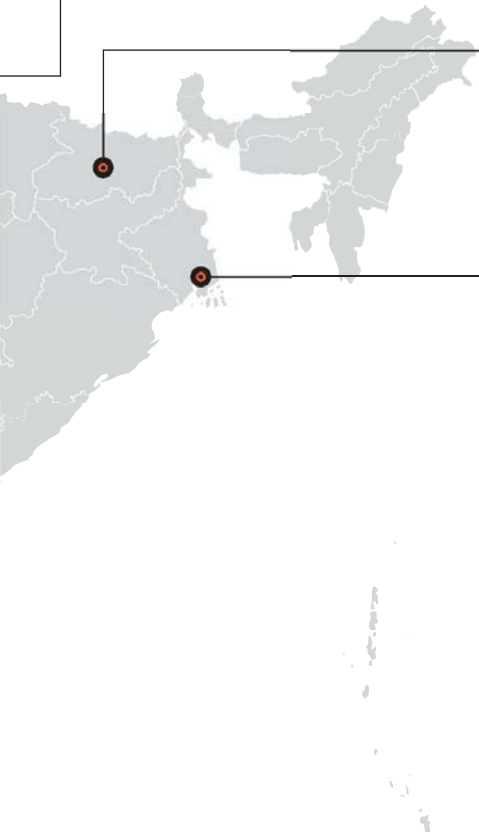
With over 195 countries reaching a final agreement at UN climate talks (COP27) in Sharm el-Sheikh, India which actively participated in the two-week long negotiations through multiple interventions welcomed its outcome paving the way for setting up of a loss and damage fund, and inclusion of “transition to sustainable lifestyles and sustainable patterns of consumption and production” in its cover decision. “Inclusion of sustainable lifestyle is the most significant for us. It is Prime Minister Narendra Modi who has made the pitch for an environmentally-friendly lifestyle through his mantra of Mission LiFE (lifestyle for environment) and the world today moved in that direction by including it in the implementation plan to address climate change,” Environment Minister Shri Bhupender Yadav said after conclusion of the climate talks.

Source: <https://economictimes.indiatimes.com/>

## India Needs \$300 Bn Investment to Meet 500 GW Green Capacity Target by 2030

India will need additional investment of around \$300 billion to complete the 500-gigawatt renewable energy capacity target by 2030, according to a report. With 165 GW generation capacity already in place, the country is on the right trajectory to meet its goal of having 50 per cent of energy needs through the renewable portfolio, the Arthur D Little (ADL) report said recently. “India needs (additional) strategic investments of over \$300 billion to achieve its clean energy capacity target of 500 GW by 2030,” the study titled ‘Powering India’s Energy Vision 2030,’ said. As per the study, India’s electricity consumption is expected to grow at an annual rate of 5.4 per cent over the next decade, with annual demand touching 2300 billion units (BUs) by 2030.

Source: <https://economictimes.indiatimes.com/>



## By 2070, 50 Per Cent of India’s Mangroves will Vanish due to Climate Change

Mangroves on Indian coasts that act as coastal guards have considerably shrunk due to climate change. By 2070, the Indian mangroves will reduce and shift by around 50 per cent, especially in southern India, due to decline in suitable habitats along the east and west coasts of India, revealed a research conducted by Birbal Sahni Institute of Palaeosciences (BSIP).

Mangroves in the southwest and southeast of the country that covers four states: Karnataka, Tamil Nadu, Kerala and Andhra Pradesh will be in the most vulnerable condition. These coastlines will submerge and the mangroves in the area will degrade more as compared to other areas.

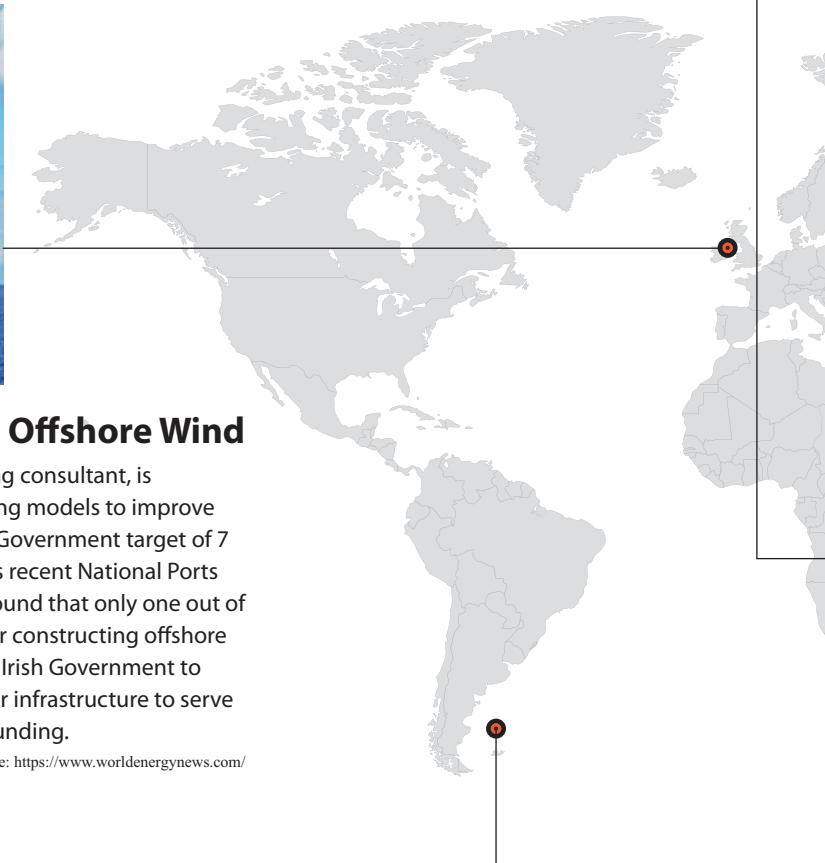
Source: <https://economictimes.indiatimes.com/>



## One-third of World Heritage Glaciers to Melt by 2050, Says UNESCO

Glaciers at many UNESCO World Heritage sites including Yellowstone and Kilimanjaro National Park will likely vanish by 2050, the UN agency warned recently, urging leaders to act fast to save the rest. The warning followed a study of 18,600 glaciers at 50 World Heritage sites—covering around 66,000 square kilometres (25,000 square miles)—which found glaciers at a third of the sites were “condemned to disappear”. The study “shows these glaciers have been retreating at an accelerated rate since 2000 due to CO2 emissions, which are warming temperatures”, UNESCO said.

Source: <https://www.hindustantimes.com/>



## New Study to Look at Irish Ports and Offshore Wind

Gavin & Doherty Geosolutions (GDG), a specialist engineering consultant, is undertaking an EU-wide study to determine potential funding models to improve Irish port infrastructure to the scale required to achieve the Government target of 7 GW of offshore wind in Irish waters by 2030. It follows GDG’s recent National Ports Study, conducted on behalf of Wind Energy Ireland, which found that only one out of 13 major ports on the island of Ireland is ready to be used for constructing offshore wind farms. A key recommendation of the study was for the Irish Government to provide additional support for ports seeking to develop their infrastructure to serve the offshore renewables sector, potentially including state funding.

Source: <https://www.worldenergynews.com/>

## Blue Whales Swallow upto 44 kg of Plastic Daily

As Earth’s largest animals, blue whales are mighty big eaters, gulping tonnes of food each day. They also now are ingesting huge amounts of plastic, according to scientists, due to the alarming volume of tiny particles of pollution choking the oceans. Researchers recently presented an estimate of the amount of microplastics ingested by three species of baleen whales—blue, fin, and humpback—off the US Pacific coast, detailing an issue posing uncertain health concerns for these marine mammals. As baleen whales, these species are filter-feeders. They strain food—shrimp-like crustaceans called krill and other small prey—from the seawater using baleen plates in the mouth made of keratin, the substance found in people’s fingernails.

Source: <https://www.hindustantimes.com/>







## Energy Crisis Sparked by Ukraine War to Speed up Green Transition

The drop in Russian fossil fuel exports after its Ukraine invasion this year will transform the global energy landscape for decades and can help to hasten a green energy transition, the International Energy Agency (IEA) said recently. The IEA's annual *World Energy Outlook* acknowledges the economic hit from reduced supplies of Russian oil, natural gas and coal but is keeping an environmental best case scenario in which no investment in new fossil fuel projects is needed. The IEA's report said the global energy crisis is causing profound and long-lasting changes that could hasten the transition to a more sustainable and secure energy system.

Source: <https://energy.economictimes.indiatimes.com/>



## Heatwaves Have Cost World Economy Trillions in Past Two Decades

Massive economic losses brought on by extreme heat induced by human-driven climate change are an issue now, not only in the distant future. According to a study published in the journal *Science Advances*, since the early 1990s, increasingly extreme heat waves brought on by global warming have already cost the global economy trillions of dollars, with the poorest and lowest carbon-generating countries suffering the most. Researchers from Dartmouth College coupled recently made available, comprehensive economic data for places all over the world with the average temperature for the hottest five days of the year for each region.

Source: <https://www.hindustantimes.com/>

## Developing Countries Risk Falling into Climate Debt Trap: Report

Rising global borrowing costs are denting the finances of some of the most climate-vulnerable countries right when they most need money to fight the devastating impacts of global warming. It's a convergence of events that risks pushing developing nations into a "debt trap," according to Prime Minister Shehbaz Sharif of Pakistan, who addressed world leaders at the COP27 climate talks in Egypt recently. Countries that borrowed heavily when interest rates were low are now struggling to fund projects that would make them more resilient to extreme weather, leaving them vulnerable to even higher borrowing costs in the future.

Source: <https://www.hindustantimes.com/>



# Cleaning Musi River

## (Concluding Part)

### Learning from International Examples

This concluding article by **Sonia Grover** and **Charu Bhanot** is an outcome of literature survey done for a project for two basins—Yamuna and Musi rivers. In the earlier article, they discussed about Yamuna River. This article is particularly on Musi River and talks about the challenges and reflections from best practices at international scale that could be used as learning to improve water quality of the basins.

**W**ater resources in Hyderabad city have been ignored to the disadvantage of long-term water security for the inhabitants, as was evident during the examination of challenges. The city's water supplies are under tremendous pressure due to the lack of enforcement of environmental rules and the haphazard planning and expansion of the metropolis. There is a lack of a robust institutional framework for Musi river pollution abatement and riverfront development. In order to solve these for Musi River in Hyderabad, we

need to take a multifaceted strategy. The city requires basin level management choices and the article refers to relevant enlisted international cases from where key lessons could be drawn to facilitate better management of Musi River.

#### Accelerated Sanitation Development for Human Settlements Program, Indonesia

In Indonesia, Community-managed DEWATS technology has been

implemented for communities with septic tanks. These include three key technologies:

- Settler (Set)+Anaerobic Baffled Reactor (ABR)+Anaerobic Filter (AF)
- Digester+Set+ABR+AF
- Settler, equalization, activated sludge, clarifier, filtration

Until comprehensive municipal sewerage and wastewater treatment becomes a reality, Indonesia's government sees this as the paramount choice for eliminating open defaecation and increasing sanitation in impoverished urban communities. DEWATS are being deployed in three different ways. Community sanitation centres (CSCs), which include toilets, washing, and laundry facilities, have made up 77 per cent of the total installations. Alternatively, a simplified sewer system (SSS) collects wastewater from domestic toilets and gravity feeds it to a DEWATS facility in 16 per cent of situations. Only 6 per cent of the population has access to a local sewer network and a community sanitation facility that provides both residential connections as well as access to sanitation for those who cannot join the network, making this the most inclusive. The user communities were given





responsibility for regular operation and maintenance, while local government and its partners give more technical and non-technical assistance as part of a co-management model of governance. Developments in sanitation and hygiene must be reinforced, supported, and monitored on a regular basis. However, the local governments still have sewage management duties, and community-managed DEWATS should not postpone more complete planning and investment in integrated sanitation improvement employing upgraded on-site and off-site wastewater infrastructure.

## Murray Darling Basin, Australia

Australia is the world's driest inhabited continent, with the coastal margins being somewhat water-rich, but the centre is dry and water limited, making it the world's most sparsely populated continent. In Australia, there is a three-tier system of elected governance. For the most part, the national or federal government focuses on issues that are of national importance. Land and water are sovereign rights of the States under the 1901 Constitution, which governs law and order, health, education,

transportation, etc. Community services and water and sewerage are the responsibility of the local government and these are also known as 'shire' in towns and rural areas. A major societal concern in Australia is the shortage of water supplies and their high fluctuation. Natural resources in Australia are managed using an integrated catchment strategy that involves the watershed management. This approach's institutional structures are constantly expanding, but they constitute one of the well-developed models available anywhere. An agreement was signed for watershed management by the governments of the three riparian states and national government. In case of River Murray, a River Murray Commission (RMC) comprised of a delegate from each jurisdiction was established as a result of the Agreement. In most cases, these officials served as the head of the water agency in their respective jurisdictions. The project for management of Murray River was provided by the commonwealth's federal government for the river's national significance. A robust institutional system was developed with involving the Ministerial Council, which has been given the duty of drafting

policy, contains three ministers from each jurisdiction representing land, water, and environmental management. The Commission, the implementing body, was also constituted, with two representatives from each jurisdiction. With the addition of a new community advisory board, the Ministerial Council has expanded its responsibilities. This committee includes representatives from regional catchment management agencies and five representatives from special interest institutions. Further, every stage of water management is supported by stakeholders. It is imperative that all urban and wastewater projects seek feedback from the general public and end-users through necessary public engagement. Investments in water projects were only made if they were economically and environmentally viable, and improved requirements for water rights were introduced and water trading was promoted. ■

*Note: This analysis is part of the project titled: 'Developing integrated river pollution management framework' supported by the Prince Albert II of Monaco Foundation.*

*Sonia Grover, Fellow and Area Convenor, WRPM, TERI and Charu Bhanot, Research Associate, WRPM, TERI, New Delhi.*

# Carbon Emissions from Green Energy Facilities

## The Implications and Solutions

A new study says that moving the world energy system away from fossil fuels and into renewable sources will generate carbon emissions by itself, as construction of wind turbines, solar panels and other new infrastructure consumes energy—some of it necessarily coming from the fossil fuels we are trying to get rid of. But if this infrastructure can be put on line quickly, the study asserts, those emissions would dramatically decrease, because far more renewable energy early on will mean far less fossil fuel needed to power the changeover.

**M**oving the world energy system away from fossil fuels and into renewable sources will generate carbon emissions by itself, as construction of wind turbines, solar panels and other new infrastructure consumes energy—some of it necessarily coming from the fossil fuels we are trying to get rid of. The good news: If this infrastructure can be put on line quickly, those emissions would dramatically decrease, because far more renewable energy early on will mean far less fossil fuel needed to power the changeover.

This is the conclusion of a study that

for the first time estimates the cost of a green transition not in dollars, but in greenhouse gases. The study appeared recently in the *Proceedings of the National Academy of Sciences*.

“The message is that it is going to take energy to rebuild the global energy system, and we need to account for that,” said lead author Corey Lesk, who did the research as a PhD student at the Columbia Climate School’s Lamont-Doherty Earth Observatory. “Any way you do it, it’s not negligible. But the more you can initially bring on renewables, the more you can power the transition with

renewables.” The researchers calculated the possible emissions produced by energy use in mining, manufacturing, transport, construction and other activities needed to create massive farms of solar panels and wind turbines, along with more limited infrastructure for geothermal and other energy sources. Previous research has projected the cost of new energy infrastructure in dollars—\$3.5 trillion a year every year until 2050 to reach net-zero emissions, according to one study, or up to about \$14 trillion for the United States alone in the same period, according to another. The new study appears to be the first to project the cost in greenhouse gases.

On the current slow pace of renewable infrastructure production (predicted to lead to 2.7°C warming by the end of the century), the researchers estimate these activities will produce 185 billion tonnes of carbon dioxide by 2100. This alone is equivalent to five or six years of current global emissions—a hefty added burden on the atmosphere. However, if the world builds the same infrastructure fast enough to limit warming to 2°C—current international agreement aims to come in under this—those emissions would be halved to 95 billion tonnes. And, if a truly ambitious path were followed, limiting warming to 1.5°C, the cost would be





only 20 billion tonnes by 2100—just six months or so of current global emissions.

The researchers point out that all their estimates are probably quite low. For one, they do not account for materials and construction needed for new electric-transmission lines, nor batteries for storage—both highly energy- and resource-intensive products. Nor do they include the cost of replacing gas- and diesel-powered vehicles with electric ones, or making existing buildings more energy efficient. The study also looks only at carbon-dioxide emissions, which currently cause about 60 per cent of ongoing warming—not other greenhouse gases including methane and nitrous oxide.

Other effects of the move to renewables are hard to quantify, but could be substantial. All this new high-tech hardware will require not just massive amounts of base metals including copper, iron and nickel, but previously lesser-used rare elements

such as lithium, cobalt, yttrium, and neodymium. Many commodities would probably have to come from previously untouched places with fragile environments, including the deep sea, African rainforests and fast-melting Greenland. Solar panels and wind turbines would directly consume large stretches of land, with attendant potential effects on ecosystems and people living there.

“We’re laying out the bottom bound,” said Lesk of the study’s estimates. “The upper bound could be much higher.” But, he says, “the result is encouraging.” Lesk said that given recent price drops for renewable technologies, 80 to 90 per cent of what the world needs could be installed in the next few decades, especially if current subsidies for fossil-fuel production are diverted to renewables. “If we get on a more ambitious path, this whole problem goes away. It’s only bad news if we don’t start investing in the next 5–10 years.”

As part of the study, Lesk and his colleagues also looked at carbon emissions from adapting to sea-level rise; they found that construction of sea walls and moving cities inland where necessary would generate 1 billion tonnes of carbon dioxide by 2100 under the 2-degree scenario. This, again, would be only part of the cost of adaptation; they did not look at infrastructure to control inland flooding, irrigation in areas that might become drier, adapting buildings to higher temperatures or other needed projects.

“Despite these limitations, we conclude that the magnitude of CO<sub>2</sub> emissions embedded in the broader climate transition are of geophysical and policy relevance,” the authors write. “Transition emissions can be greatly reduced under faster-paced decarbonization, lending new urgency to policy progress on rapid renewable energy deployment.”

Source: <https://www.sciencedaily.com/>





# Environment-Friendly Festival Chhath

## Making Waves

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In this article, **Manu Shrivastava** says Chhath Puja, celebrated with fervour across India after Diwali, is perhaps the only festival that is environment friendly. Fascinatingly, all the offerings used on this occasion are fully biodegradable. During the four-day-long festival, the devout worship Mother Nature in the most pious way—all things needed for rituals associated with Chhath are obtained naturally.

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Apart from their religious significance, many festivals are associated with harming the environment in one way or the other—whether it is the noise associated with crackers and the pollution emanating during the process, affecting the quality of air being inhaled or animal sacrifices or simply plastic waste generated in the ceremonies that find their way into our waterbodies, most festivals have arguably riders that need to be controlled.

Chhath, celebrated with fervour across India after Diwali, over four days, is perhaps the only festival that is environment friendly. Intriguingly, all the offerings used on this occasion are fully biodegradable. Here, new crops grown by the farmers are offered to Chhath Maiyya in the festival in processes that don't involve a priest.

There is no discrimination on the basis of class and caste as all share the same platform to offer puja and help one another as one large family. Why, everyone celebrating Chhath prepare the same *thekua* to offer the Sun God too. Interestingly, Chhath is the only occasion in which offerings are made to Surya Dev both during sunrise and sunset. Surya Dev, the Sun God, is the ultimate source of energy for all living organisms surviving on the planet and provides energy to green plants for photosynthesis—their primary source of food. Life, as we know, cannot exist on earth without the sun.

Chhath is believed to be performed by Karna, the son of Surya Dev and king of Anga Desha regularly. And, as per legends, the festival is said to have originated from the early Vedic

period during which mantras from Rig Veda were chanted by worshippers. In India, the Chhath festival witnesses overwhelming public participation under the banner of 'Sampoorna Swachhatha Abhiyan' when all the streets and banks of different water bodies throughout Bihar are cleaned, maintained and refurbished through community participation. Collective efforts of the government and community ensure that all the ghats along Ganga undergo a drastic transformation, overnight.

When we speak of air pollution reaching catastrophic levels in cities that include New Delhi and Patna, it's heartwarming to witness Chhath, known as Bihar's 'mahaparv', revealing the true spirit of worship without posing any threat to the environment. During the four-day-long festival, the devout



worship Mother Nature in the most pious way—all things needed for rituals associated with Chhath are obtained naturally.

For one, Chhath devotees simply do not require a temple as all the rituals are performed at a beach adjoining a sea, banks of a river, lake or any water body. The cleaning up of water bodies and the riverbank as well as restriction on the use of synthetic material among other practices make it the most eco-friendly festival. All the items used in the Chhath Puja are close to nature. For instance, the 'daura' and 'soop' used in the rituals are bamboo products and biodegradable in nature.

Chhath is a festival to worship nature itself when the devout worship entire nature by worshipping the Surya Dev, the Sun God, as all living species directly or indirectly depend on the sun for solar energy. As compared to several other festivals, when thousands of idols made of toxic material, including environmentally-damaging chemicals, Plaster of Paris, baked clay, synthetic costumes and fake jewelries are immersed in the Ganga and other water-bodies during Ganeshotsav and Dussehra; crackers in Diwali leading to noise and air pollution; harmful chemicals used in the colours played



in Holi, in the case of Chhath most items used in the four-day rituals are biodegradable. Interestingly, in Chhath, the use of kerosene stoves, LPG, even machines for making edibles including 'prasad' are usually avoided as devotees go for natural means like earthen stoves.

The items used in four-day Chhath Puja include coin (*dakshina*), camphor (*kapoor*), cotton balls (*batti*), lamp (*deepak*), *ghee*, fruits, holy water, idol of Lord Surya, idol of Lord Ganesha, incense sticks (*agarbatti*), kumkum (*roli*), date (*khajur*), matchbox (*maachis*),

panchamrit, betel leaves (*paan*), plate for performing the rituals (*puja thali*), red sandal (*laal chandan*), red cloth, sandal (*chandan*), rice (*chawal/akshat*), betel nuts (*supari*), *vrat katha* book, white flowers, and wheat (*anaaj*).

Chhath Puja is celebrated on the sixth day of Kartik Maas, from where the festival got its name. The word 'Chhath' simply means 'six'. It is in Bihar, state in eastern India, where lies the epicentre of this celebration that has pervaded to other states like Uttar Pradesh, Jharkhand, Delhi, and some western Indian states such as Madhya Pradesh and Maharashtra, even beyond borders with almost the same fervour.

The four days of Chhath include, *nahai khai* (*naha khay* or bathe-and-eat)—the first day of the festival on which the *vrattis* (the key persons fasting) take a bath in the river, pond, or any other water body close by their residence. They bring a little water home and with it they cook the *prasad*—a religious meal—commonly pumpkin, bottle-gourd and *mung-chana dal*. On this day, the devotees clean their houses and nearby compound areas. On Day One, the *vrattis* take meals, prepared without any contamination, only once. And when ready, first the *vratti* eats before other members of the family.



On Panchami or the fifth day as per Hindu calendar, the *vrattis* observe a vigorous fast for the whole day. They do not eat anything not even a drop of water before sunset. The entire day is spent preparing for the festival and procuring essentials like sugarcane, fruits and other ingredients for the puja. Later in the evening, the *vrattis* prepare a special *prasad* called *rasiao-kheer* (a concoction of jaggery, rice and milk) and *chapattis*. With these specially-made *prasad* and fruits like banana, radish, green ginger, betel leaves, spices like black cardamom and cloves, the *vrattis* worship Chhathi Maiya and offer *prasad*. After puja, the *vrattis* break their fast by eating the *prasad* and later, distribute it among family and friends. On the midnight of Kharna, people prepare *thekua*—a special *prasad* for Chhathi Maiya.

According to rituals, the third day of Chhath Puja is divided into two parts. The first being *Sandhya Arghya* also known as *Sanjhiya Ghat* or evening offering when the whole day is spent resting and preparing offerings at home (early in the morning before sunrise). During the day, the *daura* (a basket of bamboo sticks) is prepared and the offerings including *thekua* and seasonal fruits are placed into it. Then, in the evening, the *vrattis* and every family member gather at the bank of the river, pond or a reservoir decorated for the puja. The *vrattis* sit on the ghat and worship the setting sun. Folk songs are sung on the occasion and later in evening, when the sun sets, the *vrattis* offer the *Sandhya Arghya*, worship the Sun God and return home.

On the night of Sandhya Ghat or Arghya, the *vrattis* make a canopy by

using five sugarcane sticks tied together through a yellow cloth and the lighted lamps, earthen pots in the shape of an elephant are put under the canopy. The five sticks of sugarcane stand for five natural elements or *panchtatva*—earth, fire, sky, water, and air. Then there is the Kosi ritual that is followed religiously by families where a child has taken birth or a marriage has taken place recently. The lighted earthen lamps are symbolic of solar energy that sustains light. This ritual is conducted either in the *angan* (courtyard of the house), on the terrace or rooftop. Later, the *Kosis* are taken to the banks of the river. It is here that they are lit again in a ritual after which they are sent back to the home.

And there's the *Usha Arghya* (morning offerings) or *Bhorwa Ghat* in which offerings are made to the Sun God. The



*vrattis* and the family members gather once again at the bank of a water body early in the morning and sit until the sun rises. They sing songs in praise of Chhathi Maiya and when the sun rises, the morning *arghya* is offered by going into the water. After morning offerings, the *vrattis* distribute *prasad* among each other and take blessings from elders on the ghat. After that, they return home.

After returning from the ghat, the *vrattis* break their day-and-a-half-long fast by eating ginger and water. After that delicious food is prepared and offered to the *vratti* to eat. This is called *Paran* or *Parna*. After having fasted for a very long period, they usually take light food to break the fast.

During the last two years of COVID-19 lockdowns, worship in public spaces was banned by the Delhi government in India and many were compelled to share common water spots, which means the threat of infection remained despite them not visiting the Yamuna ghats, where the crowds if permitted, would have been much higher escalating the risk.

So, in 2020, there were bathtubs and cemented tanks on terraces and inflatable bathtubs and pits dug on empty plots, where Delhi's devout



offered prayers to the Sun God as part of the Chhath Puja festivities. The more fortunate, however, were able to arrange private water spots and ensure only those without any infection shared the worship space.

It was on the appeal of Chief Minister Arvind Kejriwal that residents had to then perform the Chhath prayers from their homes rather than venturing to the ghats to help prevent spread of the infection. The police had urged residents not to gather at the ghats,

made announcements in Bhojpuri, even sent out WhatsApp videos about the new rules, held over 50 meetings with local residents and deployed police personnel at the ghats to prevent a gathering, and, the festivities went off peacefully, despite the risk and caveats associated with COVID-19.

The Chhath Puja fervour has spread beyond borders to as far as the United States of America. Despite freezing temperatures in a land foreign to their origin, Indian-Americans don't lose a single opportunity to celebrate Chhath Puja during an occasion where hundreds across the east coast gather near the Potomac River in Washington DC.

It has been over a decade and a half since this ritual started with a handful of families granted permission by the local authorities. Today, it has grown into a movement. Earlier, the Chhath devout in the US would make the most out of the pujas by standing makeshift plastic tubs filled with water, today the times have changed and the Indian diaspora spreads the rich cultural heritage and traditions of the country with equal grandeur. ■

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# Expectations from COP27

## India to Strengthen Its Position as a Compelling Energy Leader

The 27th Conference of the Parties of the UNFCCC (COP27) is just around the corner and is expected to build on the successes of COP26, held last year in Glasgow, Scotland. Here, we are in conversation with **Mr Mahesh Palashikar**, President-General Electric (GE) South Asia for *TerraGreen*. He feels that along with the focus on solar, India is now well-poised to diversify and embrace alternatives in wind energy, gas power, hydrogen, etc.



**With India making robust commitments at COP26—to achieve net-zero carbon emissions by 2070 and enable the transition of at least 50 per cent of the power generation to renewable sources of energy by 2030—COP27 is being greatly**

**anticipated. What are your thoughts on this?**

At COP26, India announced its 'five elixirs' of positive climate action, including commitments to increase non-fossil capacity by 500 GW by 2030, cut the nation's carbon intensity to less than 45 per cent, and achieve net-zero emissions by 2070. Further reaffirmed last year, the share of clean sources in India's energy mix has expanded over time.

In the first half of 2022, renewable energy sources accounted for about 90.4 per cent of new power capacity additions. Policies for cutting down on emissions generated from the usage and production of thermal energy were also made. India is also encouraging renewable energy manufacturing through various schemes such as the production linked incentive (PLI) for solar PV modules and advanced cell chemistry (ACC) energy storage systems. Now, at COP27, there are expectations that India will further firm its foundation and strengthen its position as a compelling energy leader.

Along with the focus on solar, India is now well-poised to diversify and embrace alternatives in wind energy, gas power, hydrogen, etc. We also need complementing focus on new storage mechanisms like pumped storage hydropower and build robust markets with smooth financing options. Last year's commitments have instilled hope in industries and investors—continued commitment to this will be the benchmark as we approach COP27.

**Do you agree that for a country like India, which is shackled in the grips of poverty and unemployment, energy transition and decarbonization are possible only through a dynamic approach aimed at sustainability and energy *aatmanirbharta*?**

India is unique in its opportunities and challenges. As a developing nation, we have focussed on securing our people, their health and well-being—while also taking leaps to achieve economic



growth and industrial excellence. Along with these, there is a pressing need to emphasize innovation in sustainable technologies. Naturally, to achieve all these goals, our approach must be dynamic.

On one hand, as we see today, there is a need to emphasize the use and adoption of renewable sources of energy. Simultaneously, we must acknowledge the role that coal continues to play in our energy mix and economy, at large. Duly, we need to focus on developing emission control technology for coal-fired plants. Further, we need to account for energy storage systems that are on the rise worldwide. Here, the pumped storage hydropower (PSH) is proving to be rather promising. We also must focus on carbon capture technologies while we develop robust markets for carbon trading and energy financing. Together, these many diverse and dynamic options can ensure holistic energy transition in India.

**Your company, General Electric (GE), is a long-term partner in the country's power sector. How are you planning to help India in the energy transition process?**

As a long-term partner in the country's power sector, GE brings the most appropriate breadth of solutions that support India's energy transition journey. With a 120-year long presence

in the country and an expansive energy portfolio, we operate 14 manufacturing facilities in the country and offer a variety of cutting-edge technological and energy solutions for all renewable sources of power, advanced wind turbine blade design and manufacturing, end-to-end green electricity solutions to power electrolyzers, customized hybrid solutions, and superior technology for increasing efficiency, emission cuts, flexibility, and carbon capture.

Our century-long journey in India has been historic—starting with the first hydropower plant in modern-day Karnataka in 1902, today, more than 50 per cent of India’s total power passes through systems developed and operated by GE. Moving ahead, as the country prepares for its energy transition, we will be firm partners in enabling India embrace newer, cleaner forms of energy. We remain focussed on developing technologies and service solutions that can ensure the easy accommodation of renewables in the Indian electricity grid, promote gas-based power, develop storage solutions, enable hybrid power systems, advance hydrogen in India, and more.

**How is GE playing a significant role in enabling India’s energy *aatmanirbharta* with its 14 manufacturing units across the states of India?**

*Aatmanirbharta* in manufacturing remains a key focus for us at GE in India. We remain focussed on developing technologies in India and from India for the rest of the world. Our manufacturing facilities in the country are equipped to develop a range of technologies across our energy, healthcare, and aviation verticals. A number of these manufacturing facilities are also emerging as export hubs with well over a majority of their production being shipped to the rest of the world.

Since the global acquisition of LM Wind Power, GE has added wind turbine blade manufacturing capabilities to its

portfolio in India. The LM Technology Centre is the hub of breakthrough innovation in wind blade technology. Located in Bengaluru, it began operations in 2007 and has since been spearheading transformation in the blade industry, with its futuristic design, testing, and analytical capabilities. Over 60 per cent of all installed wind blades in the country come from LM Wind Power. Even our grid business, with five manufacturing sites, has become future-ready to meet the industry’s growing demand for grid equipment and services and is introducing green and digital solutions aimed at making the Indian grid smarter, resilient, and environment friendly.

All these manufacturing sites are bringing the best of global technology to India, combining it with local prowess and delivering the most-advanced solutions that match the highest global standards. As firm partners in India’s energy transition journey, focus on developing manufacturing excellence and taking the country towards *aatmanirbharta* remains a key focus for us.

**Talking about South Asia as a whole, what kind of growth the region needs to create jobs and pull millions out of poverty?**

The adverse impact of climate change is intensifying, especially in South Asia. More than half of the region’s population—about 750 million people—has suffered in the last two decades because of climate-related disasters.

Naturally, climate is going to be in sharp focus for any growth-related objective in the region. This focus gets sharpened as the global community looks to reach ‘net zero’, a journey in which the energy sector has a vital role to play. The sector is responsible for more than two-thirds of global greenhouse gas emissions. The issue is far from straightforward. South Asia is also among the regions requiring the most focussed development, an objective in

which energy plays a key role. A reliable and cost-effective supply of electricity is essential for the kind of growth the region needs to create jobs and pull millions out of poverty. Additionally, while working towards addressing the urgent priority of climate change, it is also imperative to address the energy trilemma—affordability, reliability, and sustainability—that is relevant for South Asia.

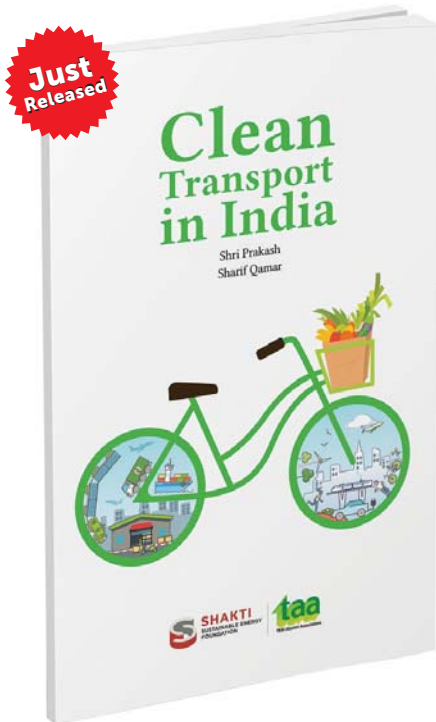
At COP26, many South Asian countries announced their transition strategy to net zero. Several corporates and not-for-profit organizations in South Asia too have vowed to become carbon-neutral or reach zero-emission levels of carbon dioxide over the next 30–50 years. Thus, the pathway for growth in the region is intertwined closely with its energy transition goals— requiring concerted efforts across multiple channels.

**What are the future plans of your organization?**

We remain optimistic about the Indian market and our prospects here. The country is emerging as a fast developer, especially in embracing renewables and enabling energy transition. India is today emerging as a hub for renewable energy innovation and our focus for the future circumscribes these goals. Moving ahead, we want to diversify the country’s approach to energy transition. We must move beyond solar and tap into our natural efficiencies in wind—both onshore and offshore. Simultaneously, we are encouraging gas and ultimately paving the way to make the switch to hydrogen. We are also focussing on developing hybrid solutions that combine the best of wind, solar, pumped storage hydropower, batteries, etc., to enable round-the-clock power that is affordable, accessible, and reliable.

We are also focussing on developing storage solutions that can overcome the intermittency and latency that naturally accompanies renewable sources. ■

# THE PATHWAY TO SUSTAINABLE TRANSPORT



## Major topics covered:

- Environment, climate change, and transport
- Transport infrastructure development
- Mobility and transport
- Sustainable transport
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This book not only presents all the relevant statistics but, more important, explains the implications of those numbers and the interconnections between different facets of transport: for example, the greater number of vehicles on roads may seem to favour mobility but in fact makes roads more congested—and the congestion makes air pollution more severe, thereby aggravating its impact on health. At the same time, the book is not a prophet of doom but also touches upon electric vehicles, hydrogen fuel cells, drones, and even flying cars.

Instead of fretting and fuming when you are caught in a traffic jam, read this book: it will not only calm you but, who knows, may inspire you to be a 'green' commuter.

This book is useful for adults who are concerned about topical issues but lack the understanding to make sense of what they read or watch in the mass media.

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# Solar Energy for India's Energy Security

## Reducing Variability and Achieving Stability

In this article, **Biba Jasmine** says India's commitment to renewable energy reflects its synergistic efforts to accelerate solar growth and provide energy access to all. It is time for the global community to come together, share ideas, and think of environment-friendly solutions to address the challenges in the energy sector, especially to harness the enormous potential of renewable energy on a large scale.



While talking about issues such as climate change mitigation, energy security, and providing clean electricity to hundreds of millions of people who currently do not have access to it, the Indian government and policymakers often think of the tremendous opportunities to develop and successfully meet the aspirations of its citizens without going down the carbon-intensive path. The energy landscape around the world, and in India in particular, has changed dramatically over the last decade, especially in light of efforts to strengthen policies to combat the threat of climate change. The growing number of net-zero emissions pledges by countries and companies reflects the increasing sense of urgency and momentum behind the clean energy transition. Statistics have shown highly impressive growth in India's renewable energy sector, where India will lead the world in areas such as solar power and batteries in the coming decades. Launched jointly by India and France in 2015 on the sidelines of the 21st Conference of the Parties (CoP21) to the United Nations Framework Convention on Climate Change (UNFCCC), International Solar Alliance is a testament to India's commitment to providing affordable, clean, and reliable energy to all its citizens, and its work towards building a brighter future for a country facing socioeconomic challenges such as high population density, relatively high water stress and land use constraints, and structural poverty, with energy affordability being a major concern.

## India's Solar Story

Recognizing India's contribution to a sustainable environment, the country is committed to increasing its contribution to achieving the Paris Agreement's agreed-upon strengthening of the global response to the threat of climate change. As per the renewable energy targets announced by the Prime Minister in 2015, India has committed to create an installed capacity of 175 GW of renewable energy by 2022, including 100 GW from solar, 60 GW from wind, 10 GW from biomass, and the remaining 5 GW from small hydro. In line with the 2022 target, India reached the 100 GW milestone in 2021. However, the recently updated Nationally Determined Contributions (NDCs) approved by the government calls for about 50 per cent of cumulative power generation capacity to come from non-fossil energy resources by 2030, falling short of the absolute target of 500 GW pledged at the 2021 CoP26 in Glasgow.

The goal of significantly increasing the country's capacity was pursued with a view to greater energy security, better access to energy, and more employment opportunities. If this ambitious goal is achieved, India will become one of the largest producers of green energy in the world, surpassing even some developed nations. As of June 2022, a total of 160.92 GW of renewable energy capacity has been installed in India. Electricity generation from various renewable energy sources (including large hydropower) in the country





by January 2022 (in MW), including large hydropower, which has small hydropower (9256.86), wind power (61,525.49), bioelectricity (13,286.66), solar power (57,869.53), large hydropower (133,610.06) with a total capacity of 275,548.60.

Clearly, the world's seventh largest nation, with a geographic area of 328.7 million hectares, accounting for 2.4 per cent of the world's land area, and the world's second largest population of more than 1.2 billion people (2011), is responsible for driving solar energy generation to power its growing population. India, which accounts for about 4.5 per cent of global emissions, has the fastest growth rate in renewable energy capacity additions of any major economy, with renewable energy capacity (including large hydro) growing 1.97 times and solar 18 times.

Looking at energy consumption in India and increasing urbanization, the policies and practices adopted by the government suggest that environmental regulation is one of the most important pillars of the Indian governance system. In line with the announcement of the National Action Plan on Climate Change (NAPCC) in June 2008, which designated the deployment of solar energy technologies in the country as a national project, the Indian government approved the Jawaharlal Nehru National Solar Project, which envisions the development and deployment of solar energy technologies across the country to achieve grid parity by 2022.

Under the NAPCC, several ministries and organizations have worked efficiently and effectively

to implement and fulfill the established goals. Most states and union territories have established a state climate change action plan to help achieve national strategies and implement national priorities. The NAPCC includes eight national missions, including the National Solar Mission (NSM), the National Mission for Improved Energy Efficiency, and the National Mission for Sustainable Habitat, which aim to reduce greenhouse gas (GHG) emissions in the country.

Under the NSM, the government has taken all appropriate steps to recognize the cost savings from solar development. Recent reports from the Ministry of New and Renewable Energy (MNRE) explain the declaration of Renewable Purchase Obligation by 2021–22, tax and financial benefits such as capital subsidies, Viability Gap Funding holes, accelerated depreciation benefits, etc., and allowing 100 per cent Foreign Direct Investment on the automatic route in the renewable energy sector.

Speaking of the rapid progress in the solar energy sector in recent years, it is noteworthy that India's cumulative installed solar energy capacity has increased from 13,114 MW in June 2017 to 57,705 MW in June 2022. A promising step in this sector is also the budgetary allocation of 33,650 million for the solar power sector, including on-grid and off-grid projects. This is an increase of 29 per cent over the previous year's budget of 26,060 million as per the Union Budget 2022–23.

As the cost of renewable energy has declined and new solar capacity can be built at a cost that can

compete with the fuel costs of existing conventional plants, we are seeing further penetration of solar energy in certain regions and sectors at varying scales and rates. Some energy-intensive sectors are described below.

## Agriculture Sector

In February 2019, the Hon'ble Prime Minister of India approved launch of 'Kisan Urja Suraksha evam Utthaan Mahabhiyan' with an objective of providing financial and water security to farmers. The proposed system consists of decentralized, ground-mounted, grid-connected renewable power plants, stand-alone solar-powered agricultural pumps, and solarization of grid-connected solar-powered agricultural pumps.

Under the decentralized grid-connected systems, renewable energy systems are set up by individual farmers/cooperatives/panchayats/farmers' organizations on their barren or cultivable land and the power generated is purchased by the distribution companies. Under the scheme, stand-alone solar-powered agricultural pumps with capacity up to 7.5 HP are allowed. And for the solarization of 1 million grid-connected solar-powered agricultural pumps, farmers will be able to use the energy generated to meet irrigation needs, and the excess available energy will be sold to distribution company (DISCOMs). The programme will have a significant impact on the environment by reducing CO<sub>2</sub> emissions. The three aspects of the programme combined are expected to result in an estimated savings of about 27 million tonnes of CO<sub>2</sub> emissions. According to the MNRE, the government has approved more than 0.359 million stand-alone solar water pumps for farmers, including small and micro farmers, in various states/UTs across the country by March 2022 under the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Scheme (PM-KUSUM).



## Telecom and Communication Sector

Systems such as solar PV-based hybrid systems offer a less polluting alternative to diesel fuel, serve as a hedge against rising diesel fuel prices, and help minimize the logistical challenges of transporting and storing diesel fuel at remote tower sites. In addition, the government plans to make it mandatory for cell towers to be powered by solar energy, in the hope of reducing pollution and curbing one of the main reasons for diesel consumption in the country.

The number of telecom towers is expected to increase by another 0.1 million in the next year, and it is important to note that the newer telecom towers are being installed based on new technology that uses less electricity and also eliminates the need for air conditioning, which is so important to telecom towers. Industry experts believe that for the older 0.3 million towers, grid power will be more economical than a solar-powered tower.

## Urban Infrastructure

Urbanization and economic development are rapidly increasing energy demand in our nation's urban areas, which in turn is increasing greenhouse gas emissions. Many cities around the world are setting goals and implementing policies to promote renewable energy and reduce GHG emissions. In this context, several Indian cities and towns are experiencing a rapid increase in peak electricity demand. Local governments and electric utilities are struggling to cope with this rapid increase in demand, leaving most cities with electricity shortages. In this context, the Solar Cities Development programme aims to help local

governments create a roadmap to guide their cities towards becoming 'renewable energy cities' or 'solar cities.'

The MNRE has asked each state/union territory to select at least one city to be developed as a solar city. A concept paper for development of solar cities has been sent to the states/unions with a request to prepare an action plan for developing the selected cities as solar cities and implement the plan in a timely manner. Funds available under various programmes can be used for the development of solar cities.

The Prime Minister also inaugurated the National Rooftop Solar Portal, which will allow following online the process of rooftop solar installation, starting from the registration of applications to the release of subsidies to the bank account of private consumers ('beneficiaries') after the installation and inspection of the system. The estimated capacity under the national rooftop solar programme is 4000 MW. This is an important step in unlocking the nationwide rooftop solar potential and contributes to India's goal of generating 450 GW of energy through non-fossil fuels.

## Railway Sector

In addition to urbanization and urban growth, mobility plays an important role. India has built one of the largest and most complex transportation networks in the world. The transport sector remains a key driver of development and must also grow sustainably for the country to achieve its development goals.

Indian Railways (IR), the second largest rail network in the world and the single largest consumer of electricity in India, consumes 2.6 billion litres of diesel annually, or 3.2 per cent of India's total transport sector diesel consumption, according to the Climate Policy Initiative's 2017 report titled 'Decarbonization of Indian Railways'. In addition, energy demand from IR is expected to triple to 49 TWh by 2030 due to increasing passenger volumes.

This presents a unique opportunity to embark on a low-carbon pathway for the transport sector that is also consistent with India's NDC goals. The country has already initiated a process to embark on such a path through a variety of initiatives across different transport modes. India has focused its low-carbon initiatives on the development of railroads, waterways, rapid mass transit systems, and other forms of public transport. Initiatives such as Dedicated Freight Corridors and Sagarmala projects aim to increase the share and volume of freight transported by the more energy-efficient modes of rail and water.

The United Nations Development Programme (UNDP) India announced in 2016 its partnership with IR to achieve the target of 5 GW by 2025. It did so by using unused land and rooftops of IR to house and support solar at no cost to the project, increasing private sector involvement, increasing investment, and developing innovative business models for low-risk projects.

In 2017, IR unveiled the first set of train cars with solar panels on the roof that powered the lighting, fans and information display systems inside. The carriages were used for suburban services in New Delhi, and the railroads estimated that each train with six solar-powered carriages could save about 21,000 litres of diesel each year, worth about 1.2 million.

The Guwahati railroad station is a fully solar-powered station that handles about 20,000 passengers a day. The station building has grid-connected rooftop solar panels with a total capacity of 700 kW (0.7 MW), which meet the electricity needs of the station, the bus depot, and the Northeast Frontier Railway colony. The solar installation will allow the rail network to save about INR 6.77 million (about USD 99,900) in electricity costs annually. Several other railroad stations in small towns across the country, such as Mangaluru, Thiruvananthapuram and Jaipur, are also partially powered by solar electricity.

To accelerate the railroad's mission to achieve the goal of becoming a "net zero carbon emission railroad,"



IR has developed a mega plan to install 20 GW of solar capacity by using its vacant land by 2030. IR also has a mega plan to install solar plants with a capacity of 20 GW by utilizing its vacant land by 2030. Some of the solar stations are Varanasi, New Delhi, Old Delhi, Jaipur, Secunderabad, Kolkata, Guwahati, Hyderabad, Howrah, etc.

## India's Changing Solar Landscape

Specifically, under the off-grid and distributed solar PV programme, the MNRE provides centralized financial assistance for the installation of solar streetlights, solar pumps, solar power packs, and other solar applications to meet the country's electricity and lighting needs.

The promotion of domestic production of solar cells and panels in India is supported by the Government of India through the Modified Special Incentive Package Scheme (M-SIPS) of the Ministry of Electronics & Information Technology. The scheme basically provides 20–25 per cent subsidy on capital expenditure for construction of manufacturing plant and reimbursement of counter vailing duty/excise tax on capital goods for plants located outside the Special Economic Zone. There is a need for increased capacity building for professionals involved in demystifying the business, financial, technological, and regulatory landscape of solar energy. MNRE's Human Resources Development Programme provides funding to various academic and professional organizations for skills development and training at various levels. Training programmes allow for the exchange of information on technological development and implementation of renewable energy projects. Interested parties include policymakers, businesses, government officials, zilla parishad, district, and taluk level officials,

and unemployed youth, especially women's self-help groups. The Ministry also actively supports short-term training programmes for professionals and technologists to improve their skills in product development, system integration, deployment, monitoring, operation, repair, and maintenance of solar power projects. Training programmes such as Suryamitra aim to develop trained personnel for the installation of solar power projects by solar companies, NGOs, etc.

The government is building solar power plants at airports nationwide to meet their electricity needs. The Airports Authority of India (AAI) is setting up solar power plants at various airports to meet its own electricity needs based on the capacity allowed under the net metering policies of the respective states and depending on technical feasibility. The AAI has installed solar power plants on 35 airports/buildings with a cumulative capacity of 30.43 MWp. However, the difficulties in installing solar power plants are primarily due to the multiple reviews by the regulatory authorities for land use in the airport operating area, the delay in the approval of DISCOMs for grid connections, and the non-extension of the net metering system for ground-mounted solar power plants.

## But Big and Small Bottlenecks Still Remain

Although India is one of the fastest growing solar energy countries in the world, where access to and use of energy has expanded across the length and breadth, there are still challenges that India must overcome. To achieve consistent development in the solar sector, it is important to ensure that the renewable energy sector infrastructure is strong and modern. Issues related to land acquisition in renewable energy development, integrating a greater share of renewables into the power grid, providing financing for larger solar deployment targets, long-term international financing, developing an appropriate risk mitigation mechanism, fostering entrepreneurial innovation and a manufacturing ecosystem, improving renewable energy penetration in hard to decarbonize sectors are some of the major challenges that need to be urgently addressed if the country's energy needs and the government's sustainable growth agenda are to be met.

On the contrary, small and large initiatives such as installation of solar panels on more and more houses, accelerating the production of 'Made in India' solar photovoltaic panels and improving production-linked incentives for the manufacture of high-efficiency





photovoltaic panels, launching a national rooftop solar portal that allows online tracking of the process of installing rooftop solar panels, mobilizing resources for green infrastructure through sovereign Green Bonds to encouraging the establishment of at least one solar city in each state are just a few examples of India's dynamic renewable energy plan aimed at achieving energy security, energy access, and low-carbon development.

## Solar Energy is Ready to Fill the Energy Gap in India—clearly

India remains a bright spot in the global economy. With a strong domestic economy and a supportive policy environment, the government is committed to achieving holistic, inclusive, and sustainable economic development. As India looks to become USD 5 trillion economy in the near future, it must secure affordable and sustainable energy to sustain high growth and provide energy access to 1.2 billion people. Therefore, it is important that we utilize all sources of energy. To this end, the Indian government is also taking several steps to overhaul the hydrocarbon sector to ensure the country's energy security while pursuing a green path of progress.

India is the world's third largest energy consumer and, according to the International Energy Agency, needs to formulate a comprehensive energy policy and launch extensive programmes to balance socioeconomic growth and environmental protection.

Developers and manufacturers need to clearly express their needs and clearly respond to the impact of the policy. India also needs a comprehensive strategy on issues such as effective procurement of critical minerals and investment in research and development. Another area to explore is the development of innovative financing measures, such as clean energy funds, incentive-linked loan repayments, and green bonds, which could provide a solution to meeting the financial needs of this sector. India's commitment to renewable energy reflects its synergistic efforts to accelerate solar growth and provide energy access to all. It is time for the global community to come together, share ideas, and think of environmentally friendly solutions to address the challenges in the energy sector, especially to harness the enormous potential of renewable energy on a large scale. It is time to connect the dots and revisit the articulated long-term visions, existing implementation plans, roadmaps, and institutional framework for the cross-sector deployment of solar energy to be able to witness great leaps in clean energy innovation in response to climate change and sustainable future. ■

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*Biba Jasmine is a Nehru-Fulbright scholar with a major in sustainable development and conservation biology at the University of Maryland, College Park, USA. She is also a Policy Leader Fellowship recipient at the School of Transnational Governance, European University Institute, Florence, Italy. The fellowship was co-funded by the European Union's Erasmus programme. The views expressed are personal.*

# Model Farm School

## A Case Study

In this article, **Dr R Mohanraj** presents a case study of a model farm school (MFS) with scope for inclusion and mainstreaming into post COVID CLOUD Society.

Conventional farm schools are extension education programme (EEP) of schools as part of academic curriculum. They provide knowledge and skills in agricultural and on-farm productivity through vocational training and 'experiential learning projects (ELPs)'. The objective of extension education is to provide the option of productivity and experiential-based learning to students. In EEPs such as farm schools, 'academic-athletic combine' or skills development in arts and crafts, the proportion of 'Doing by learning': 'Text book based learning' is about 60:40. Extension education provides scope for application of

multiple intelligence in the students. And, more scope for learning in the student based on Blooms Taxonomy of 'knowing', 'understanding', 'applying', 'analysing', 'creating' and 'evaluating' as the learning sequence.

Over the past decade, the academic sector has been increasing its emphasis on 'knowledge and skills in agricultural and on-farm productivity for students'. The new education policy (NEP) 2020 gives emphasis on transformation of the 'student' as 'learner'. And, make the purpose of learning as 'How to learn?' Under the perspectives of NEP 2020, the child is to become a human resource with skills for independent productivity

in their area of interest at 18 years of age. This is to be through 'low order thinking' of knowledge and 'high order thinking' of skills in the child as an individual.

### The Model Farm School

The Model Farm School (MFS) incorporates the changes recommended for enterprises in post COVID Cloud society, available in *TerraGreen* on request. This model was initiated by Mr Nambirajan, an environmentalist, popularly known as 'Nambi', in the year 2018, through the banner of 'Gather 2 Garden', which is a social enterprise promoting livelihood assurance through micro-enterprises. Nambi is also a professional in solar promotion. Besides his engagement in SELCO, the solar promotion company, 'Nambi' leads a team that promotes micro-enterprises for people around poverty line in communities as prototypes with scope for incubation into models with inclusion, mainstreaming, replicability, growth, and sustainability.

### Profile of the Model Farm School

#### Goal

To develop a prototype of MFS as an enterprise of the academic school with all the conditionalities of change of post COVID CLOUD Society incorporated







into it and incubate it into an upgraded model with inclusion, mainstreaming, replicability, and sustainability.

### Strategies for achievement of the goal

**Capital valuation, productivity, and income:** The starting point of the project in 2018 was valuation of capital. The valuation of capital is a virtualization process. The capital value fixed for the project was INR 500,000. The sources for this capital value included: (i) Price value of 10 acres of land taken on 'use and develop' agreement with multiple sources, including: the schools, land 'given for use and promotion' by an agricultural start-up company, and 'compassionate lease for use' given by a parent. The market value of these lands in different rural areas adjacent to Madurai city was INR 30,000 per acre,

totalling INR 300,000; (ii) 40 per cent of this total land value as working capital, raised by G2G as grants, donations and loan with soft interest of 2 per cent from donors and funders, including Corporate Social Responsibility (CSR) projects. This is addition of INR 120,000 to the land capital value; (iii) The balance amount of INR 80,000 to the capital value was raised through share contributions from the five partners of the project.

The five partners included: (i) The first partners were the students. There were 100 students from two schools in classes 9–10. The 100 students worked as 10 groups with each group working in one acre land. Each group of 10 students agreed to put in their share to the capital. The students were the main stakeholders of the project. They are the producers; (ii) The second partners were the volunteer supervisors. This was a total group of 20 individuals who

were teachers from the two schools and parents of the 100 students who volunteered to work with the student producers. This was 2 per group in each acre of land. Their role was to follow up, mentor, monitor and motivate the 10 students in their group. They also agreed to put in their share to the capital; (iii) The two schools are the third shareholders. The schools willingly put in their share to the capital; (iv) The fourth shareholder was G2G, the promoter of the project. While the entire shareholders have equity share and accountability in the project, the proportion of equity and shares was based on the actual holding of investment, productivity, and profit and income expenditure. In this norm, G2G was the 'capital, share and dividend' holding partner of the project; (v) The start-up agricultural company (SUAC) that allowed 'use and promotion of their land' and the others who gave their lands



on compassionate agreement were the fifth partners. They will also contribute their share to the capital. The capital, shares and dividends were based on the equity and dividend principles and virtual values. Reconciliation with the real was based on actual cash and kind.

**Operational methodology of the project:**

This was the main body of the project, consisting of productivity and income earning. The methodology included: (i) The one acre unit of land was divided into two equal portions of 50:50 for purposes of productivity. For the productivity in one portion of the one acre land, G2G took responsibility for utilization and productivity of the land. The producer group of 10 students and two volunteer supervisors replicated the productivity in the portion done by G2G in the other portion of the land; (ii) G2G used the strategy of 'condensed farming' for optimal 'per acre yield (PAY)' and 'per acre income' (PAI) from the total land productivity. Production plan was changed as found necessary for optimal YPA and IPA. For YPA and IPA, G2G adopted micro planning.

**Water management:** Three mini structures were installed in each one acre land unit. They were: a percolation pit, a pit with plastic lining for open water

collection and storage and, a compost pit. An assessment on water availability was done. Required supplementation was arranged through water sharing agreement with neighbouring farmers, the schools, parents, self-help groups, and community-based organizations (CBOs).

**Crop selection:** Priority was given to selection of crops that were monsoon based and rain dependent. Crops such as curry leaves, neem and low water consumption crops like gourd varieties

were given priority. Fast growing plants such as greens and herbs were included in the priority. Based on soil testing done in three of the one acre land units, because of acidic nature of soil, lemon and drumstick trees were included in the priority.

(iii) Post harvest processing and marketing of products was done by the SUAC through their marketing linkages, under their banner. The work and cost of work in each activity was calculated for the purpose of share, capital, and dividend. As mentioned earlier, all items related to 'cash and kind' were virtual, subjected to their reconciliation of the real.

**Project Performance Pre COVID 2018–2019 and Post COVID Cloud Society 2021–2022**

The project has gone through three time phases of productivity and economy. First is the start-up phase of 2018–2019. Second is the COVID period of 2019–2020. Third is the post COVID CLOUD society 2021–2022. The project was evaluated during the first and third phases of its project cycle. Second phase



of 2019–2020 was a lockdown period of the project.

### 2018–2019

**Productivity:** Out of the 10 one acre plots, G2G successfully commenced production in eight plots after making all the micro planning and arrangements. During the year, three cycles of harvest of vegetables and weekly harvest or greens and herbs were done. Out of the eight plots, in five of those plots, the productivity was at the level of about 46 per cent of 'yield and income' compared to the neighbourhood farmers. By the end of the year, two more came into production with about 25 per cent of 'yield and income' by the student producers and their volunteer supervisors. It was found out that the remaining three groups had personal and personality problems because of which they couldn't start up. The constraints were attitudinal and technical as well.

### 2020–2021

Because of the COVID lockdown, the groups were more onto their own for their survival. Collective support and assistance was more spontaneous than planned. The SUAC continued its possible support for marketing of products. G2G provided possible support in all the areas of the productivity cycle.

### 2021–2022

**Productivity:** Out of the seven one acre plots that were in production, six survived the COVID lockdowns. The lemon, drumstick, neem, guava and curry leaves saplings had grown ready for harvest. Monsoon was regular and yield was good. Short-term trees like banana, and herbs such as mint, coriander and ginger contributed to PAY and PAI, significantly. The appearance of the plots became green and 'seen'. The SUAC said that the price of the one acre plots with productivity has increased by INR 7000–10,000. They gave a view of grandeur to the land! This gave all the seven plots an increase in motivation



for increasing the productivity. Out of seven plots that were in production, productivity has increased from 46 to 61 per cent, in comparison to neighbouring farmers. The SUAC decided to find sale for the remaining three plots that were not able to enter production. Three more land owners have approached the SUAC to help them develop the productivity and value of their lands! In terms of quantum performance in productivity, the achievement is 70 per cent!

**Rate of returns:** The COVID-19 pandemic has brought in a feeling of 'solidarity for survival' among the farmers during its severity. The neighbouring farmers increased their cooperation and helping hand to the seven student producer groups that were in production. Post COVID-19 also increased the market value of organic and rural products by 30–40 per cent. The MFS has increased its working capital from INR 70,000 in 2018 to INR 168,865 in September 2022. The schools gave a helping hand by contributing INR 50,000 each totalling the capital value to INR 268,865 for the year 2023.

**Shares and dividends:** The group did an evaluation of the situation and confirmed

that building the working capital for productivity phenomenally contributed to the increase in the techno-economic feasibility of the MFS prototype. The prototype is incubating with a model with replicability for the year 2023–2025, with increase in capital value.

**Plans for 2023–2025:** The prototype building of the MFS as an enterprise of the two academic schools is planned through the 'Build, Operate and Transfer (BOT) methodology being adopted by G2G. The five partners are to work as two groups. (i) The continuation of model building is to be taken by the two schools and the SUAC as their enterprise; (ii) The group of student producers and their volunteer supervisors are to outsource the productivity in the new group of 10 one acre lands with new benchmarking and baselines of capital, returns on capital, shares and dividend; (iii) G2G will continue to play a facilitation role as found necessary. ■

*Dr R Mohanraj is an Organization Development (OD) practitioner who provides management service support to the projects of G2G. He is also a regular contributor to TerraGreen.*

(Part 2)

# Sacred Groves

## Cultural and Environmental Significance

Sacred groves are forest fragments of varying sizes, which are protected, and which usually have a significant religious connotation for the protecting community. Hunting and logging are usually strictly prohibited within these areas. In this article, **Shakti Bishnoi** and **A S Bishnoi** discuss about the cultural and ecological significance of sacred groves in Indian culture.

**T**he sacred groves are often associated with ponds and streams, and meet water requirements of local communities. It is now scientifically proven that water is because of trees and not vice versa. Sacred groves are scattered all over India, and are referred

by different names in different parts of India. For example, Kovil Kadu in Puducherry and Tamil Nadu, Gumpa Forest in Sikkim and Arunachal Pradesh, Sarna in Jharkhand and Chhattisgarh, and so on. Sacred groves occur in a variety of places—from scrub forests in

the Thar Desert of Rajasthan maintained by the Bishnoi community, to rainforest in the Western Ghats of Maharashtra, Karnataka, and Kerala. 363 Bishnois of Khejarli village were killed by king's soldiers in September 1730 when they were trying to peacefully protect





the trees of their village by holding the tree trunk. This was the first Chipko movement of the world history. Women, children and elders of the village were slaughtered holding the trees.

Our country is full of such examples. A Gujjar settlement appears like a human-inhabited sacred grove because they plant neem for worshipping. Mangar Bani, the last surviving natural forest of Delhi, is protected by Gujjars (or Gurjars) of nearby area. Mangar Bani is one of the last remaining natural tropical forest in the Aravalli range. It has more than 30 native tree species thriving along with the 100 native shrubs and herbs, all of which provide shelter to the wildlife, animals and rare birds, leopards. 14,000 sacred groves have been reported from all over India. Experts believe our entire country was a sacred grove inhabited by various deities and looked after by all

human beings under the able guidance of our saints and tribal leaders.

Every piece of land comes with responsibility. The Sarpanch of every Indian village has an important role to play in the panchayat land of their respective village. He/she should make sacred grove, ghanavan (urban forest),

and herbal garden in every village. He/she should approach the district forest officer and make village panchayat land useful for each villager by planting sacred groves and herbs. The Sarpanch should strive to make his/her village panchayat land useful for each villager by planting sacred groves and herbs. And, if the land



is with the Government of India in their custody it's all the more important for them to fulfil the responsibility even if they are in charge of that land for a month. Every landowner should do tree-based farming. It will sustain your life, protect our soil, solve water problems, and balance the environment.

The concept of sacred grove and ghanavan has been part of earth and our ancestors' lives. The knowledge of plants has been deeply rooted in us. But over the years, we have started living superficially. We think we exist on conditioned air, filtered water, and packet foods. It is time to wake up and be enlightened.

### Sacred Grove (Deorai/Devrai) Plantation

For planting a deorai or devrai, one needs minimum 100 X 100 ft or 200 X 200 ft (ideal) land. And you don't need to cut the existing trees of that area. You just need to remove the invasive plant species. You may contact Mr Raghunath

Dhole for saplings and plantation guidance.

### Urban Forest or 'Ghanavan' Plantation

Any piece of land in any shape or size is eligible for ghanavan or urban forest plantation. It is a dense forest and secluded habitat for birds, honey bees, butterflies, and other insects. And you can contact Mr Raghunath Dhole for saplings and plantation guidance.

### Lockdown Effect

COVID-19 pandemic did a surprise check on humans. Suddenly, humans were scared! The people in metropolitan cities were caged in their pigeon holes. As per the capacity of an individual, they made changes in their lives. Everything came to a standstill. Responsibility saw light. Life skills became the most important part of our daily routine. The first lockdown (March–May 2020) was the turning point and it helped many people

to turn inwards and realize their role in the universe and at home. Some people could understand how they were wasting their time in doing useless things. After a long time many people realized the relevance of plants in our lives. The way we have been treating them and taking things for granted has resulted in global warming.

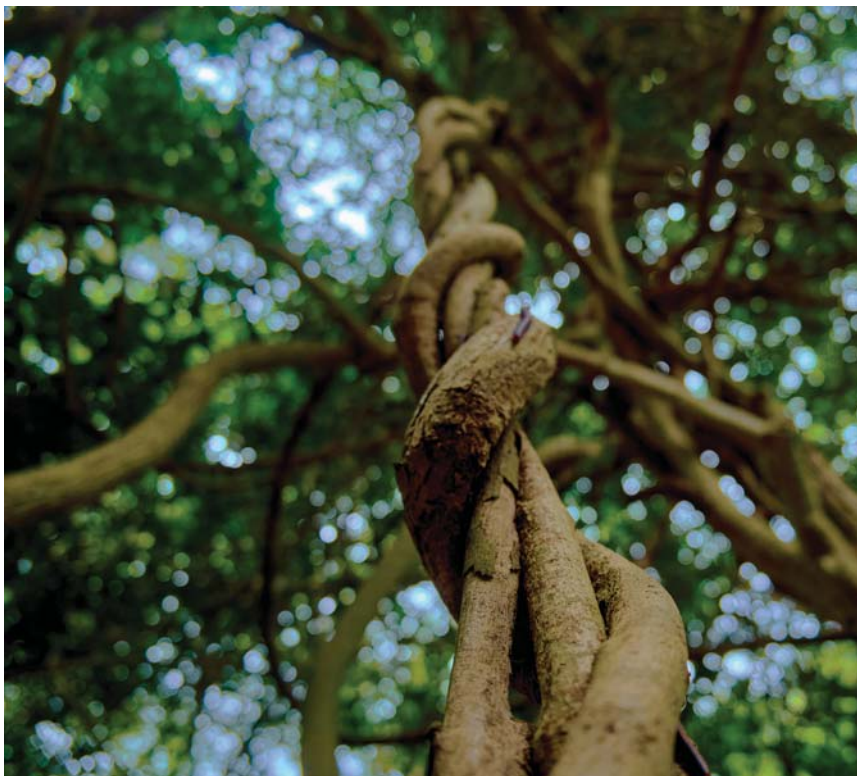
Lockdown gave us the opportunity to contribute more than pre-corona times. One of the authors of this article (A S Bishnoi) planted 1500 saplings in MILIT (including devrai) and nearby places (Dhonje, Singhad, and Khanapur) since March 2020. Now, every month they visit the site for a brief talk with plants giving them the assurance that they are there to look after them and nurture them with love. The authors celebrate every important occasion in their lives by planting trees and share the responsibility with their daughter to look after the plants.

### What Every Individual Can Do

First, stop complaining. Start observing. Walk, cycle or run around the area you live. Find places where you can contribute. If you want to plant, get native saplings (no invasive or hybrids). Plant the saplings and look after them. If you are attentive, you will know what to do. Remember, plants don't survive only on water. Be there for them—they have always been there for us. Grow your own vegetables and fruits. After first monsoon shower, plant the saplings and they will thrive.

Mr Raghunath Dhole can be contacted on mobile number 9822245645 for saplings and plantation guidance. He supplies saplings to all parts of India. ■

*Mrs Shakti Bishnoi is a counsellor, ornithologist, botanist, wildlife photographer, and marathon runner. She strives to increase the green cover by planting native trees. Mr A S Bishnoi is an entomologist and qualified ornithologist. He planted Pune's first sacred grove and has also planted 1215 native saplings around his Pune home.*





# Terra Youth



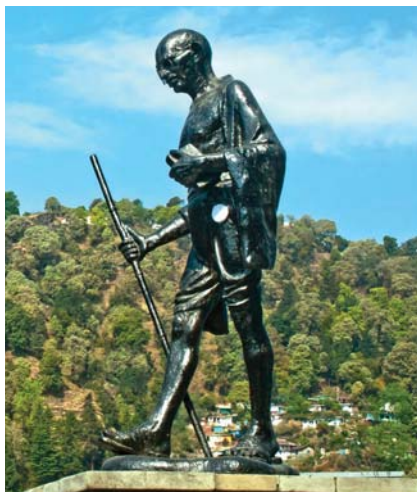
Joining Hands  
for a Greener  
Tomorrow

# Understanding Sustainability through Gandhi

## The Gram Swaraj

Today, as the world grapples with terrorism, climate change, migration, and development and invests billions of dollars in the process to overcome the adversities of these global challenges, Mahatma Gandhi has become even more relevant and significant for us. In this article, **Himanshu Kumar** and **Prof. Vivek Kumar** opine that it is high time we slowly get back to our roots and understand the concepts of life from the depths of Gandhian Principles.

India is a land of rivers, mountains, deserts, 1.38 billion people, and numerous cultures, languages, dialects, and ontologies. Connecting them are numerous things, but the two most prominent ones are the Tiranga (the tricolour flag of the nation) and the “The Mahatma”— Gandhi, the architect of India’s independence struggle. A simple man, clad in a dhoti, wearing chappals and round glasses, led millions of people through truth and non-violence to independence. The Gandhi that the world knows and understands is the guiding light for the world and the epitome of simplicity, love, truth, and non-violence. A life dedicated to the masses and he lived each second to liberate the people



from the colonial regime, the social evils, and intellectual barriers that pushed the Indian society into the helm of poverty, drudgery, and dependence.

With an enormous potential of natural, physical, and human capital, India embarked on a development journey after attaining independence in 1947, an arduous journey in which it was essential to strike a balance between resource consumption and production. The country had to ensure food for its then 340 million population and to prepare itself for the upcoming centuries in terms of technological advancements and economic reforms. The Indian school of thought, belief systems, and way of life did play a crucial role in understanding development and also ensuring that in the process of development, we cater to the needs of the most downtrodden and deprived sections of the society, we consume our resources judiciously and carve our niche for the world to understand and follow.

This was possible because we believed that society’s ideas, thoughts, and psychology could deal with the problem of production, consumption, and the mismatch between demand and supply. This could be further explained by understanding India’s historical thinking about the consumption of resources; we always believed in rational consumption instead of unlimited wants. Gandhiji

emphasized preserving our ecosystems, using everything organic and eco-friendly, reducing our consumption, and not stressing the environment. For this, he even reduced his consumption demands, spilling the roots of sustainability in Indian society.

As the world understands it today, development is a complex set of variables and a highly contested and ambiguous nature; different societies, countries, individuals, and groups draw other inferences. Still, a vague definition could bring about social change that allows people to achieve their human potential. Development is a process and not an outcome, and it could have various dimensions, both positive and negative. The School of Oriental and African Studies (SOAS) describes the development as a political process leading to the power tussle.

The Gandhian way of understanding development dwells deeper into philosophy and conscience very aptly; he stated that development is of two types, physical and intellectual; a combination of both is necessary for a society to progress and call itself a developing/ developed one. Also, development is impossible without taking care of our environment and utilizing the available resources most judiciously. Gandhiji, therefore, clearly understood the interrelationship between the three



pillars of sustainability, that is, social, ecological, and economic, and laid stress on striking a balance between the three for constructing a progressive society.

Human civilizations have co-evolved and co-existed with nature, and the human environment's continual survival must be kept at the core, which is precisely why the world devised the millennium development goals in 2000 and later, the sustainable development goals in 2015. However, if we look at the rural population in India and understand their philosophy and way of life, we will appreciate the sustainable systems existing in those societies; the tribal and indigenous communities could be an excellent example of this. These communities have understood sustainability in a more profound sense and have implemented it as a way of life.

## The Gram Swaraj Model

In his book *Gram Swaraj*, Gandhiji explains the idea of a self-reliant village; his concept of *Gram Swaraj* could be one of the most excellent models, focusing primarily on the development of the individual without compromising the integrity of the society and developing a self-sustainable economy.

He believed that we need not look up to the west for development; instead, we should focus on indigenous modes of growth, precisely defining them based on the available social, economic, and environmental resources, in a way talking about the concept of sustainability at the local level. Today, we often hear about the bottom-up approaches to development and the local area plans and local adaptation strategies. However, Gandhiji's farsightedness is that he understood these concepts way before their time. A focus on traditional businesses was highly prioritized for the inclusive growth and development of society as a whole; he mentioned that the real meaning of development is when every individual in the community grows and not just a handful of them when he

said, "Equality for all, opportunities for all, and a feeling of respect for all countrymen."

The modern world now wishes to adopt and is struggling to implement the concept of sustainability, which has been long prevalent in rural India; the fabric of the rural community was embedded with sustainability. It is noteworthy that while the formal definition of sustainable development was introduced in 1987 by the Brundtland commission, Gandhiji had been preaching the concept since the 1920s. The villages in India have functioned primarily on the ideas of 'Minimalism,' 'Mutualism,' 'Farm to Fork,' 'Zero Waste,' 'Circular Economy,' and encompassing all of them is 'Sustainability.' A close observation of the Indian village society would lead us to better understand these concepts; the Indian farmer has since time immemorial followed the practice of farm to fork; he grows the crop and keeps a portion of it for the needs of his family, the practice of kitchen gardens have also been prevalent in many parts of the country. Before the green revolution overpowered the Indian agriculture systems, the source of fertilizers was the animal waste or 'gobar khaad,' which the modern world has now realized and an enormous market for organic had been developed over the years, nothing was a waste, and everything was either reused or recycled into something in the Indian village, which is prevalent till now.

Gandhiji's idea of development was that the flow of dependency should be from village to town and not vice versa; he laid stress on the use of technology but not compromising the traditional knowledge, skills, and art forms; he firmly believed that technology is a mere tool, and we should not depend exclusively on the (Yantras). He was a man way ahead of his time; that reflects in his works, his thought and intellect were beyond the imagination of the people of his time, and now, Gandhi has become so relevant to the world that the whole world is interested in knowing the Gandhian way, the most simplistic form of living,



and contributing to the global good through local actions. Gandhiji had warned humanity against social and political turmoil, ecological devastation, and misery until the modern civilizations understood the importance of nature and learned to live in harmony with it and contain its hyper-consumerist behaviour. He warned that unlimited-consumerist tendencies and callous indifference to values would not help humanity progress towards peace.

Today, when the world struggles with terrorism, climate change, migration, and development and invests billions of dollars in the process to overcome the adversities of these global challenges, Gandhi has become even more relevant and significant for us, and it is high time we slowly get back to our roots and understand the concepts of life from the depths of Gandhian Principles.

The principles of being honest and truthful, utilizing the resources judiciously, growing our food, ensuring cleanliness, and non-discrimination on caste, creed, and religion. Aptly said, in his own words, "There is enough for a man's needs but not for his greed." This could well be the modern-day definition of sustainability, which encompasses the principles of both equity and equality. ■

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*Himanshu Kumar and Prof. Vivek Kumar, Centre for Rural Development and Technology, IIT-Delhi.*



# GREEN Quiz



GREEN Olympiad Secretariat welcomes you to GREEN Quiz Section! Through this section, the Secretariat aims to reach out to student readers to avail an opportunity to prepare for GREEN Olympiad examination scheduled for October/November 2022.

The month of October is auspicious due to lights, colours, sweets, and lots of other festivities. This section reminds you of your role as responsible citizens and hope that you follow the principles of 'sustainable consumption' while enjoying with your family and friends.

- Shipping is one of the most dominant modes of transport to supply goods and commodities across the globe. Which of the below listed option is NOT an environmental issue caused by the shipping industry?
  - Pollution of seas on account of the release of ballast water
  - Release of noxious oxides of nitrogen and sulphur
  - Collision with marine mammals such as whales, dolphins, etc.
  - Movement of people from one place to another
- Soil pollution occurs when soil productivity is decreased due to the presence of contaminants in the soil. Which of the below listed items is NOT a soil contaminant?
  - Plastic
  - Pesticides
  - Fertilizers
  - Dried leaves
- Name the farming practice that is followed to reduce soil pollution by using natural sources of soil nutrients and natural methods of crop and weed control.
  - Pastoral farming
  - Organic farming
  - Subsistence farming
  - Commercial farming

4. Air pollution is caused on account of release of chemicals, gases, fumes, particles and odour into the air and atmosphere. There are natural and manmade causes of air pollution. Pick the odd one out from the options listed below.
  - a. Exhaust from vehicles
  - b. Volcanoes
  - c. Fumes from spray cans
  - d. Smoking
  
5. The various aspects of the environment that can be impacted directly and indirectly by burning firecrackers are listed below. Choose the most appropriate option.
  - a. Fire crackers do not cause any kind of pollution
  - b. Fire crackers cause only air and noise pollution
  - c. Fire crackers cause air, noise, and water pollution
  - d. Fire crackers cause air, water, soil and noise pollution
  
6. The release of biodegradable waste into water bodies encourages microorganism growth, which uses up the oxygen in water. What happens to fish in water bodies with less oxygen?
  - a. It does not affect the fish as they don't need oxygen
  - b. They can no longer float in water
  - c. It can impair their activities and cause them to die
  - d. They become blind
  
7. Indoor air pollution is caused when air pollutants contaminate indoor areas. This is a serious problem as exposure to such pollutants can cause adverse health impacts. Which of the following is not a cause for indoor air pollution?
  - a. Smoking tobacco
  - b. Smoke released from the chimney
  - c. Use of fuelwood and animal dung for cooking
  - d. Damp environment indoor results in the growth of mould, bacteria, dust mites, and mildew.
  
8. Air pollution can increase the risk of acid rain. Which of the following is NOT an adverse impact of acid rain?
  - a. Staining building and historical structures
  - b. Damage crops
  - c. Increases the size of particulate matter in air
  - d. Adversely affect marine life
  
9. Excessive use of plastic is causing serious environmental and health problems. Which harmful gases are released into the atmosphere on burning of plastics?
  - a. Furans
  - b. Dioxins
  - c. Polychlorinated Biphenyls
  - d. All of the above

Answer key:  
1. (d); 2. (d); 3. (b); 4. (b); 5. (d); 6. (c); 7. (b); 8. (c); 9. (d)

# Patrolling Vehicles at Ranthambore National Park

## TACO Supports Ranthambore NP to Boost Conservation Efforts

The Animal Care Organization (TACO), an animal welfare project of Anil Agarwal Foundation (AAF), philanthropic arm of Vedanta, has flagged off first of the six patrolling vehicles at the Ranthambore National Park to bolster the monitoring and surveillance of the tiger reserve and its habitation.

On November 9, 2022, at Sawai Madhopur, Rajasthan, The Animal Care Organization (TACO) flagged off first of the six patrolling vehicles at the Ranthambore National Park to bolster the monitoring and surveillance of the tiger reserve and its habitation. The vehicles were flagged off by Ms Priya Agarwal Hebbar, Non-Executive Director, Vedanta & Anchor, TACO with Shri Danish

Abrar, Hon'ble MLA, Sawai Madhopur & Advisor to the Chief Minister of Rajasthan in the presence of Shri Suresh Kumar Ola, District Collector of Sawai Madhopur.

TACO was founded by Priya Agarwal Hebbar with a vision to create a nurturing environment for animals by advancing care and enhancing welfare. With an initial budget of INR 100 crore, the programme is already operational

in Haryana and Rajasthan currently and will be expanded throughout numerous other Indian States.

Earlier this year on International Tiger Day, TACO granted a sum of INR 1 crore to the Forest Department, Government of Rajasthan. The grant has been utilized by the forest department to procure the patrolling vehicles, hence, bolstering the current conservation efforts and infrastructure for monitoring at the Ranthambore National Park.

On this occasion, Ms Priya Agarwal Hebbar said, "The Ranthambore National Park is a biodiversity haven with a large number of flora and fauna, including apex predators such as the tiger. TACO's efforts of supporting the reserve with patrolling vehicles will be instrumental in the protection of this diverse ecological hotspot. These vehicles will empower the forest guards and strengthen the monitoring and surveillance, ensuring holistic wildlife conservation."

Sharing his thoughts, Shri Danish Abrar, Hon'ble MLA, Sawai Madhopur & Advisor to the Chief Minister of Rajasthan commented, "Tigers are a symbol of national pride and Ranthambore National Park is a natural habitat of these big cats. It is heartening to see the support





that Anil Agarwal Foundation's TACO has extended to the reserve in creating a more robust patrol-based monitoring system. I am sure this shall prove to be a pertinent step towards the Rajasthan government's journey to holistic wildlife conservation, safeguarding them from poaching and ensuring a safe environment to flourish."



According to the 2018 census, India has 2967 tigers, the highest number of tigers in the world. The Government of Rajasthan under the 'Project Tiger' diligently undertakes several initiatives to halt poaching and encroachment to ensure the protection of tigers. Ranthambore National Park, which is situated in the Sawai Madhopur District is one of the largest and most well-known tiger reserves in the nation. The national park in Rajasthan is well recognized for being a home to 74 Royal Bengal Tigers. In addition to these, the national park is home to many other animals, including sloth bears, jackals, chitals (spotted deer), marsh crocodiles, palm civets, and leopards.

TACO is a unique animal welfare project providing world-class infrastructure, veterinary services, a training facility, and animal shelters to heal and protect animals. TACO's three pillars of shelter, hospital and academy aims to develop international standards for animal welfare. Advanced animal

healthcare, preventive veterinary care, a spay and neuter programme, diagnostics, and mobile emergency care units will be the main priorities of the proposed multi-specialty veterinary hospital. A TACO run academy will offer short-term courses for a variety of target groups, including veterinarians and paraprofessionals, the animal shelter will concentrate on rescue, rehabilitation, geriatric and palliative care, animal housing services, nutrition, and well-being.

The Anil Agarwal Foundation is the umbrella entity for Vedanta's community and social initiatives. The focus areas of the Foundation are Healthcare, Women and Child development, Animal Welfare Projects, and Sports Initiatives. Anil Agarwal Foundation aims to empower communities, transform lives, and facilitate nation building through sustainable and inclusive growth. ■

For further information please contact: Mr Sudeep Mishra, Group Head - PR & Strategic Communication, Vedanta Ltd, Email: sudeep.mishra@cairnindia.com



## Bird Personalities Help Population Cope with Climate Change

The areas in the Wadden Sea where red knots, plump migratory birds, spend the winter are under pressure. The Wadden Sea is changing due to human influences such as mining for gas, tourism and due to sea level rise. Ecologists have studied how 'personalities' of individual red knots differ and affect the way they search for food. Individuals that are fast explorers and take the risk to forage in different areas, also eat different food. This could make the total population of red knots a lot more resilient while their environment is changing. Red knots could copy the food-gathering behaviour of adventurous peers who succeed in new places. Differences in character between red knots seem to be an important ingredient for the resilience of the whole group.

Source: <https://www.sciencedaily.com/>

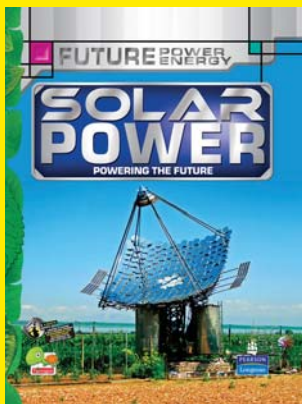
## Earth's Many New Lakes

The number of lakes on our planet has increased substantially in recent decades, according to a unique global survey of 3.4 million lakes that the University of Copenhagen has taken part in. There has been a particular increase in the number of small lakes, which unfortunately, emit large amounts of greenhouse gas. The development is of great importance for Earth's carbon account, global ecosystems, and human access to water resources. Bacteria and fungi feeding on dead plants and animals at the bottom of a lake emit vast amounts of CO<sub>2</sub>, methane, nitrous oxide, and other gases. Some of these gases end up in the atmosphere. This mechanism causes lakes to act like greenhouse gas factories. In fact, freshwater lakes probably account for 20 per cent of all global CO<sub>2</sub> fossil fuel emissions into Earth's atmosphere.

Source: <https://www.sciencedaily.com/>



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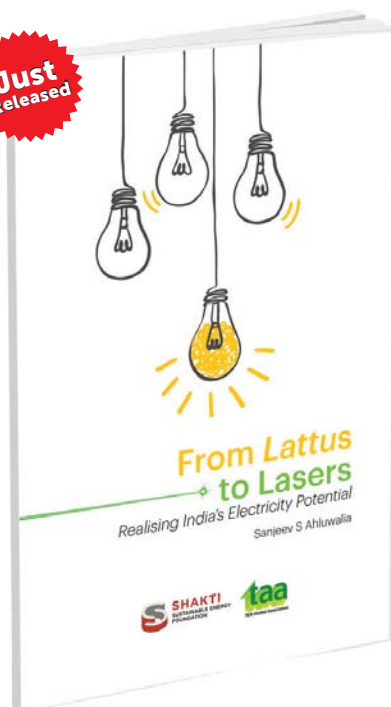
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Can you imagine having no petrol for your car? Can you imagine no electricity to power your lights, fridge, and television? The fuels we use today are going to be over sooner or later. They are also causing pollution. We need clean and renewable sources of energy. This book takes a close look at solar energy as a future source of power

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The history of electricity in India traces an inverted arc – like a smiley – which starts in the colonial period with private electricity capacity leading, regresses to a mode of near complete public sector monopoly by the 1980s and then traces the upward incline to a near 50% share for private electricity suppliers – not a full smiley but a slightly lop-sided one. The half-smile – like Mona Lisa's – masks long periods of misallocation of public capital, unabashed populism, and careless adherence to 'path dependencies' which plagues bureaucracies the world over. This book asks a few inconvenient questions and provides some out-of-the-box solutions with the intention of enlarging the public debate around how the electricity sector should be regulated and developed going forward.

This book is useful for adults who are concerned about topical issues but lack the understanding to make sense of what they read or watch in the mass media.

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# Rescuing Joymala

## A Mission Unaccomplished

Female elephant Joymala from Assam remains shackled in chains on a hard concrete floor in Tamil Nadu. In this article, **Nava Thakuria** tells us about her plight as she was leased for only six months, but she has not been returned to the custodian even after its expiry long back.

**F**irst things first. Assam's elephant Joymala, which is in the custody of Tamil Nadu's Srivilliputhur Nachiyar Thirukovil temple authority, remains shackled in chains on a hard concrete floor. Leased out from a private owner in Assam in 2008, the young female elephant has been kept in complete isolation from others of her kind. Logically, Joymala (also known as Jeymalyatha) was leased for only six months, but she has not been returned to the custodian even after its expiry long back.

People for the Ethical Treatment of Animals (PeTA) India, which recently brought Joymala's matter to the public through video evidence, lately refuted the claim of the charitable endowment department where it explained about measures taken against the caretaker and that Joymala was doing good. PeTA India affirms that Joymala is living with deep wounds on legs indicating her long-term chaining and she continues to be captive in Tamil Nadu with no legal permission. After a veterinary inspection visit was made to Joymala in July, the

pro-animal organization submitted a report to Tamil Nadu officials explaining that her feet are painfully infected and Joymala's skin is brutally twisted with pliers to control her. She is forced to live on unhealthy surfaces that lead to infection and osteomyelitis. It also noted that no visitors were allowed to enter the area where Joymala is being kept.

"Our investigation shows Joymala is living a miserable life of pain and fear, denied the opportunity to move around freely or to socialize with other elephants. Enough is enough. It is high





time for Joymala to be seized and sent to a rehabilitation centre, where she can feel safe, recover from her trauma, and be in the company of other elephants," said PeTA India's campaign manager Radhika Suryavanshi. Meanwhile, following a massive public uproar in both mainstream and alternative media, the Chief Minister of Assam sent an expert team to Chennai for inspecting Joymala's physical condition and her probable early return. But shockingly, the visiting team was not allowed by the temple authority to witness Joymala.

Now the State Environment & Forest Department is seeking directions for her transfer from Tamil Nadu through Gauhati High Court. However, PeTA India argued that any decision regarding her custody should be made in the best interest of Joymala only. PeTA India even lodged complaints against both the forest departments of Assam and Tamil Nadu. It recommended that Joymala be sent to a specialized rehabilitation centre skilled in handling abused elephants, where she can live unchained and in the company of other elephants.

Need not to mention that abused elephants may retaliate with the people around. According to Heritage Animal Task Force findings, the captive elephants killed over 525 people in Kerala during the last 15 years. There are a number of incidents across India where frustrated captive elephants attacked mahouts (caretaker/operator) to death. In recent times, Deivanai killed the mahout at Subramaniya Swami temple and Masini did the same at Samayapuram Mariamman temple, added PeTA India, whose motto reads animals are not born to be abused by humans.

Recently, internationally famed musician Paul McCartney, who was part of the globally renowned band The Beatles, sent a letter to the Union Ministry of Environment, Forest and Climate Change to take immediate initiatives for shifting Joymala to a suitable rescue centre. "I have considered India a spiritual



place ever since I travelled there in the 1960s. I was impressed by India's cultural love for animals. I know India reveres elephants, its national heritage animal, but cruelty to animals happens everywhere, even in India," commented McCartney. A vegetarian by choice McCartney in his letter also added that Joymala should receive the specialized care she urgently needs for her psychological wounds. Arguing that she suffered more than enough, McCartney asserted that Joymala deserves to spend the rest of her time away from abusive trainers. In nature, female elephants live in a family herd, but Joymala is still being forced to live in solitary confinement, he lamented.

Amidst all hue and cry, many social media users uploaded a different photograph (as being of Joymala) which portrays an old male elephant. After cross checking, it is found that the weak and ailing elephant was photographed in Bangkok some years back by acclaimed American photojournalist Kirsten Luce. Responding to queries from this writer, the independent wildlife photographer revealed that the image was taken by herself during an assignment in Thailand from National Geographic. But, Joymala is not the only elephant leased out of

Assam as convincing source claims that no less than hundred elephants have been leased (or sold in secret) in the last decade. The State forest department, which provides a certificate for transferring an elephant from one place to another, needs to clarify that it has not leased or sold Joymala to TN temple authority, rather it was taken from a private owner following some understanding, best known to the individual and Joymala's present custodian.

Soumyadeep Datta, a wildlife expert associated with the Union government's Project Elephant initiative, argues that the elephant, even though it may be domesticated, is always recognized as wild in India and hence the forest authorities have some responsibilities all the time. He argued that if anyone wants to lease an elephant (for being unable to support the care or any other reason), the forest department avoids giving permission and the owner should be advised (directed) to release it in the wild after necessary preparations. ■

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*Nava Thakuria is a professional journalist with the academic qualification of engineering (mechanical/automobile), and is based in northeast India.*

# A Generation of Sustainability

## How Gen Z is Forcing Businesses to Go Green

The world has become more environmentally conscious, especially after COVID-19, and the UK is not far behind. Thirty-six per cent of consumers only support environmentally friendly companies. There's no doubt that sustainability is taking centre stage when it comes to economic and political conversations. Gen Z continues to campaign for climate change-related causes actively. Consequently, businesses are under the radar and actively held accountable for their actions, raising hopes for a future that doesn't see the average temperatures rising to more than 2°C.

**G**eneration Z, born between 1995 and 2012, are the first generation to grow up with the internet and social media while also being the most racially and ethnically diverse generation in history. Now that they are coming of age, Gen Z, known for being highly vocal and passionate about the issues, are using their purchasing power to support businesses that share their values.

Reconomy—a leading supplier of sustainable waste management

solutions, offers insight into the potential impact of the upcoming generation's environmental consciousness on businesses.

### What Does Gen Z Think?

According to Forbes, 62 per cent of Generation Z prefer to purchase from sustainable brands and are willing to pay more for ethically produced goods. Meanwhile, a survey by Bupa reveals

that 63 per cent of Gen Z and millennial respondents reported feeling the burden of climate change, compared to only 37 per cent of Gen X and 28 per cent of baby boomers. These are powerful statistics showing that sustainability is a priority for this generation.

Thanks to the powerhouse voices of Greta Thunberg, Vanessa Nakate, and Mya-Rose Craig, Gen Z has gradually become the most sustainable generation yet. Robust media coverage, which saw an uptick post the Paris agreement, has also helped raise awareness of the damage caused by our behaviour and galvanized Gen Z into action.

There are several reasons why sustainability is essential to Gen Z. They are the generation most affected by climate change. They also hold high awareness of the problems caused by pollution and waste. In addition, their actions are often motivated by a desire to make the world a better place.

Gen Z values have gone on to influence older generations' behaviours. According to a survey conducted by Deloitte, 39 per cent of adults reduced the number of new goods they bought between 2020 and 2021 due to Gen Z and millennials.



## The Impact on Businesses

Gen Z continues to influence change in the business world through their spending habits and advocacy. Businesses are increasingly under pressure to become more sustainable to appeal to this crucial demographic regarding their national and global carbon footprints.

Gen Z's preference for social media and digital channels has spurred businesses to adopt more communication practices that promote their efforts. For instance, many brands communicate their commitment to sustainability through online content and social media campaigns. This shift is not only helping businesses connect with Gen Z consumers but is also raising awareness about the importance of sustainability among a wider audience.

Brands are now more conscious of their environmental impact and are trying to reduce their carbon footprint. This is often done by investing in renewable energy sources, such as solar and wind power, or by introducing more efficient production methods. As a result of this increased awareness, many businesses are becoming more transparent about their environmental practices, providing consumers with information about where their products come from and how they were produced.

Many businesses have adopted environmentally friendly practices due



to pressure from Gen Z consumers. For example, some companies have switched to using recycled or recyclable materials, introduced energy-saving initiatives, or used alternative energy sources.

Businesses are taking note of Gen Z's advocacy and making changes to their practices, but those which fail to adapt are likely to face extinction.

### How Can Businesses Respond

There are many ways businesses can be cognizant of Gen Z's environmental concerns; a cohort that would comprise most of their customer base in the near

future. Here are a few examples:

- Reducing the amount of waste produced in the first place through careful planning and design
- Reusing or repurposing materials whenever possible instead of sending them to landfill—recycling as much waste as possible
- Working with suppliers with sustainable and environmentally friendly practices

Businesses can adopt several sustainable waste management solutions, depending on the type of waste they produce. For example, companies that generate large amounts of food waste could consider composting or anaerobic digestion. At the same time, those with a lot of paper and cardboard could invest in recycling facilities.

Ultimately, the best way for businesses to tackle climate change is to prevent waste from being generated in the first place through initiatives such as reducing packaging, encouraging employees to reuse or recycle materials wherever possible, and promoting responsible consumption habits among customers and suppliers. ■

Source: <https://www.mediaworks.co.uk/>



# Turning Plastic Waste to Fuel

## Start-ups Pioneer Plastics-to-fuel Oil Technology

In this article, **Dr Rina Mukherji** tells us that in recent years, there are quite a few Indian companies that have developed processes to produce fuel oil from plastics. The processes used are zero-emission and zero-effluent, and hence, environment-friendly. Read on to know more...

**E**ven as the Ukraine–Russian war reaches its ninth month, with the world preparing itself for a fuel-starved winter, several pioneering ventures may as yet hold the key to solving the fuel situation staring us in the face. In India, as per statistics furnished by the Central Pollution Control Board, the total amount of plastic waste generated is over 34 lakh tonnes. A large part of this

waste is non-biodegradable. Being non-biodegradable, these plastics remain in the environment for thousands of years, ending up in landfills or else polluting the waterbodies, and at times, the air we breathe. Non-biodegradable multilayer plastics (MLPs) are the biggest burden on the environment. There are several other genres which are just as intractable. These include PETs, PPs, and HDPEs too.

Being non-biodegradable, these plastics remain in the environment for thousands of years, ending up in landfills or else polluting the waterbodies, and at times, the air we breathe.

Since plastics are made out of petroleum, burning plastic waste to very high temperatures through pyrolysis can help retrieve fuel oil of high calorific content. However, the process can



*AP Chemi pyrolysis plant*

release toxic emissions. Hence, it is imperative that it be undertaken under the right safeguards, with adequate anti-pollution measures.

## Start-ups Pioneer Plastics-to-fuel Oil Technology

In recent years, there are quite a few Indian companies that have developed processes to produce fuel oil from plastics. The conversion rate of plastics to fuel oil is upwards of 65–70 per cent (depending on the quality of the waste), with gases produced (a mixture of methane, propane, ethane, and chlorine) being re-used in the process. Thus, the processes used are zero-emission and zero-effluent, and hence, environment-friendly.

One of these companies is Pune-based Rudra Environmental Systems, founded by Dr Medha Tadpatikar. The Thermocatalytic depolymerization process patented by Rudra since the last 4–5 years, is nearly zero-waste and zero-emission and is a form of pyrolysis. MLPs, polypropylenes (PPEs), polyethylene (PET) bottles, and the like are used for the purpose. These are blended, and after being ignited by a liquefied petroleum gas (LPG) flame, get melted at high temperatures in the range of 400°C, resulting in syngas, which is a mixture of propane, methane, ethane, and chlorine and fuel oil. The gases are removed around 200°C, and the fuel oil is collected at the appropriate temperature. Part of the fuel oil produced is re-used in the pyrolysis process, while the rest is sold off as polyfuel. The char or slag left behind in the process finds its use in road construction.

There are two grades of polyfuels produced by Rudra. The unrefined polyfuel is of slightly lower calorific value, while the refined, Grade I variety has a calorific value higher than 11,000 kcal/kg, while the unrefined polyfuel ranges around 10,500–11,000 kcal/kg, depending on the quality of waste

Municipal plastic waste being readied for being melted into fuel



handled. While the refined variety is in demand for use in burners, the unrefined variety has a ready market in rural areas for use in trawlers and boilers.

AP Chemi of Mumbai has been using pyrolysis to turn post-consumer plastic waste into fuel oil since 2007. Equipped with high-end anti-pollution measures, the company has been at work since more than a decade. The conversion rate for plastic waste, in the case of AP Chemi, varies between 60 and 75 per cent. The pyro oil produced as a result of the conversion, has a calorific value of 10,000–10,300 kcal/kg, while the impure oil produced has a calorific value of 9000–10,300 kcal/kg. The pyro oil is sold to petrochemical companies and refineries at the rate of INR 80–90 per litre, while the impure oil sells at INR 40 per litre. Since AP Chemi uses exhaust scrubbers and other measures, as per the specifications spelt out by the Pollution Control Board, the entire process is environment-friendly, with zero liquid discharge.

Both Rudra and A P Chemi are in the process of manufacturing and delivering plastics recycling plants that are non-polluting, and green. Chennai-based Paterson Energy started operations in 2016. Paterson Energy uses a mix of high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene (PP) and polystyrene (PS) for its plastic feedstock, which is bought at INR



15–16 a kg, to convert through thermal depolymerization into fuel oil. Herein, the plastic waste is treated in a cylindrical reactor at high temperature in the absence of oxygen, and in the presence of a catalyst. This produces high-energy gas, oils, and carbon black. Since a continuous batch process is used here, there are no toxic gases released into the atmosphere. The flue gases and energy released from the process are collected and routed back into the reactor as a heating agent. The only residue is carbon, which has commercial applications. On an average, this waste to energy process handles 3–20 tonnes per day of plastic waste to yield—what Patterson Energy terms—Pyro Oil. The product has a calorific value of 8350 kcal/kg, and is far more economical than the petrol



*Plastic waste after being washed for use in plant*

and diesel sold in market. The oil thus produced is generally sold to industrial and corporate consumers for running generators. Although nearly as good a fuel as the petrol and diesel sold in the market, the fuel oil costs at least 30 per cent lesser in price, as Patterson Energy Managing Director Vidya Amarnath, points out.

The conversion process from plastics to fuel oil, in all the three cases, is highly efficient. While Rudra Environmental Systems manages an average of 70 per cent conversion of its plastics feed, Paterson Energy reports 95 per cent conversion.

## Is Pyrolysis a Bad Practice?

Burning plastics can be toxic to human health. Hence, pyrolysis is often criticized as dangerous because of the release of emissions that can cause respiratory problems and cancer. The criticism may even be valid in many cases, since there are several unregistered, 'flexible approach' ventures that do not follow any anti-pollution measures, or environmental norms laid down by the government. But, when one looks at the waste-to-energy plants cited, which melt

plastics, and use them as a resource to generate fuel oil by using environment-friendly technologies, the criticism looks unjustified.

The problem, one finds, lies with unregulated recyclers who burn plastics for oil, disregarding anti-pollution regulations. As per a report by the CPCB, there are 823 unregistered recyclers all over India. Being unregistered, they are beyond regulation. This is where action needs to be taken. On the other hand, start-ups using green technology to produce fuel oil from plastic waste need to be encouraged.

## Problems Faced by Waste-to-energy Plants

In spite of the service rendered in cleaning up the environment, access to adequate plastic waste is a major problem for all these waste-to-energy ventures. As Suhas Dixit of A P Chemi points out, "It is ironical that the plastic waste value chain remains unorganized, although 90 per cent of our plastic waste ends up in landfills." To meet its requirements, AP Chemi gets its feedstock from material recovery facilities, dry waste collection centres, scrap dealers and rejects from

mechanical recycling operations. It also sources segregated plastic waste from Mumbai's Mithi River through its Finnish partner-River Recycle. Paterson Energy, in spite of having an MoU in place with 18 municipalities in Tamil Nadu for obtaining plastic waste, and being an authorized recycler for the Municipal Corporation of Chennai admits facing a 'challenge.' The plastics collected as part of municipal solid waste (MSW) is also, dirty and of poor quality. Hence, the company has to "procure the same from plastic vendors," as Managing Director Vidya Amarnath informs me.

Rudra Environment Solutions, too, faces a similar problem, and is compelled to source its plastic waste through the Keshav Sita Trust, which collects plastic waste from 15,000 households in Pune, Thane, and other towns. This is, in spite of waste-recycling plants paying up to INR 15-16 per kg for the waste.

## Right Approach

Clearly, we need good recycling strategies to manage the colossal burden of our existing plastic waste. For this, there ought to be ample encouragement given to recyclers by way of subsidies, and/or land. At the same time, the government needs to keep an eye on the methods used by recyclers, to ensure that environment-friendly methods are in operation, lest the very purpose of recycling be lost. Efforts must also be made to get the plastic waste collection value chain organized at the municipal level nationwide, so that good quality plastic waste is easily accessible for recyclers, making operations smoother. This will not only help overcome our plastic waste dilemma, but ensure that we have a home-grown, viable alternative to traditional fossil fuels in the near future. ■

*Dr Rina Mukherji is an independent journalist with an exhaustive experience. She holds a doctorate in African Studies and has several media and academic awards to her credit.*

# Scientists Convert Waste Paper into Battery Parts

## For Smartphones and Electric Vehicles

Scientists have developed a technique to convert waste paper, from single-use packaging and bags, and cardboard boxes, into a crucial component of lithium-ion batteries. Through a process called carbonization, which converts paper into pure carbon, the researchers turned the paper's fibres into electrodes, which can be made into rechargeable batteries that power mobile phones, medical equipment, and electric vehicles.

Scientists from Nanyang Technological University, Singapore (NTU Singapore) have developed a technique to convert waste paper, from single-use packaging and bags, and cardboard boxes, into a crucial component of lithium-ion batteries. Through a process called carbonization, which converts paper into pure carbon, the NTU researchers turned the paper's fibres into electrodes, which can be made into rechargeable batteries that power mobile phones, medical equipment, and electric vehicles.

To carbonize the paper, the team exposed the paper to high temperatures, which reduces it to pure carbon, water vapour and oils that can be used for biofuel. As carbonization takes place in the absence of oxygen, this emits negligible amounts of carbon dioxide, and the process is a greener alternative to disposing of kraft paper through incineration, producing large amounts of greenhouse gases.

The carbon anodes produced by the research team also demonstrated superior durability, flexibility, and electrochemical properties. Laboratory tests showed that the anodes could be charged and discharged up to 1200 times, which is at least twice as durable

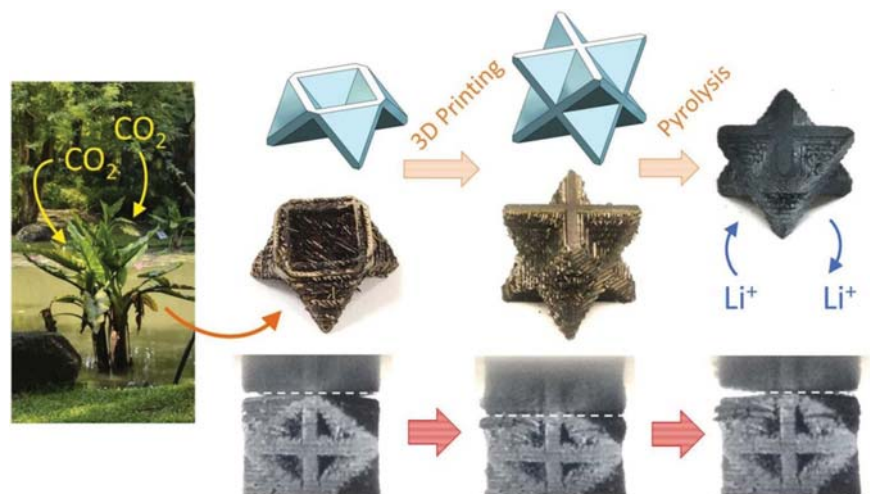
as anodes in current phone batteries. The batteries that use the NTU-made anodes could also withstand more physical stress than their counterparts, absorbing crushing energy up to five times better.

The NTU-developed method also uses less energy-intensive processes and heavy metals compared to current industrial methods of manufacturing battery anodes. As the anode is worth 10 per cent to 15 per cent of the total cost of a lithium-ion battery, this latest method, which uses a low-cost waste material, is expected to also bring down the cost of manufacturing them. The findings were published in the scientific peer-reviewed

journal *Additive Manufacturing* in October 2022.

Using waste paper as the raw material to produce battery anodes would also ease our reliance on conventional sources for carbon, such as carbonaceous fillers and carbon-yielding binders, which are mined and later processed with harsh chemicals and machinery. Paper waste, which comprises disposed paper bags cardboard, newspaper, and other paper packaging, accounted for nearly a fifth of the waste generated in Singapore in 2020.

Kraft paper bags, which make up the bulk of Singapore's paper



waste, were also found to have large environmental footprints compared to their counterparts made of cotton and plastic, due to their greater contribution to global warming when incinerated and the eco-toxicity potential in producing them, a separate 2020 NTU study found.

The current innovation which presents an opportunity to upcycle waste products and reduce our dependence on fossil fuels, accelerating our transition towards a circular economy, green materials, and clean energy, reflects NTU's commitment to mitigate our impact on the environment, which is one of four humanity's grand challenges that the University seeks to address through its NTU 2025 strategic plan.

Assistant Professor Lai Changquan, from NTU's School of Mechanical & Aerospace Engineering, who led the project, said "Paper is used in many facets in our daily lives, from gift wrapping and arts and crafts, to a myriad of industrial uses, such as heavy-duty packaging, protective wrapping, and the filling of voids in construction. However, little is done to manage it when it is disposed of, besides incineration, which generates high levels of carbon emissions due

to their composition. Our method to give kraft paper another lease of life, funnelling it into the growing need for devices such as electric vehicles and smartphones, would not only help cut down on carbon emissions but would also ease the reliance on mining and heavy industrial methods."

## The Recipe for Greener Battery Parts

To produce the carbon anodes, the NTU researchers joined and laser cut several thin sheets of kraft paper to form different lattice geometries, some resembling a spikey piñata. The paper was then heated to 1200°C in a furnace without the presence of oxygen, to convert it into carbon, forming the anodes.

The NTU team attributes the anode's superior durability, flexibility, and electrochemical properties to the arrangement of the paper fibres. They said the combination of strength and mechanical toughness shown by the NTU-made anodes would allow batteries of phones, laptops and automobiles to better withstand shocks from falls and crashes.

Current lithium battery technology relies on internal carbon electrodes that gradually crack and crumble after physical shocks from being dropped, which is one of the main reasons why battery life gets shorter with time.

The researchers say that their anodes, which are harder than current electrodes used in batteries, would help address this problem and extend the life of batteries in a wide array of uses, from electronics to electric vehicles.

Asst. Prof. Lai added "Our method converts a common and ubiquitous material—paper—into another that is extremely durable and in high demand. We hope that our anodes will serve the world's quickly growing need for a sustainable and greener material for batteries, whose manufacturing and improper waste management have shown to have a negative impact on our environment."

Highlighting the significance of the work done by the NTU research team, Professor Juan Hinestroza from the Department of Human Centered Design of Cornell University, US, who was not involved in the research, said "As kraft paper is produced in very large quantities and disposed likewise all over the world, I believe that the creative approach pioneered by the researchers at NTU Singapore has a great potential for impact at a global scale. Any discovery that will allow the use of waste as a raw material for high-value products like electrodes and foams is indeed a great contribution. I think that this work may open a new avenue and motivate other researchers to find pathways for the transformation of other cellulose-based substrates, such as textiles and packaging materials, which are being discarded in large quantities all over the globe."

The NTU team will be conducting further research to improve the energy storage capacity of their material and minimize the heat energy required to convert the paper into carbon. ■

Source: <https://www.sciencedaily.com/>





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# TerraGreen

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TerraGreen promotes the concept of sustainable development. Launched in June 2004, this magazine from TERI is an effort to bring forth information and knowledge in the fields of energy, environment, and sustainable development. The magazine is in keeping with our mission to expand the base of environmentally conscious readers and popularize sustainability issues at the local level. TerraGreen aims to provide the readers with the necessary inputs to enable them to be a part of the process of change. The magazine stays away from all jargon, so that the educated, informed, yet lay readers are updated on all that happens around them everyday.

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# Green events

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December 4, 2022

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### International Conference on Renewable, Environment and Agriculture

December 12, 2022

Mysuru, India

Website: <https://10times.com/>

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December 15, 2022

New Delhi, India

Website: <https://solarquarter.com/>

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December 18, 2022

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Website: <https://10times.com/>



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- Green Challenges  Terra Youth  Review

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- 1  2  3  4  5

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.....  
.....

### 7. Which other environmental magazine(s) do you read?

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.....  
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