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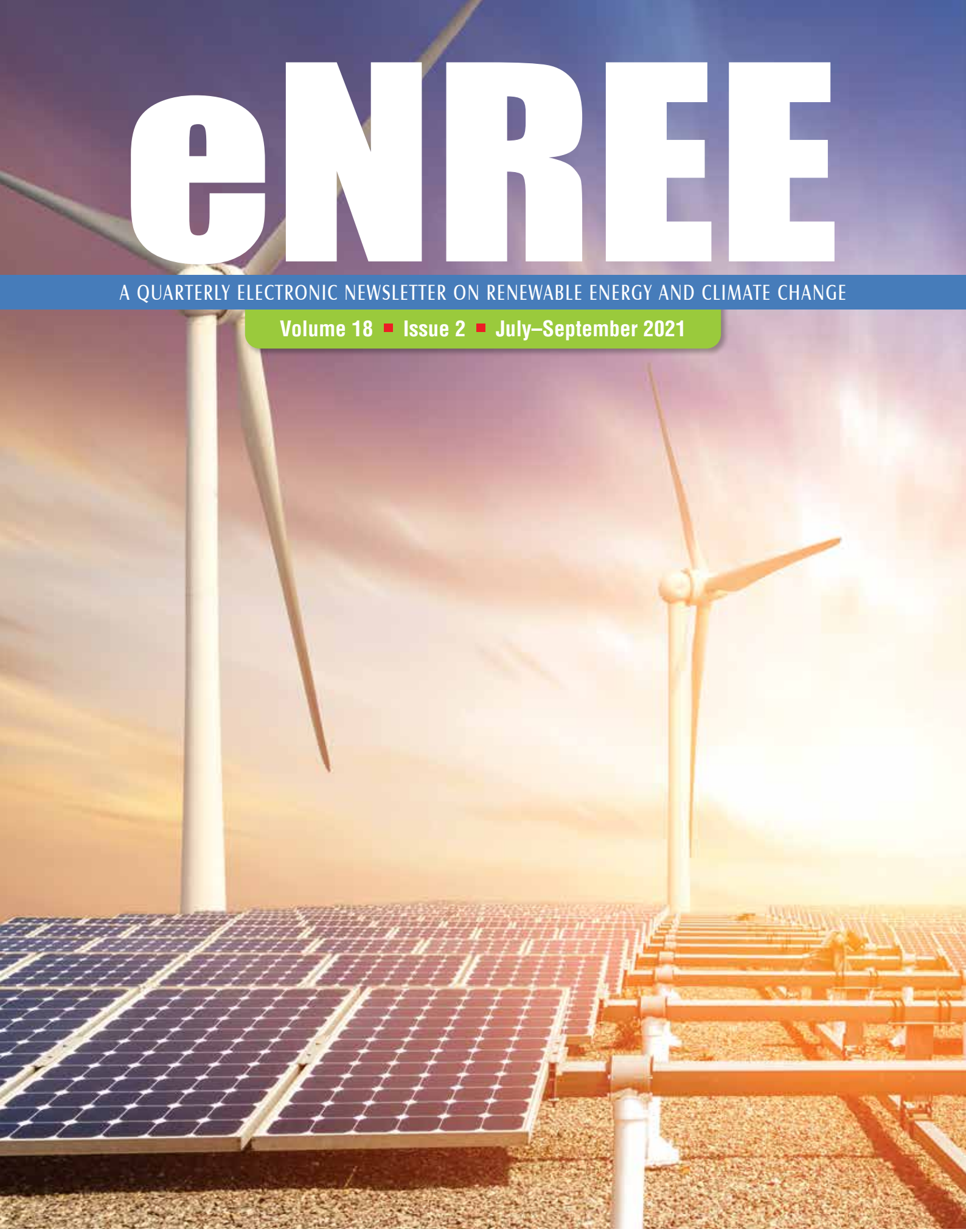

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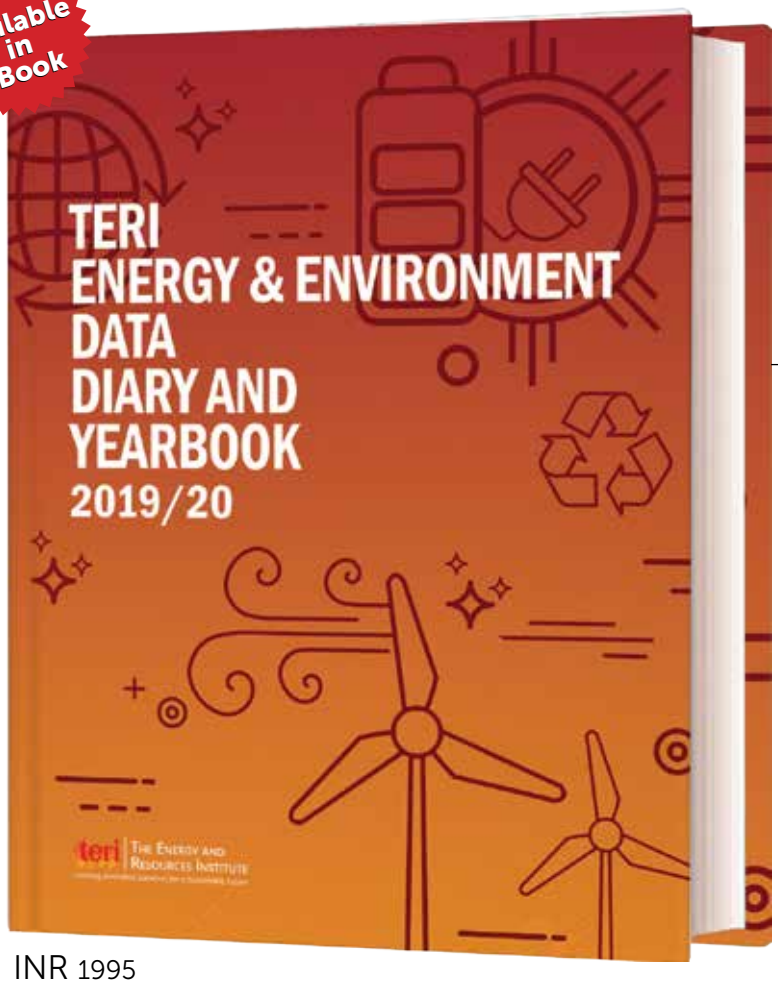

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IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH AND WELL-BEING

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Abstract

Climate change has become a pressing concern throughout the world. The adverse impacts of climate change are seen in every walk of life, from the food that is consumed to the surrounding air and water and also the weather that is observed. The changes abound due to increased emissions and extreme weather events threaten human health and well-being. This article helps to understand these climate change-induced stressors that lead to health risks and also highlights that there is a need to improve public health and safety systems to combat what lies ahead as a global challenge.

Introduction

Climate change is one of the most complex problems the world is facing at the moment. It impacts various aspects of human life including their health and well-being. Climate change has brought about temperature changes, affected air quality and food security, leads to extreme disaster events, water-related, and vector-borne diseases, and also adversely affected mental health and well-being. All these impacts of climate change were not foreseen, at least to this extent. These impacts are most felt by the poor populations with the least resources as they are more vulnerable to environmental determinants of health and have the least capacity to cope with environmental changes. Climate change is likely to affect the lives and livelihood of millions of people. According to a recent report by Monash University and Shandong University, climate change is responsible for causing 5 million deaths globally each year (Zhao, Guo, Ye, *et al.* 2021).

Greenhouse gas (GHG) emissions globally have resulted in rising temperatures, which has led to an increase in deaths. People suffer from heat strokes, dehydration, and even chronic illnesses such as cardiovascular diseases, chronic obstructive

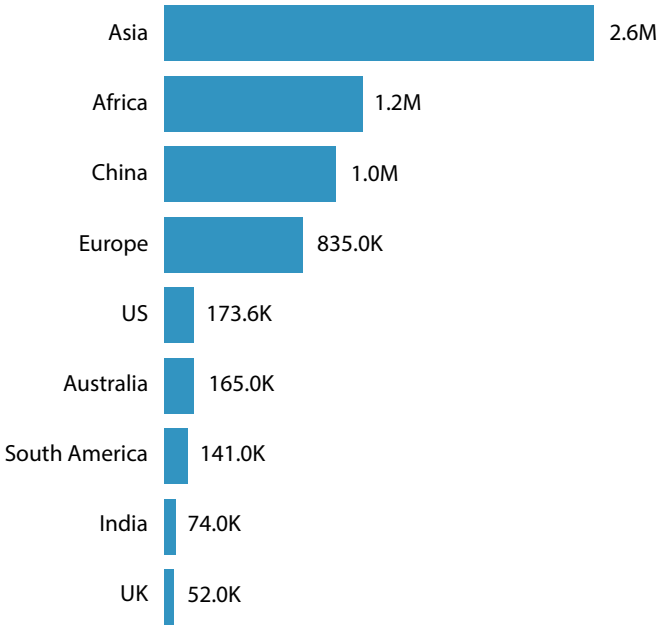

Figure 1: Excess heat and cold responsible for 5 million deaths annually

Source: Zhao, Guo, Ye, et al. (2021)

pulmonary disease, respiratory, and cerebrovascular diseases. Due to high temperatures, the concentration of ground-level ozone is increasing which deteriorates the air quality, aggravating respiratory diseases. Water-borne illnesses and vector-borne diseases are on a rise, which can be attributed to the flood events caused by increased precipitation or storm surges. Floodwaters carry sewage, chemicals, and vector agents that cause diseases such as malaria, dengue, etc.

Climate change also influences food security, safety, and distribution. Elevated sea surface temperatures, extreme weather events, and rising carbon dioxide concentrations are all responsible for damage, contamination, and spoilage of food. Extreme weather events that have become common in current times not only cause immediate damage to life and property but also impact the mental health and well-being of humans. The adverse effects on mental health are primarily felt by vulnerable populations which typically include children, women, the elderly, and people having some pre-existing serious mental illness.

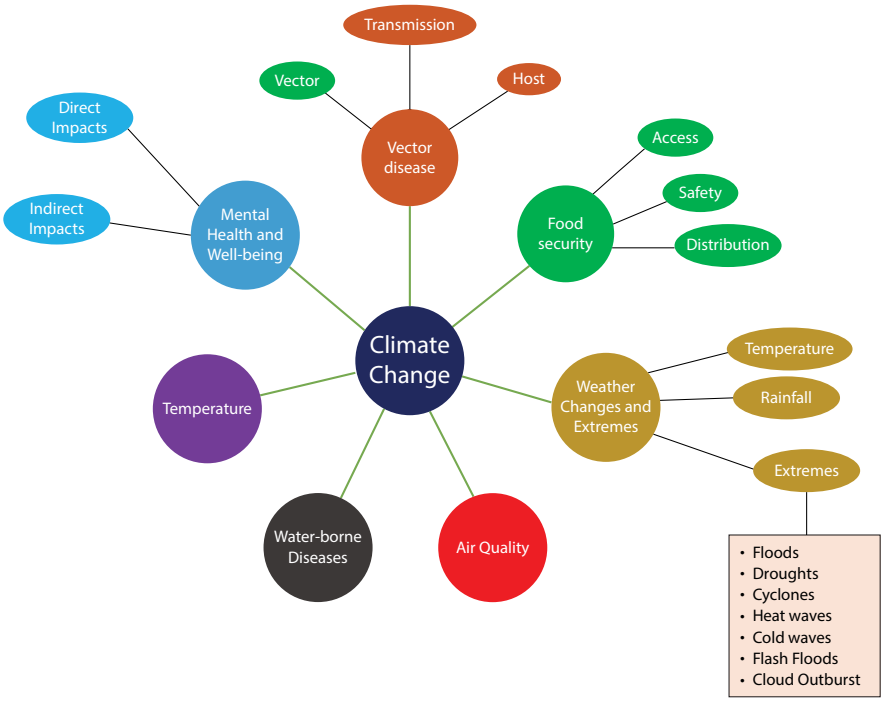

Figure 3: Various pathways showing the impacts of climate change on human health

1.1 Temperature-related Death and Illness

Temperature changes affect health both directly and indirectly. As the temperature changes, the days become hotter in summers and colder in winters, which leads to various health-related complications. This may be because the body is not able to regulate its temperature with rapid changes in the surrounding temperature. 'Loss of internal temperature control can result in a cascade of illnesses, including heat cramps, heat exhaustion, heatstroke, and hyperthermia in the presence of extreme heat, and hypothermia and frostbite in the presence of extreme cold. Several diseases such as cardiovascular disease, respiratory disease, cerebrovascular disease, kidney disorders, and diabetes-related conditions occur and worsen due to increase in extreme temperature conditions' (USGCRP 2016).

Also, people with persisting medical conditions may find it even more difficult to cope up with the increasing temperatures due to a lack of immunity or inability to handle extreme temperature changes. 'India is projected to see an increase of death rates due to climate change equal to about 10% of the current death rate. That is 60 deaths per 100,000 population by the end of the century under a scenario of continued emissions' (CIL 2019).

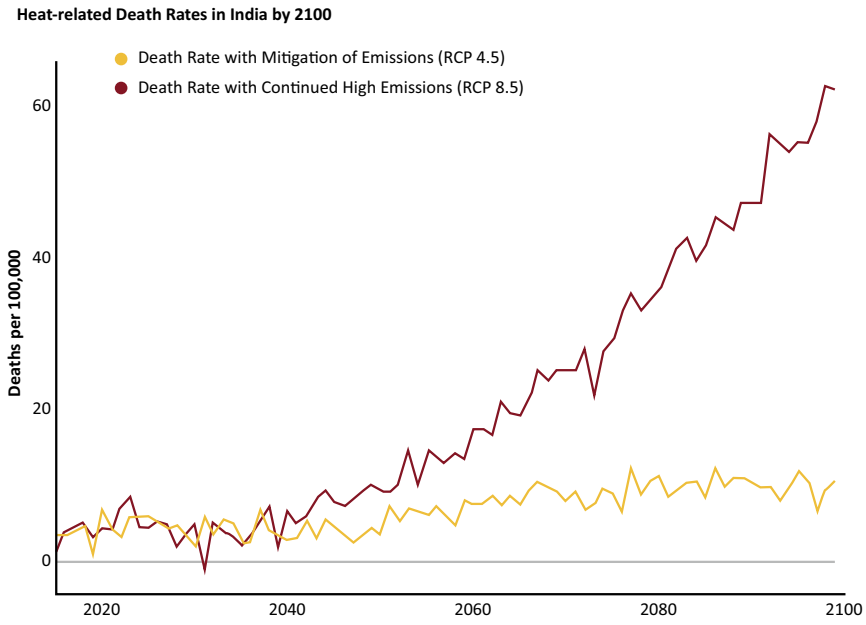

Figure 4: The graph shows the projections of death based on two emission scenarios in India by 2100

Source: CIL (2019)

1.2 Air Quality Impacts

Anthropogenic climate change affects air pollution levels and has the potential to increase ground-level ozone levels and particulate matter concentrations. These are very harmful pollutants as they cause severe respiratory diseases such as asthma and are also responsible for cardiovascular health effects. Globally, the number and severity of wildfires have been increasing which led to smoke and other unhealthy air pollutants, impacting health both directly and indirectly. Airborne allergens are also on the rise due to high temperatures and rising CO_2 levels. Pollen and other aeroallergen levels remain higher in extreme heat. These can trigger asthma, which affects around 300 million people worldwide (WHO 2018).

1.3 Vector Diseases

The world is moving towards a warmer and more unstable climate, which is leading to the expansion of infectious diseases to new areas. The issue needs to be addressed immediately to ensure that diseases are curbed, as due to climate change diseases are showing new patterns of propagation and expansion that were not seen before. Vector-borne diseases such as Zika virus, dengue fever, malaria, and Lyme disease are also expected to rise due to climate change by altering conditions that affect the development and dynamics of the disease vectors and the pathogens they carry.

1.4 Water-borne Diseases

Climate change causes extreme flood events and flood water, which are the best grounds for the transmission of diseases. Such events increase the possibility of mixing human or animal faecal matter with water, thus increasing the risk of faecal–oral transmission of diseases. It may lead to the transmission of rodent or vector-borne diseases, for example, malaria, rotavirus, and leptospirosis.

Various factors including deforestation, clearing of land, and change in temperature increase the risk of malaria transmission. Even a sudden increase in vector production may lead to faster transmissions. Other endemic South Asian mosquito-borne diseases such as chikungunya fever and dengue, parasitic diseases such as leishmaniasis, lymphatic filariasis, and onchocerciasis, and tick-borne diseases, which might change their transmission frequency and spread over existing or new locations, might lead to increased or decreased transmissions (Dhara, Schramm, and Luber 2013).

1.5 Food Security

Food security refers to obtaining and using adequate amounts of safe, healthy, and nutritious food. It encompasses food access, food safety, and food distribution. Food security is a very basic human need and achieving it for all people across the globe is one of the major United Nations Sustainable Development

Goals for 2030. Climate change is one of the major drivers of alterations in food production worldwide. Climatic conditions majorly govern agricultural production, which affects the food available for consumption. Nonetheless, climatic conditions also disrupt food access, food utilization, food stability, and food distribution. Irregularities in temperature and precipitation impact cropping patterns and also increase pest invasion. According to The Climate Change, Global Food Security, and U S Food System assessment report, "For an individual, food insecurity may manifest as a reduced capacity to perform physically, diminished mental health and development, and an increased risk of chronic disease" (USGCRP 2016). "Collectively, food insecurity diminishes global economic productivity by 2%–3% annually (USD 1.4–2.1 trillion), with individual country costs estimated at up to 10% of country GDP. There are currently about 805 million people, or 11% of the global population, who are undernourished according to the Food and Agriculture Organization of the United Nations, down from about 1.01 billion, or 19%, in 1990–1992. At least 2 billion people currently receive insufficient nutrition" (Brown, Antle, Backlund, *et al.* 2015).

1.6 Weather Changes and Extremes

In recent times, extreme weather and climate events such as heatwaves, tsunamis, droughts, floods, and other disasters have become frequent with greater intensity. Around 22.5 million people have been displaced annually due to extreme events driven by climate change since 2008 (USGCRP 2016). The impact is essentially greater on the people living in disaster-prone areas, that is, areas close to the shores that are susceptible to coastal storms, droughts, floods, and rise in sea level. The worst affected by these extreme events are the poor, elderly, children, pregnant women, indigenous people, refugees, and immigrant communities.

Floods and droughts are major causes of concern as they adversely impact food safety and security. The worst affected are the third-world countries, majorly located in the Asian and African subcontinent, which suffer from poverty, therefore, it is hard to recover and rehabilitate the population. Due to climate change, there are recurrent incidences of both floods and droughts and sometimes they even coexist or succeed each other over time, increasing the risk of flooding and landslides. There has been an increase of 46% in the occurrence of climate-related disasters from 2007 to 2016 (USGCRP 2016).

1.7 Mental Health and Well-being

Mental health is the emotional, psychological, and behavioural well-being of a person. Climate change has immediate, gradual, and indirect impacts on mental health and well-being. The sudden onset of

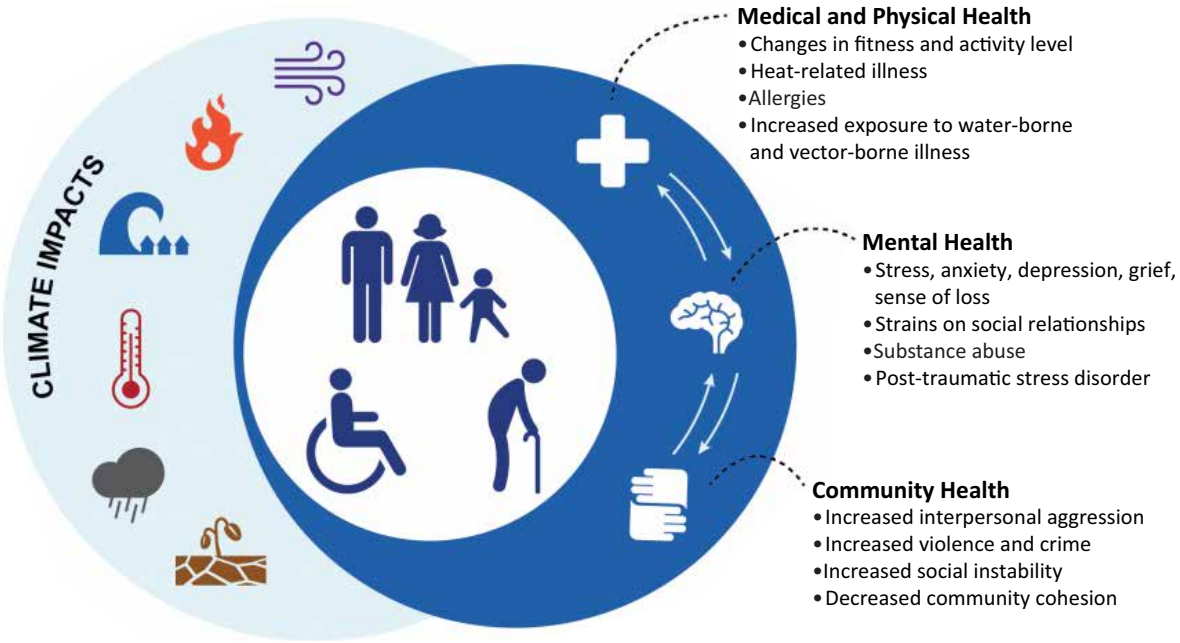

Figure 5: Impact of climate change on physical, mental, and community health

Source: USGCRP (2016)

climate-induced disasters makes people homeless and their livelihoods are lost leading to severe depression, anxiety, post-traumatic stress disorder, stress, and sometimes in these cases people resort to self-harm and substance abuse. These immediate impacts can also lead to gradual chronic stress. Not only this, after experiencing such disaster events, people suffer from identity crises and many of them confine themselves in solace and stop social interaction, leading to a non-cooperative society.

Conclusion

Climate change affects various aspects of human health and well-being as aforementioned. The impact of climate change on human health and well-being is evident which brings to the surface the need for strict actions and mitigation efforts at the soonest. The climate imbalance has proven to be more taxing for marginalized groups including poverty-stricken groups, tribal, and indigenous people, which requires even greater efforts in terms of policies and implementation to reduce the pronounced effects they tolerate in the face of disasters.

The need to exponentially cut down emissions cannot be focused enough than right now. Clean energy, a circular economy, and a green economy shall not remain mere terms to define but should also jump into action as the situation demands.

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STUDY THE FEASIBILITY AND POTENTIAL OF SOLAR APPLICATIONS IN MICRO, SMALL, AND MEDIUM ENTERPRISES IN RURAL INDIA

Introduction

The study was conducted to assist the government and the private sector in promoting and expanding clean energy use to ensure reliable and quality power, improve micro-enterprise productivity, and increase income opportunities for entrepreneurs. The key objectives of the study are as follows:

- Identification of 8–10 micro and small industries clusters in different states in India to explore the potential of the adoption of solar energy as a reliable and sustainable energy resource.
- Develop a roadmap (along with detailed feasibility reports for the selected clusters) for possible market development to scale up solar-based interventions in micro-enterprise sectors.
- Create evidence for policy/project intervention for augmentation of solar energy use in the micro-enterprise sector.

Scope and Approach

The study adopted a variety of approaches including secondary research, primary survey, and consultations with sector experts and important stakeholders at the local and national levels. The following is the brief description of the steps followed in the study:

- **Secondary research, stakeholder consultations, and state selection:** At the beginning of the project, secondary research was conducted which included a careful evaluation of the available literature on the state of the micro, small, and medium enterprise (MSME) sector and the context of energy use in the sector. A thorough review of important policies affecting MSMEs, industry, and renewable energy was also carried out. The literature and policy reviews, supported by consultations with stakeholders from national-level institutions working for MSME development, helped in identifying five states (Gujarat, Karnataka, Jharkhand, Uttar Pradesh, and Telangana) for scoping.
- **Scoping study in selected states:** Engagements with state-level authorities and other sector specialists were held during the scoping visits. Stakeholders' inputs were used to identify suitable micro-enterprise clusters and their compatibility with solar intervention.
- **Primary survey in selected clusters:** From the scoping visits, 15–20 clusters were identified, which were then screened to produce nine shortlisted (power loom, silk twisting, stone idol making, wooden toy, salt, pottery, sewing [readymade garment], silk reeling, and brass utensil) clusters in Karnataka, Gujarat, and Jharkhand.
- **Documentation and workshop:** Initially, micro-enterprise clusters were surveyed and their energy needs were assessed. The data from the initial survey were analysed, and comprehensive feasibility assessments for each micro-entrepreneurial cluster were generated. Accordingly, solar models that best suit to meet the energy needs of the individual firms were recommended.

To disseminate the initial findings and to receive feedback on the study, a stakeholder workshop was organized in Ranchi, Jharkhand. Along with this, online consultations were also organized in Bengaluru. Further, to seek expert opinions on aspects of policy, institutional, technical, social, financial, etc., and further course of action for scaling up of solar PVs in micro-enterprises, a national-level consultation workshop was organized in the form of a webinar.

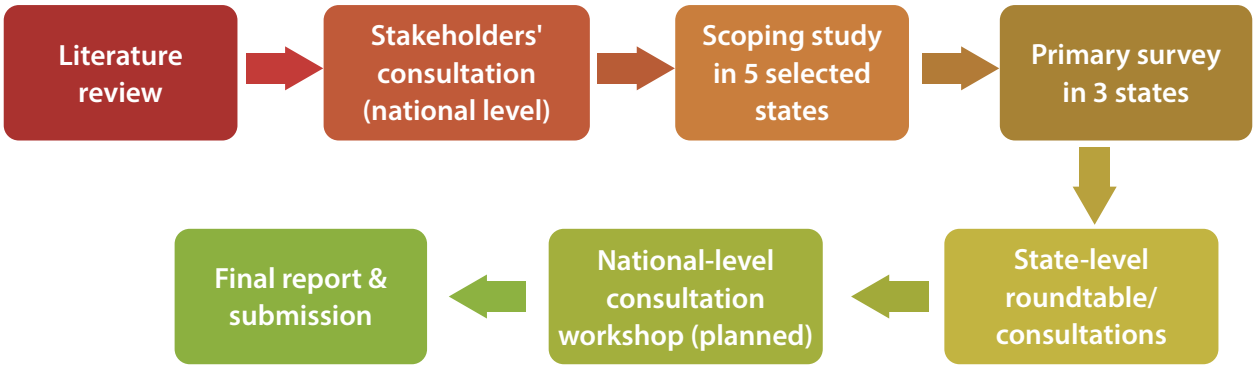

Figure 1: Flow diagram of the study approach

Challenges Experienced

1. **Literature review:** There is a scarcity of literature on solar PV applications in small and micro businesses, and reviewing relevant policies from multiple states needs a lot of time.
2. **Stakeholder consultation**: An early meeting with some of the key stakeholders could not be scheduled due to prior engagements of various stakeholders and a delay in receiving responses from essential stakeholders.
3. **Scoping study in four to five key states**: There was limited availability of the relevant comprehensive cluster-level data regarding the potential of solar applications with state government departments and non-availability of information related to energy challenges at the cluster level with stakeholders. Thus, selecting a relevant cluster for the survey became a bit challenging and took extra time and effort to finalize.
4. **Primary survey**: Entrepreneurs in a few clusters were not enthusiastic about sharing information regarding their business operations. It took extra effort to gain their trust by explaining the study's goal in detail to obtain the necessary information.
5. **Documentation and dissemination**: Due to lockdown, the team was unable to physically meet some of the state-level stakeholders' post-survey, particularly in Karnataka, for feedback and filling information gap, and reaching them virtually or over the phone posed limitations.
6. **Dissemination of the study results**: Despite the fact that study results were delivered through a national-level webinar, one-on-one physical meetings with officials would have been more beneficial.

Most of these challenges were resolved and the team plans to share the findings of the study with the relevant state-level stakeholders whenever opportunities arise.

Lessons Learned (Programmatic and Institutional)

While undertaking the project activities, it was found that the primary survey in the nine selected clusters and the dissemination of the report through a national-level workshop were the most effective strategies. Visits to the clusters and interaction with entrepreneurs enabled the team to understand the workings of the technology, assess the scope for solarization, gauge entrepreneurs' interest in switching to new technologies, and gain nuanced perspectives on ground-level hurdles faced by the micro-enterprise owners and operators.

The interaction with the state-level stakeholders to understand the state policy regime for the promotion of solar energy in micro and small industries clusters was least effective. Further, some stakeholders did not have adequate information related to clusters and were not able to guide the team on choosing appropriate clusters for the study.

Based on the experience of undertaking this project, it is suggested that a deeper engagement with local-level stakeholders (including local-level district officials, financial institutions, etc.) must be conducted and a survey of a larger sample size of clusters is required to get more robust information. This would help in understanding the challenges related to local-level implementation.

Principal Outcomes

Table 1. Outcome map – progress against tactics and outputs

Tactics	Outputs	Explanation
Document Analysis ▪ Review of literature/government reports and previous studies on MSME clusters ▪ Interactions and discussions with key state-level stakeholders for scoping visit	**Month 1** ▪ Reviewing of reports, case studies, etc., and relevant national and state policies of MSMEs, industries, and renewable energy ▪ Inputs from national-level stakeholders	A situation analysis report has been completed ▪ Current policy and regulatory framework related to energy use in the small and micro-enterprise sector identified and documented
Scoping study in 4–5 key Indian states ▪ Local stakeholders' consultations and secondary data collection ▪ Scoping visit to micro-enterprise clusters	**Months 2 and 3** ▪ Identification of key micro-enterprise sectors for solar energy use and shortlisting of 15–20 micro-enterprise clusters in 4–5 states	▪ Selection of 5 states completed based on a set of indicators
Primary survey in 8–10 micro-enterprises clusters in 2–3 states ▪ Primary and secondary data collection in shortlisted clusters ▪ Interactions with industry/ stakeholders at the state level on policy and regulatory issues	**Months 4, 5, and 6** ▪ Capturing micro-enterprise operational aspects, energy consumption pattern, business issues, site assessment, solar resource availability, drivers, and barriers for solar energy use at the cluster level ▪ Identifying schemes or programmes that can aid in the pilot implementation	▪ Survey was conducted in 9 micro-enterprise clusters of 3 states and relevant data have been collected and analysed ▪ Schemes were identified and put in the business models section of the report ▪ State-level stakeholders' consultation was undertaken in Jharkhand ▪ Stakeholders' consultation in Karnataka was undertaken through an online mode due to travel restriction
Documentation and dissemination of study report/workshop ▪ Data analysis and preparation of roadmap and feasibility report for each identified cluster ▪ Organizing stakeholders' workshops	**Months 6 and 7** ▪ Preparation of the draft and the final report ▪ Conducting workshops	▪ Draft report prepared and submitted ▪ National-level workshops were organized ▪ Final report completed

Table 2. Outcome map – progress against outcomes

Outcomes	Explanation
▪ Roadmap (along with detailed feasibility reports for 8–10 selected clusters) for using solar-based electricity in micro and small industries	▪ In this study, a knowledge base on the micro-enterprise sector in India, in the context of energy, through extensive literature and policy reviews was developed ▪ The solar designs and business models proposed in the study could be used as a template for future research and implementation of clean energy in MSMEs ▪ Through consultations in states, the study was able to open doors for dialogue on the prospects of solar application in the micro-enterprise domain and the need for addressing gaps between policy and practice

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Renewable Energy

Green to greener: GAIL eyes 1 GW renewable energy capacity, to set up biogas, ethanol plants

GAIL India Ltd will invest about ₹5000 crore to build a portfolio of at least 1 GW of renewable energy and set up compressed biogas as well as ethanol plants as it steps up efforts to expand the business beyond natural gas. As part of a push to embrace cleaner forms of energy, GAIL will be laying pipeline infrastructure to connect consumption centres to gas sources and spend as much as ₹4000 crore on renewable energy. Also, it plans to set up ethanol units that can convert agriculture waste or sugarcane into less polluting fuel that can be doped in petrol, helping cut India's import dependence. India, which imports 85% of its crude oil needs, is stepping up efforts to explore new forms of energy to clean up the skies and reduce dependence on imported fuels.

Source: Details available at https://economictimes.indiatimes.com/industry/renewables/green-to-greener-gail-eyes-1-gw-renewable-energy-capacity-to-set-up-biogas-ethanol-plants/articleshow/84010489.cms, last accessed on July 28, 2021

Floating solar power plant to be ready soon in Telangana

India's largest floating solar power plant with a power generation capacity of 100 MW will be ready soon. Being developed in the National Thermal Power Corporation (NTPC)-Ramagundam reservoir, the project is expected to give a boost to the share of renewable energy in Telangana. NTPC is already generating 10 MW of solar power at Ramagundam, for the past few years, and this 100-MW floating project will add to the efforts of the Corporation to meet the rising demand for power. The project was commissioned by the NTPC with an aim to reduce pollution caused by thermal power plants in India. The plant is being jointly developed by NTPC and Bharat Heavy Electricals Limited (BHEL), across 450 acres of water surface area. The salient features of the project include the fact that the officials did not acquire even a single acre of land for commissioning the plant as all PV cells are installed above the surface of water. As a result, the project will not cause any pollution and affect the environment.

Source: Details available at https://www.newindianexpress.com/states/telangana/2021/jul/02/floating-solar-power-plant-to-be-ready-soon-in-telangana-2324372.html, last accessed on July 28, 2021

Vijayawada railway platforms get solar rooftop

South Central Railway Vijayawada Divisional Manager virtually commissioned 65 kWp building-integrated photovoltaics (BIPV) solar cover on platforms in Vijayawada Railway Station. With this, Vijayawada Railway Station boasts an innovative solar photovoltaic cover-over platform having the highest capacity of 130 kWp across the Indian Railway network. This BIPV solar roof with integrated solar panels (without any galvanized sheets) in addition to its power generation harnessing solar energy will act as a shelter to passengers on the platform. This solar roof has been set up at a cost of ₹ 62 lakh. The innovative solar platform cover will result in saving ₹ 8.1 lakh per annum. The Divisional Manager said that the power generation from the panels caters to around 17.8% of the power needs of Vijayawada Railway Station. On recommendations of the Divisional Railway Manager to cover the gap between existing shelter and BIPV roof for a length of 32 meters on Platform Nos. 4 and 5, another 65 kWp solar plant was sanctioned.

Source: Details available at https://www.newindianexpress.com/cities/vijayawada/2021/jul/01/vijayawada-railway-platforms-get-solar-rooftop-2323866.html, last accessed on July 28, 2021

Climate Change

The paradox of global financing of climate change

Among the global environmental issues, climate change is the biggest challenge for humanity triggered by the mounting greenhouse gases and consequent increase in earth's average temperature by 0.18°C in the last decade. The UN is striving to restore the earth's ecosystems by 2030 with the active support and commitment of investors, businesses, governments, and communities. However, this largely depends on the commitment of countries to achieve climate targets as per the international agreement under the United Nations Framework Convention on Climate Change (UNFCCC). The failure to achieve the targets of the Kyoto Protocol and lack of consensus among the countries in the Paris Agreement show the collective failure of the international community. The World Economic Forum's Report on Global Risk, 2020 observes that 'climate action failure' is a threat to

the economic stability of the world countries, which witnessed unprecedented extreme weather and intense and more frequent natural disasters.

Source: Details available at https://www.deccanherald.com/opinion/panorama/the-paradox-of-global-financing-of-climate-change-1004926.html, last accessed on July 28, 2021

Climate risks call for green financial system

Climate risks are uncertain and irreversible. With increasing frequency and severity, climate disasters have the potential to rupture economic activity, financial system, monetary policy, price stability, inflation, and interest rates. Any corresponding reduction in asset values will impact banks, investors, lenders, and capital markets. Payments and the clearing system could be affected. The challenge is unique. Recognizing this, financial regulators worldwide have voluntarily established a network for greening the financial system (NGFS). This consensus-driven forum has the mandate to share best practices to foster a greener financial system.

Source: Details available at https://www.tribuneindia.com/news/comment/climate-risks-call-for-green-financial-system-277485, last accessed on July 28, 2021

A farmer-friendly solution to cut cattle methane emissions

Belching cattle, buffaloes, sheep, and goats in India emit an estimated 9.25–14.2 million tonne (mt) of methane annually, out of a global total of 90 mt plus from livestock. As methane's global warming potential is 25 times of carbon dioxide (CO_2) over 100 years, it is a more potent greenhouse gas, which is a cause for concern. The Indian Council of Agricultural Research Institute has developed an anti-methanogenic feed supplement '*Harit Dhara*'. When given to bovines and sheep, it not only cuts down their methane emissions by 17–20% but also results in higher milk production and body weight gain. *Harit Dhara* acts by decreasing the population of protozoa microbes in the rumen, responsible for hydrogen production and making it available to the archaea for reduction of CO_2 to methane. Tropical plants containing tannins – bitter and astringent chemical compounds – are known to suppress or remove protozoa from the rumen.

Source: Details available at https://indianexpress.com/article/india/feed-developed-by-icar-also-increases-weight-milk-production-feed-supplement-reduces-methane-emissions-by-livestock-7389140/, last accessed on July 28, 2021

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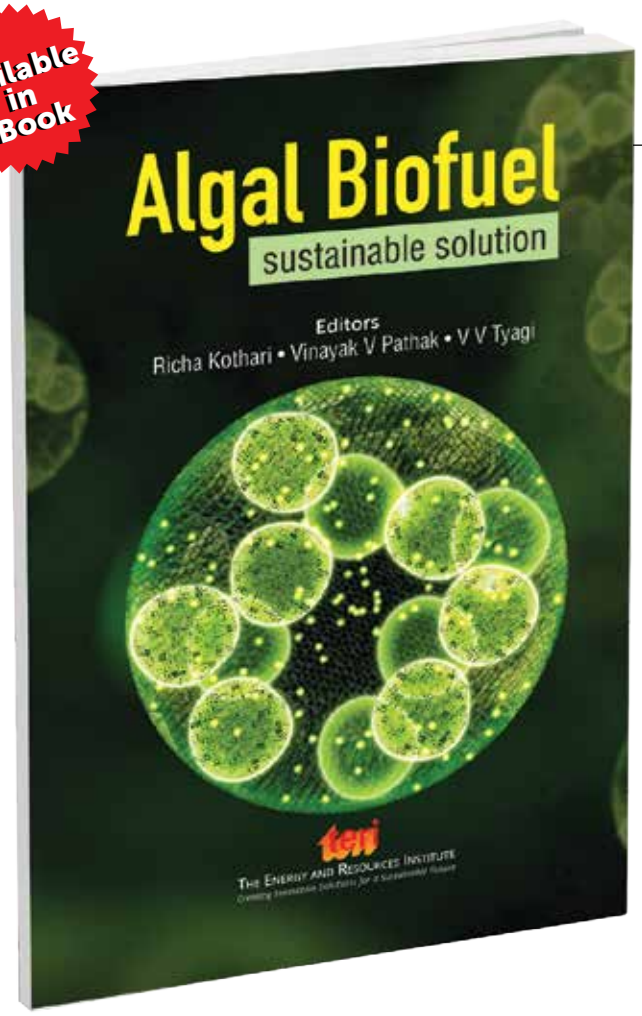

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A low-cost way to make efficient, stable perovskite solar cells

Source: Details available at https://www.sciencedaily.com/releases/2021/06/210630115408.htm, last accessed on July 1, 2021

Researchers have identified a way to create nickel oxide (NiO) films of sufficient quality in solution and at relatively low temperatures of less than 150°C. The researchers used 4-hydroxybenzoic acid or trimethyloxonium tetrafluoroborate ligand-modified NiO nanoparticles and a microfluidic mixer, which promotes high-pressure mixing of low-volume liquids, to distribute the nanoparticles evenly prior to depositing them on the substrate. The chemical process, developed, could contribute to the scalable fabrication of inorganic and inexpensive, high-performance films able to be used in the commercial production of flexible solar panels.

The researchers have recorded power-conversion efficiencies of 17.9% and 17.5%, respectively, in prototype devices, compared to 16% for a previous comparable approach, which lacked the advantages of the ligand exchange and also required a post-processing oxygen-plasma treatment step. Significantly, the new devices exhibited just a 0.2% reduction in efficiency over an intensive 300-hour testing period, providing a strong indication of their potential suitability for commercial applications. According to the researchers, their work showcases that high-temperature processing of functional materials for solar cells can be omitted using facile processing ways. It is a crucial step for commercialization of the perovskite technology.

New model simulates the tsunamis caused by iceberg calving

Source: Details available at https://www.sciencedaily.com/releases/2021/06/210621123816.htm, last accessed on July 2, 2021

A team of scientists has developed a new model for simulating both iceberg calving and tsunamis that are triggered as a result. Their method can help improve hazard assessments in coastal areas and refine the empirical calving models used to evaluate rising sea levels. These scientists are the first to simulate the phenomena of both glacier fracture and wave formation when the iceberg falls into the water. Their goal was to model the explicit interaction between water and ice, but that has a substantial cost in terms of computing time. Therefore, they decided to use a continuum model, which is numerically very powerful and gives results that are both conclusive and consistent with much of the experimental data. The researchers found that calving occurs when chunks of ice on the edge of a glacier break off and fall into the sea. The mechanisms behind the rupture generally depend on how high the water is. If the water level is low, the iceberg breaks off from the top of the glacier. If the water level is high, the iceberg is longer and breaks off from the bottom, before eventually floating to the surface owing to buoyancy. These different mechanisms create icebergs of different sizes and, therefore, waves of different amplitudes. Another event that can trigger a tsunami is when an iceberg's centre of gravity changes, causing the iceberg itself to rotate.

Renewable Energy

Experimental evaluation of used engine oil based thermal energy storage coupled with novel evacuated tube solar air collector (NETAC)

Mehla, N. and A. Kumar. 2021

Journal of Energy Storage 39: 102656

The significant challenge in vacuum tube solar air collector is its worse performance after sunset, which prompts the thermal energy storage. In this paper, the used engine oil-based thermal energy storage coupled with a novel evacuated tube solar air collector (NETAC) was developed. The NETAC investigation was evaluated during the winter season for hot air production for 13 h at diverse airflow rates and different directions of airflow (parallel airflow and counter airflow). The maximal temperature difference (24.8°C) of air was obtained at a low airflow rate (79.5 kg/h) and maximal mean efficiency (28.8%) of NETAC at a high airflow rate (159 kg/h) with circular fin and counter flow arrangement. The maximal mean energy efficiency (27.15%) and energy efficiency (24.8%) of an oil thermal storage tank were attained at a high airflow rate (159 kg/h) with circular fin and parallel flow arrangement. The maximal mean energy gain (538.7 W) by air was obtained at a high airflow rate (159 kg/h) with circular fin and parallel flow arrangement.

Techno-economic optimisation of battery storage for grid-level energy services using curtailed energy from wind

Rayit, N. S., J. I. Chowdhury, and N. Balta-Ozkana. 2021

Journal of Energy Storage 39: 102641

The increasing integration of renewable energy sources causes balancing an electricity grid challenging due to their intermittency. Renewable energy can be curtailed especially when production exceeds demand or when there are transmission and/or distribution network congestions within a grid. However, curtailment would become unnecessary with battery storage, provided the battery storage has enough available storage capacity, which can store energy during the time of excess generation and in turn discharge it to the grid once the demand is high during peak times. Hence, stored energy from batteries can potentially offset supply from expensive and environmentally harmful peak plants, e.g., open/combined cycle gas turbines. The researchers investigated the techno-economic prospects of the utilization of curtailed energy from the wind with bulk battery storage to replace open and combined cycle gas turbine power plants, by taking the UK as a case study. A techno-economic model to size and optimize a Li-ion type battery was developed. The optimization aimed to determine at what cost and size the storage can be commercially viable for grid-level energy applications. Results show that under base-case assumptions of a 15% day-to-day curtailment from wind and £200/kWh battery cost, an optimized battery size of 1.25 GWh could supply 285 GWh peak demand per annum and its corresponding net present value of £22.4 m, internal rate of return of 1.7%, and a payback period of 14 years could be achieved. However, to achieve the internal rate of return of 8%, a minimum hurdle rate for investment, the cost of the battery would need to be below £150/kWh. Sensitivity analysis with parameters such as curtailed wind, depth of discharge, battery efficiency, and cost and income of battery shows that all techno-economic parameters considered in this research have a significant impact on the commercial viability of battery storage for grid applications.

Energy emissions, consumption and impact of urban households: A review

Verma, P., T. Kumari, and A. S. Raghubanshi. 2021

Renewable and Sustainable Energy Reviews 147: 111210

Household energy consumption is steadily increasing across cities due to the urbanization of rural areas and more economic and travel activities. In this review, multiple correspondence analyses and other bibliometric tools were applied to determine the conceptual structure and typological thematic areas of household emissions in urban areas. The current state of knowledge and opportunities towards creating carbon-neutral cities indicates that while most of the research was focused on cities and regions of developed countries and China, the mitigation activities were grouped under the three broad heads – reducing emissions, consumption, and impact of household emissions. Strong heterogeneity between the urban and the rural areas, fuel options, and human choices gave rise to fuel-stacking in developing countries. Integrated modelling and inclusion of environmental and human behavioural components

into economic models were recognized as emerging fields oriented towards a systems approach. Accessibility and availability of clean energy and clean energy appliances were identified as the biggest challenges. To create carbon-neutral urban areas, integrated modelling should include categorization of the carbon policy according to the local conditions, analysis of feedback loops, embedded emissions, the global and regional impact of household consumption patterns, and uncertainty associated with mitigation measures.

Climate Change

A framework for understanding the key drivers of cities' climate actions in city networks

Mokhles, S. and K. Davidson. 2021

Urban Climate 38: 100902

Due to the complexity of environmental city networks, the incentives of climate actions in these networks are unclear. Despite their rise, the literature is yet to fully engage with this complexity, as siloed disciplinary focuses on specific aspects of climate actions in city networks are far behind in explaining the reality of these networks. Since there is a dispersed understanding of climate actions in city networks across different fields of research, the authors adopted an interdisciplinary approach to identify the key drivers of climate actions in city networks. Urban studies' focus is on networking and the political economy behind it. On the other hand, sustainability transition studies have provided an in-depth understanding of the socio-cultural context, and scholars in environmental science illuminate the environmental context of cities. By synthesizing these three fields, this paper proposes a framework that ensures a comprehensive understanding of the drivers of climate actions in city networks. It consists of 13 attributes under 4 themes of networking context, political economy, socio-cultural context, and environmental context. The framework's utility is that it identifies the limitations of the studies and it provides a comprehensive comparison of cities to unpack the drivers of climate actions in city networks to encourage networking.

Appraising climate change impacts on future water resources and agricultural productivity in agro-urban river basins

Aliyari, F., R. T. Bailey, and M. Arabi. 2021

Science of the Total Environment 788: 147717

This study quantifies the future availability of surface water and groundwater and associated crop production in a large semi-arid agro-urban river basin in which agricultural irrigation leads to water consumption. The region of study is the South Platte River Basin (72,000 km^2), Colorado, USA. The coupled SWAT-MODFLOW modelling code is used as the hydrologic simulator and forced with five different CMIP5 climate models downscaled by multivariate adaptive constructed analogues, each for two climate scenarios. The hydrologic model accounts for surface runoff, soil lateral flow, groundwater flow, groundwater–surface water interactions, irrigation from surface water and groundwater, and crop yield on a per-field basis. In all climate models and emission scenarios, an increase of 3–5°C in annual average temperature is projected. Whereas, variation in the projected precipitation depends on the topography and distances from mountains. Based on the results of this study, the worst-case climate model in the basin is IPSL-CM5A-MR-8.5. Under this climate scenario, for a 1°C increase in temperature and the 1.3% reduction in annual precipitation, the basin will experience an 8.5% decrease in stream discharge, 2–5% decline in groundwater storage, and 11% reduction in crop yield. These results indicate the significant effect of climate change on water and food resources of a large river basin, pointing to the need for immediate implementation of conservation practices.

Risk perception of climate change and natural hazards in global mountain regions: A critical review

Schneiderbauer, S., P. F. Pisa, J. L. Delves, L. Pedoth, S. Rufat, M. Erschbamer, T. Thaler, F. Carnelli, and S. Granados-Chahin. 2021

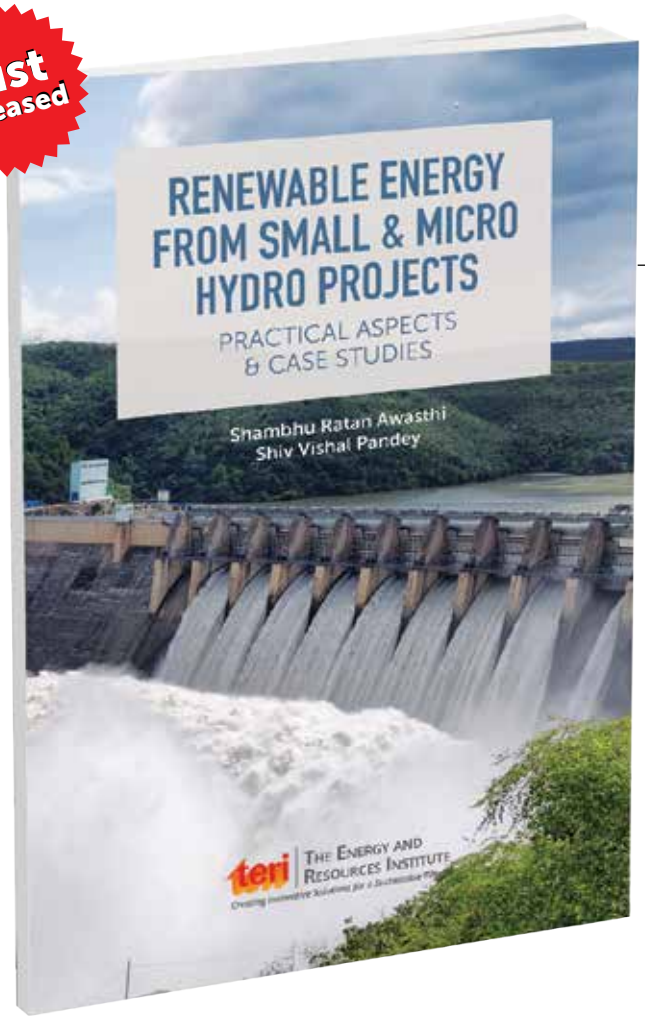
Science of the Total Environment 784: 146957

This article presents the findings of a literature review of recent English language publications on risk perception in connection to climate change

and related natural hazards in mountain regions worldwide. Studies were selected from recorded entries in *JSTOR, Science Direct, Scopus*, and *Web of Science* covering the period 2000–2019. They were analysed in two steps (structured exploratory analysis, n = 249 and in-depth analysis, n = 72) with respect to the studies' research question, methodology, geographical scope, and risk perception drivers. The review reveals that socio-demographic factors, such as gender, age, and personal experiences, have a crucial impact on individual risk perception. Some of the less tangible but decisive factors are important in mountain regions such as place attachment and socio-cultural practices. In conclusion, there is, however, little information in the literature that addresses the specific situation of risk perception in mountain areas and its influence on communities' responses to environmental changes. Further, the authors observed a strong gap concerning the integration of indigenous knowledge in risk perception research. Many studies overlook or oversimplify local knowledge and the cultural dimensions of risk perception. Based on these results, the paper identifies several gaps in research and knowledge which may influence the design of climate risk management strategies as well as their successful implementation.

PRACTICAL ASPECTS OF HARNESSING RENEWABLE ENERGY

Just Released



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- Hydro Turbines
- Project Execution and Financial Aspects
- Environmental Aspects
- Policies for Sustainable Development of Hydropower

- ISBN: 9789386530929
- Print / eBook Subscription Price: ₹550
- Perpetual Price: On request

Energy production and utilization are directly associated with climate change. Harnessing energy from renewables can provide a viable path towards achieving sustainability and reducing carbon footprints, which can help mitigate the harmful effects of climate change. India is endowed with substantial hydropower potential. Under this light, *Renewable Energy from Small & Micro Hydro Projects: practical aspects & case studies* introduces the process of developing hydropower projects, especially in Indian context. The role of hydroelectric power, as part of water management, in combating climate change also forms the subject matter of this book.

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IMPACT OF GREEN SKILL DEVELOPMENT PROGRAMME ON SOLAR ENERGY FOR LIVELIHOOD GENERATION

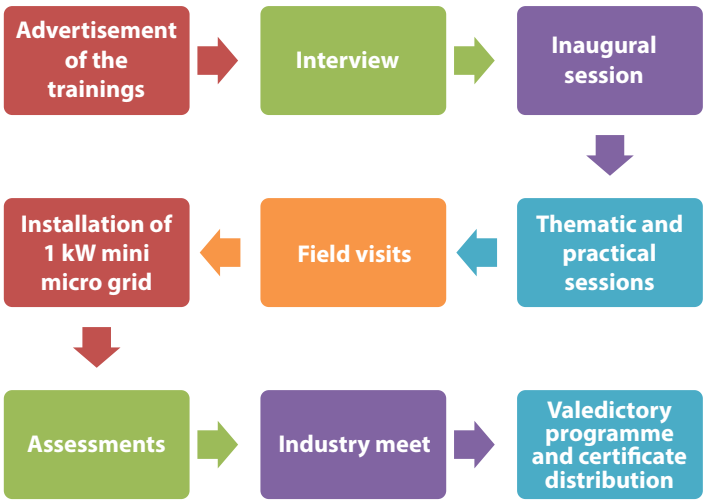
Background

As the effects of the COVID-19 pandemic continue to ripple around the globe, millions live in uncertainty about their ability to provide for their families because of daily wage and labour work drying up. The issue, however, is that they have not had the opportunity to learn the skills needed in today's job markets, either for a job or for entrepreneurship. It is estimated that only 2.3% of the workforce in India has undergone formal skill training as compared to 68% in the UK, 75% in Germany, 52% in the USA, 80% in Japan, and 96% in South Korea (Ministry of Skill Development and Entrepreneurship). In line with the Skill India Mission of Hon'ble Prime Minister, Ministry of Environment, Forest and Climate Change (MoEF&CC) utilizing the vast network of Environment Information System (ENVIS) and National Mission on Himalayan Studies has taken up an initiative for skill development. The programme endeavours to develop a green skilled workforce having technical knowledge and commitment to sustainable development. It helps the country in attaining its Nationally Determined Contributions (NDCs), Sustainable Development Goals (SDGs), National Biodiversity Targets (NBTs), as well as Waste Management Rules (2016).

Since 2018, as part of the ENVIS programme, TERI has successfully conducted 14 residential Green Skill Development Programmes (GSDP) on 'Sustain and Enhance Technical Knowledge in Solar Energy Systems' in Bihar, Uttarakhand, Uttar Pradesh, West Bengal, and Jharkhand. Each programme spanned 240 hours and over 450 students have been trained so far under this initiative. In this, unemployed youths including standard 10th and 12th dropouts and ITI and graduate students get a chance to learn about solar energy technologies. The course involves training by subject experts and hands-on exposure to solar energy technologies and applications.

About Training

The following are the key steps for conducting the residential training programme:



The programme consists of both theoretical and practical training sessions conducted by TERI subject experts and external faculty. In addition, field visits to provide a clear understanding of the ground problems and their solutions are organized. Special emphasis is given to hands-on training with practical exposure to the participants so that they can understand the practical difficulties they may face after the course. In line with this goal, a working model is made available at all training venues for the connections of all solar and electrical equipment so that students can repeatedly practice the connections to clear their doubts.

Impact of GSDP Training

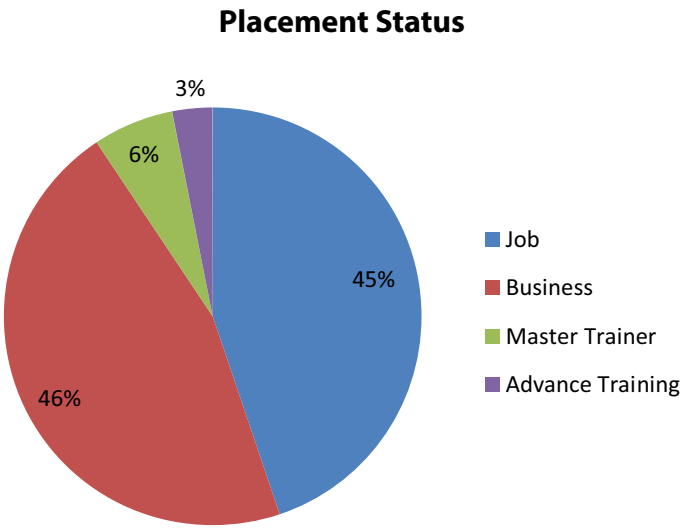
The course aims to make the students self-reliant so that they can earn a decent living by becoming service providers, entrepreneurs, master trainers, etc., in the field of solar energy. To support the candidates in getting jobs, the following measures were taken up:

a. A brochure was prepared comprising the candidates' profiles and a brief overview of GSDP
b. Mass distribution of the brochure in the solar industry was done to ensure maximum outreach.
c. A list of industries, vendors, manufacturers, etc., was attached and distributed to trainees for their future reference.

Hitherto, the GSDP training conducted at different places in India led to many participants achieve the following:

1. Established their businesses
2. Got jobs
3. Joined advance courses
4. Became master trainers, etc.

Solar water plant installation by participants



TERI ENVIS Resource Partner (RP) remains in contact with the participants through ENVIS mobile app, WhatsApp, etc. Interviews of a few participants about their new jobs and business opportunities were conducted. The following are the case studies of three of the participants.

Case 1

Sandeep Yadav, a graduate in Agricultural Sciences, received one-month GSDP training on Sustain, and Enhance Technical Knowledge in Solar Energy Systems in Kanpur, Uttar Pradesh. Through this training, he was able to start his own business of solar products and services in Dibba Nivada, Kanjti, Kanpur. He majorly deals in retailing of solar energy street lights and batteries for solar panels. He also provides repairing services to solar energy street lights, both for households and commercial set-ups. He is successfully utilizing his learning from the GSDP training and his venture is doing well. Also, he is trying to create job opportunities for the local people. He is thankful to TERI ENVIS and GSDP for providing him the skills to run the business. Even after the lockdown due to COVID-19, his business is going well and his family is thriving.

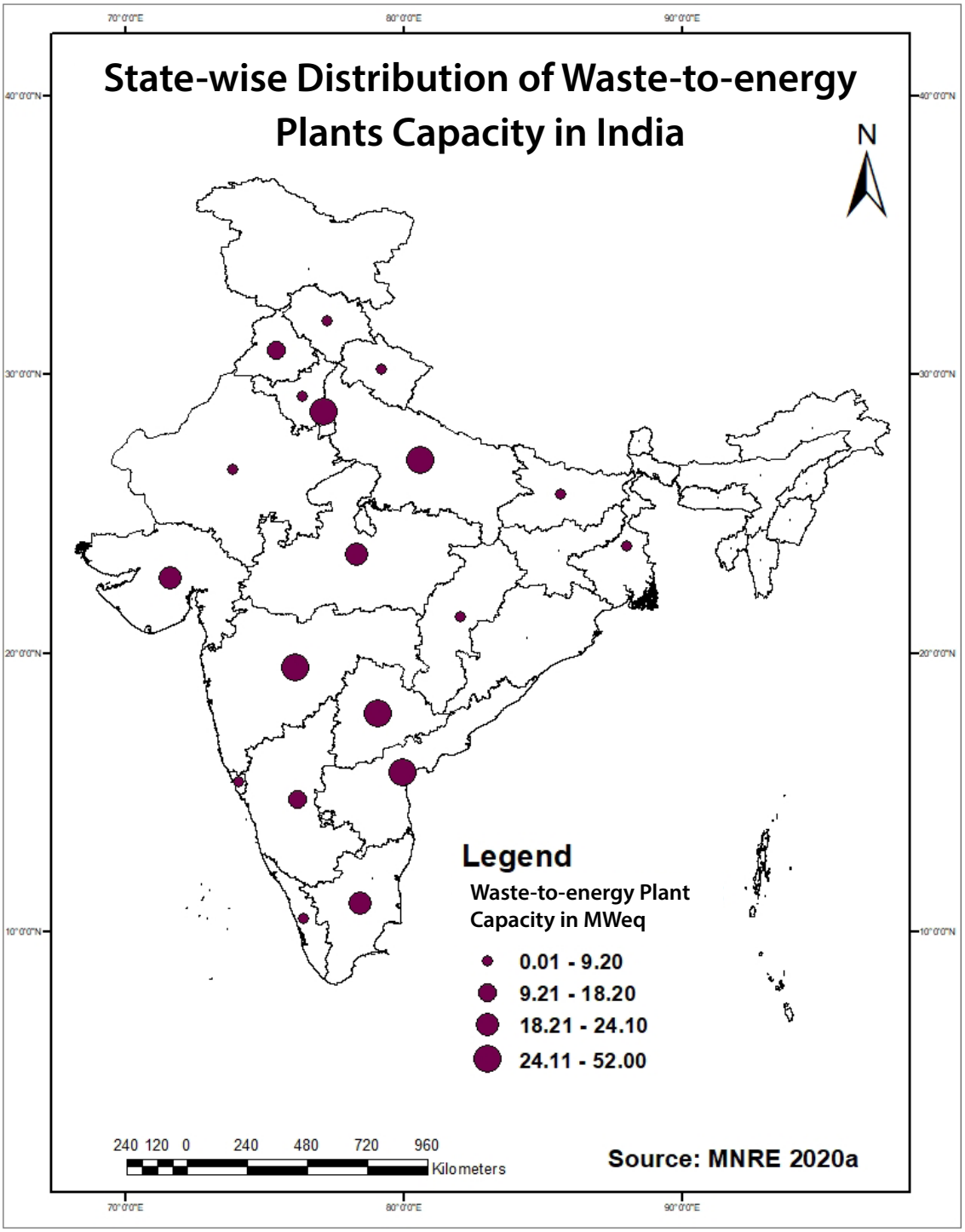
Case 2

Nishant Kumar Tiwari, who earlier ran a restaurant business that could not sustain, came to know about one-month GSDP in Kanpur, Uttar Pradesh. According to him, the training proves to be a boon for his career. After completing the training, he landed a job at Sadana Solar Mart, Kanpur in Sales and Marketing. Majorly, his customers included petrol pumps, hospitals, hotels, and other commercial establishments in Uttar Pradesh. While in job, he became aware of the enormous opportunities that the renewable energy sector offers. This encouraged him to start his own business in solar power. GSDP has played a vital role in building his career. He is working hard to be able to establish his own business of installing solar power plants.

Case 3

Sangeeta Devi received one-month GSDP training on Sustain and Enhance Technical Knowledge in Solar Energy Systems in Kanpur, Uttar Pradesh. She was involved with a self-help group for a few years where she was first introduced to the solar market. Since she was so involved in her daily household chores, she was quite unsure that she would be able to do it. First, she was given a 4 days training wherein she was taught about assembly and distribution of solar lamps. She then became a part of a group of ladies who used to first assemble and then distribute the lamps to government schools. She had started earning about ₹8000–10,000 per month from this. Thereafter, she was given training on solar lamps repairing along with the installation of solar home-light system by TERI ENVIS in GSDP Kanpur. This training helped her a lot in opening her solar shop, named as 'Shivani S-mart' in Manpur, Gaya, where she earns from selling solar equipment such as solar lamps/torch, etc. This shop helps her earn a decent amount for her family to live happily. She thanks TERI ENVIS for training her in this programme and enabling her to build a small business for herself and her family.

1. State/Union territory-wise installed capacity of waste-to-energy plants set up in India, as on August 31, 2020



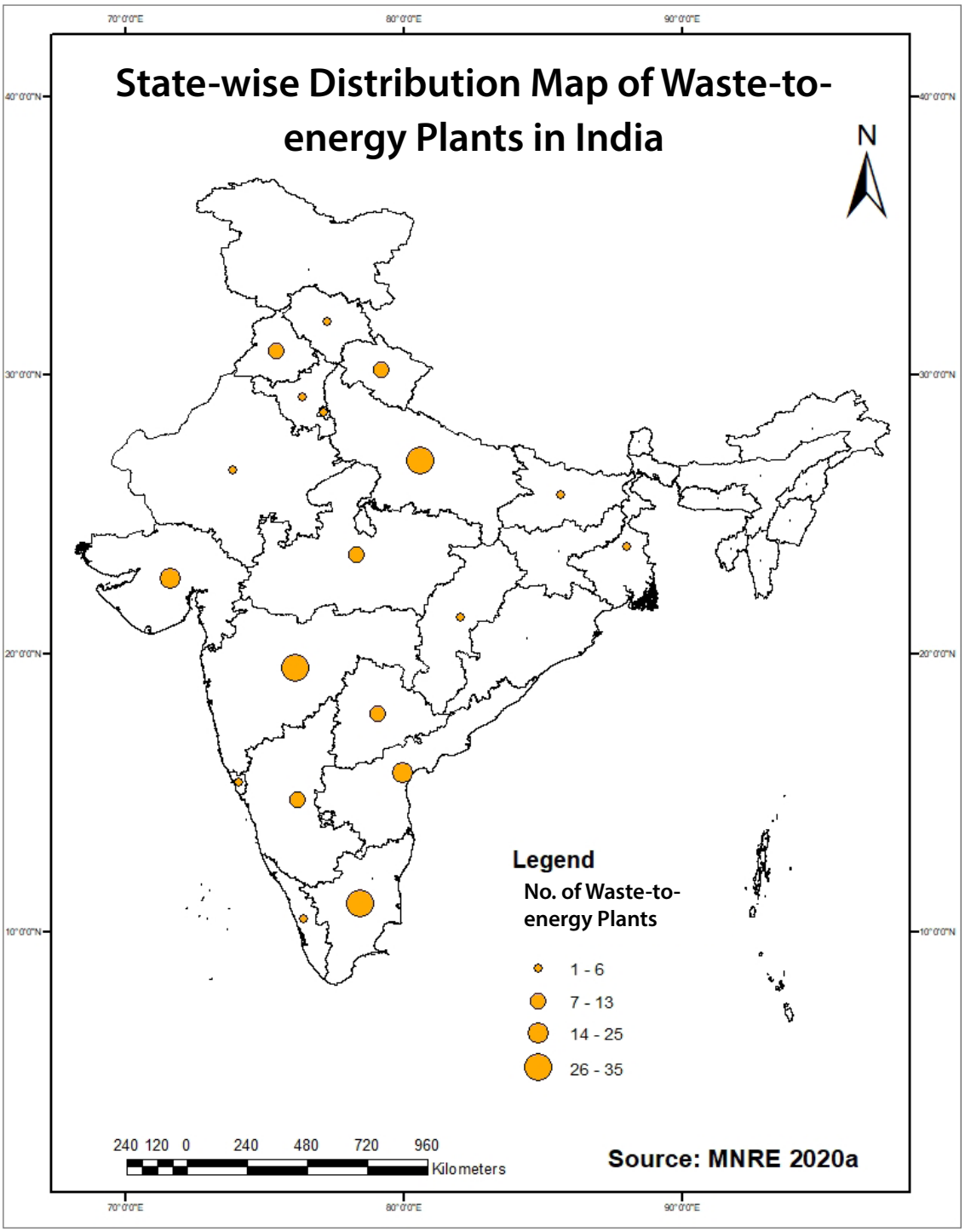
Source: Details available at https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf, last accessed on July 29, 2021

2. State-wise installations of rooftop solar capacity as on February 2021

States/Union Territories	Capacity Installed (MW)
Andaman & Nicobar Islands	4.18
Andhra Pradesh	138.82
Arunachal Pradesh	0.22
Assam	20.68
Bihar	12.09
Chandigarh	38.82
Chhattisgarh	28.65
Goa	6.49
Gujarat	941.66
Haryana	304.55
Himachal Pradesh	14.17
Jammu & Kashmir	12.98
Jharkhand	29.58
Karnataka	100.64
Kerala	107.40
Lakshadweep	0.00
Ladakh	0.00
Madhya Pradesh	90.56
Maharashtra	693.85
Manipur	4.50
Meghalaya	0.12
Mizoram	1.37
Nagaland	0.08
NCT of Delhi	141.19
Odisha	18.15
Puducherry	9.30
Punjab	124.54
Rajasthan	418.98
Sikkim	0.07
Dadra & Nagar Haveli and Daman & Diu	0.39
Tamil Nadu	99.26
Telangana	168.65
Tripura	3.08
Uttarakhand	257.25
Uttar Pradesh	117.30
West Bengal	7.90
Total	**3917.44**

Source: Details available at https://renewablewatch.in/2021/05/31/rooftop-solar-statistics-2/, last accessed on July 29, 2021

3. State/Union territory-wise number of waste-to-energy plants set up in India, as on August 31, 2020



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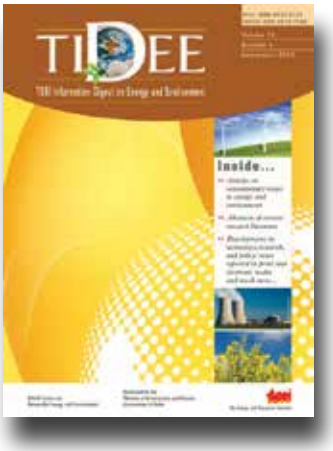

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TERI ENVIS RESEARCH PARTNER'S KEY HIGHLIGHTS

TERI ENVIS Resource Partner's Highlights

Glimpses of a webinar on 'World Environment Day: Green Skill Development Training during COVID-19: Present Scenario, Opportunities, and Impacts of Training' on June 5, 2021

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