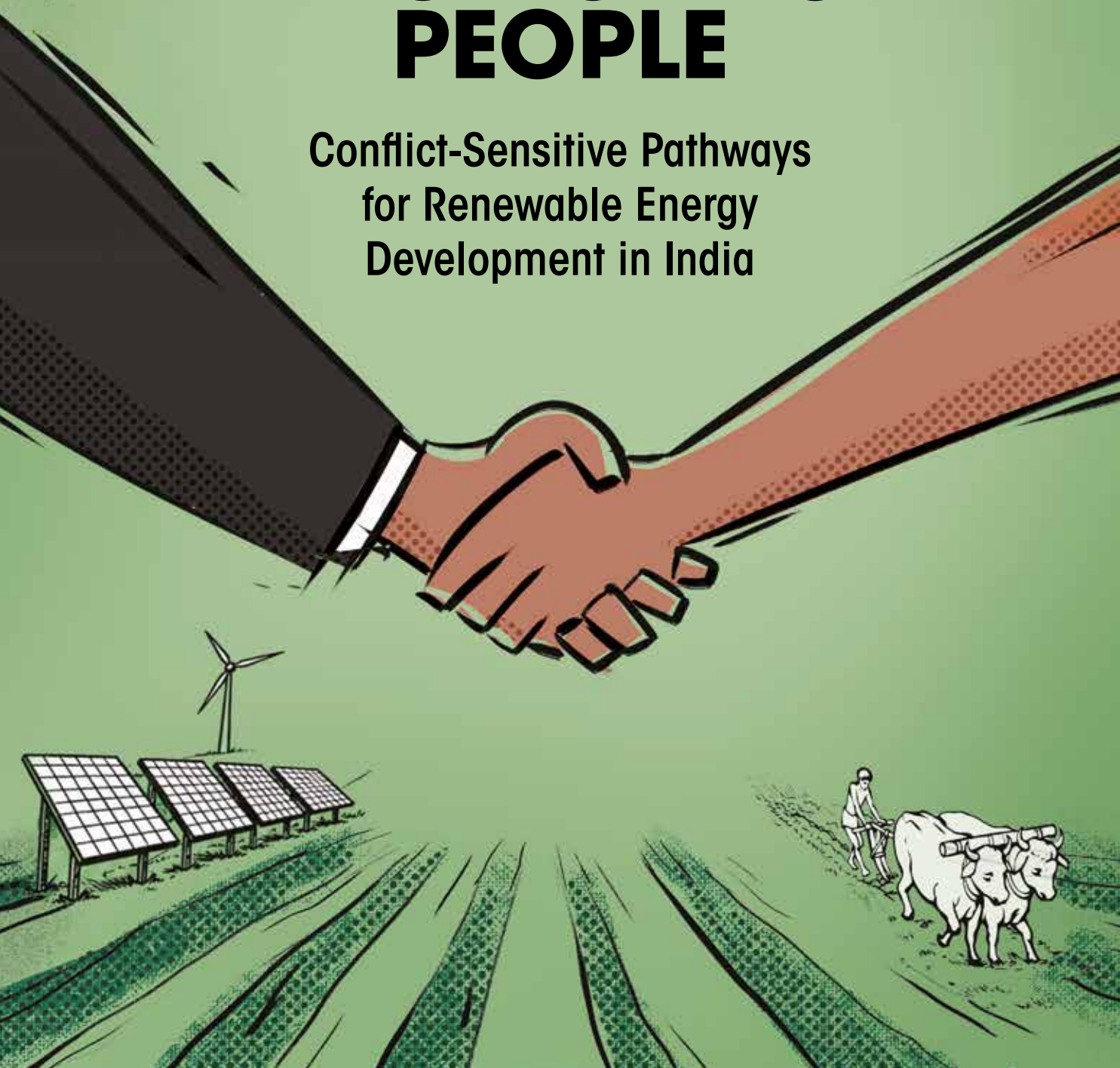
POWERING PROGRESS, PROTECTING PEOPLE

Conflict-Sensitive Pathways for Renewable Energy Development in India





POWERING PROGRESS, PROTECTING PEOPLE

Conflict-Sensitive Pathways for Renewable Energy Development in India

Research direction: Nivit Kumar Yadav

Author: Binit Das

Research support: Ishita Garg, Shambhavi Singh

Editor: Souparno Banerjee

Cover and design: Ajit Bajaj, Ritika Bohra

Graphics: Vineet Tripathi

Illustrations: Yogendra Anand

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

breadfortheworld
HAVE FAITH. END HUNGER.

The Centre for Science and Environment is grateful to Bread for the World (BfW) for their support.

The case studies in this report draw on publicly available sources, including news reports, academic research, government publications, policy reports, and publications by civil society organisations and renewable energy companies. All sources have been acknowledged through appropriate citations.

© 2026 Centre for Science and Environment

Maps used in this document are not to scale.

Citation: Binit Das and Nivit Kumar Yadav, 2026, *Powering Progress, Protecting People: Conflict-Sensitive Pathways for Renewable Energy Development in India*, Centre for Science and Environment, New Delhi

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000
Fax: 91-11-29955879
E-mail: cse@cseindia.org
Website: www.cseindia.org

CONTENTS

Executive Summary P7

1. Introduction P11

Land, social and environmental challenges of RE expansion **P13**

Land classification **P15**

Siting criteria and land requirements for solar and wind projects **P15**

2. Social Challenges of RE Development P17

Land governance conflicts **P18**

Livelihood and commons-related conflicts (pastoralism) **P19**

Cultural and customary landscape conflicts **P19**

Case Study 1: Phalodi-Pokaran Solar Park, Rajasthan P20

Case Study 2: The Nedan Solar Park dispute, Rajasthan P24

Case Study 3: Dispute over Orans: Baiya, Rajasthan P27

Case Study 4: The Assam Solar Project, Karbi Anglong P30

Distributional justice conflicts **P33**

Case Study 1: Kurnool Ultra Mega Solar Park, Andhra Pradesh P33

Case Study 2: NP Kunta Solar Park, Andhra Pradesh P36

Case Study 3: Charanka Solar Park, Gujarat P39

Case Study 4: Rewa Ultra Mega Solar Project, Madhya Pradesh P42

3. Environmental Challenges of RE Development P47

Habitat fragmentation and ecological connectivity **P48**

Case Study 1: Khavda RE Park, Gujarat P49

Disturbance of ecologically sensitive landscapes **P52**

Case Study 1: Sambhar Solar Project, Rajasthan P53

Case Study 2: Dholera Solar Park, Gujarat P57

Case Study 3: Kamuthi Solar Project, Tamil Nadu P59

4. Innovations for Conflict Resolution P64

Land governance innovations **P65**

Case Study 1: Pavagada Solar Project, Karnataka P66

Case Study 2: Canal-top Solar, Punjab P68

Case Study 3: Agrovoltaic Solar Systems P71

Case Study 4: Floating Solar Infrastructure P73

Water stewardship **P74**

Case Study 1: Reviving Traditional Water Systems – ReNew P75

Case Study 2: Drycleaning Solar Panels – Adani Green Energy P76

Local livelihoods and skills for a just energy transition **P78**

Case Study 1: Project Surya, Gujarat P78

Community infrastructure and service delivery **P80**

Case Study 1: Lighting Lives P80

Waste management and resource recovery **P82**

5. The Way Ahead P84

Institutionalise environmental and social accountability **P85**

Adopt inclusive siting criteria **P86**

Pursue transformative project design **P86**

Institutionalise benefit sharing **P87**

Establish end-of-life lifecycle traceability **P88**

References **P89**

EXECUTIVE SUMMARY



India's renewable energy expansion has reached a stage where the quality of deployment matters as much as the pace. Under the 2022 NDCs, India had committed to cut emissions intensity by 45 per cent from 2005 levels, and ensure that 50 per cent of its installed power capacity was based on non-fossil sources by 2030, including 500 GW from renewable sources.

The updated NDCs approved in March 2026 for 2031 to 2035 raise the goals to a 47 per cent cut in emissions intensity and 60 per cent non-fossil capacity. A record 55.3 GW was added in FY 2025-26; non-fossil capacity crossed 297 GW by June 2026; and solar has reached 162 GW, moving India from fifth to the third spot globally in solar power capacity. Wind stands at about 56 GW, the fourth highest in the world. Reaching 500 GW still requires nearly 150 GW of new solar over four years, about 37 GW a year.

Execution lags. As of June 2024, 34.5 GW of awarded capacity with signed power purchase agreements remained uncommissioned because of delays in agreements and transmission, and around 45 GW of grid connectivity is stranded, mainly in Rajasthan, Andhra Pradesh, Karnataka and Madhya Pradesh. Land is the second constraint. The 500 GW target needs an estimated 0.3 to 0.46 million hectare (mha). India supports 18 per cent of the world's population on 2.4 per cent of its land area, and over 65 per cent of Indians depend on agriculture, livestock, forests and common property resources. A utility-scale solar project occupies four to five acre per MW, so a one-GW plant will take up 4,000 to 5,000 acre.

Solar and wind projects sit in the White Category under the EIA Notification, 2006, which exempts them from mandatory environmental impact assessments and public hearings.

The central finding of this study report is that there are conflicts, and these conflicts trace back to a gap between formal land classification and actual land use. Wastelands cover 55.77 mha, or 16.96 per cent of India. Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Jammu and Kashmir with Ladakh, and Andhra Pradesh hold the largest shares, and the same states are the main renewable hubs. Land recorded as barren or government land often works as grazing commons, sacred *Orans*, seasonal farmland and water catchment. In 2026, 31 renewable projects have been tied to ongoing social conflicts affecting more than 57,000 people and nearly 35,900 hectare, and nearly half involve commons or land classified as wasteland.

Four land governance cases show the pattern. At the 750-MW Phalodi-Pokaran park, the Rajasthan High Court had, in June 2021, ordered a fresh survey, approach

roads and cancellation of wrongly allotted public utility land; revised allotments came only in February 2024. At Nedan, 1,452.13 *bigha*s were cancelled. At Baiya, a 600-MW project on land villagers identify as an *Oran* with more than 6,000 khejri trees faces a tree-felling stay and an expert committee review. In Karbi Anglong, 23 to 24 villages and around 20,000 people are affected by a 1,000-MWp project on 2,396 hectare, and the Asian Development Bank cancelled a US $434.25 million loan for it in May 2025.

Distributional conflicts follow a similar logic. Compensation is tied to formal title, which leaves out pastoralists, landless households, tenants and users of commons. At Kurnool, nearly 800 cultivators lost access to assigned land and about 180 were compensated. At NP Kunta, 932 cultivators were found eligible for about Rs 9.32 crore, with some claims still disputed. At Charanka and Rewa, construction jobs gave way to few operational posts, grazing access shrank; at Rewa, journeys of two to three km stretched to 14 to 15 km around the fenced park.

Environmental cases cover habitat, wetlands, coasts and water. Fewer than 150 Great Indian Bustards survive, and overhead power lines are a major risk. The Supreme Court's December 2025 judgment adopted a risk-based framework that includes undergrounding or rerouting 79.2 km of 33 kV lines and 64.9 km of 66 kV lines. The 4,000-MW Sambhar proposal lost momentum, and a 100-MW project outside the notified wetland was allowed in April 2026 with safeguards. At Dholera, 92.5 per cent of the proposed 4,400-MW park fell in an ecologically sensitive coastal zone, and 629 hectare were set aside as permanent no-development buffer. At Kamuthi, about 200,000 litre of groundwater a day went to panel cleaning until the operator moved to treated brackish water and robotic cleaning.

Several solutions already work. At Pavagada, about 2,300 landowners leased nearly 13,000 acre for 28 years at Rs 21,000 per acre with a 5 per cent rise every two years, though landless workers and pastoralists gained little. Punjab's 20-MW canal-top programme saved around 110 acre, and its canal network offers over 1,500 MW of potential. At the 2-MW Indra agrivoltaic farm, shading cut evapotranspiration by about 17 per cent and irrigation needs by about 25 per cent. Omkareshwar's floating park has more than 400 MW operating, yet about 300 fishermen raised access concerns. Dry cleaning has saved around 546 million litre of water a year at one developer's parks. Project Surya trained 575 Agariya women, and 78 per cent of those assessed reported a significant income rise. Solar PV waste could reach around 200 kilotonne by 2030.

Five priorities emerge:

- A proportionate Environmental and Social Impact Assessment for utility-scale projects above a capacity threshold, whatever the source of finance, leading to a management plan with timelines and monitoring indicators.
- Inclusive siting through community-verified GIS maps that separate available land from *gochars, orans*, grazing routes and water systems, with access corridors written into lease agreements.
- Project design that weighs rooftop, canal-top, floating and decentralised models against greenfield parks, since conflict-reduction potential is high for the former and moderate for solar parks.
- A Community Benefit Fund for large projects, linked to capacity or revenue, overseen by Gram Panchayats and district authorities, with local hiring targets and skills training.
- Digital traceability for modules, batteries, inverters and turbine components, tied to Extended Producer Responsibility and CPCB platforms.

INTRODUCTION



India's transition from fossil fuels to clean renewable energy is reshaping its energy management system; it has become central to its climate, energy security and economic development objectives. Under its 2022 Nationally Determined Contributions (NDCs), India committed to reducing emissions intensity by 45 per cent from 2005 levels and achieving 50 per cent of installed power capacity from non-fossil sources by 2030, alongside scaling renewable energy capacity to 500 GW. Building on this trajectory, the updated NDC approved in March 2026 for 2031-2035, raises ambition further, targeting a 47 per cent reduction in GDP emissions intensity and 60 per cent non-fossil power capacity.[1]

As of April 2026, India ranks third globally in total installed renewable energy capacity.[2] With a record addition of 55.3 GW in FY 2025-26, the country's non-fossil capacity crossed 297 GW by June 2026.[3] Solar energy has emerged as the primary driver, with installed capacity reaching 162 GW, making India the third largest globally, up from the fifth position in 2024. In wind energy, India holds the fourth position with about 56 GW of installed capacity.[4] Achieving the 500 GW target will require India to add nearly 150 GW of solar capacity over the next four years – about 37 GW annually.

Despite rapid capacity additions, project execution remains slow. As of June 2024, 34.5 GW of awarded renewable energy capacity with signed PPAs remained yet to be commissioned, primarily because of delays in PPAs, PSAs and transmission infrastructure. Around 45 GW of grid connectivity also remains stranded, particularly in Rajasthan, Andhra Pradesh, Karnataka and Madhya Pradesh.[5]

Alongside transmission constraints, land availability has emerged as one of the most significant barriers to renewable energy expansion. Utility-scale solar and wind projects require large contiguous land parcels, creating increasing pressure on landscapes that also support agriculture, grazing and other community uses. Achieving India's 500 GW target is estimated to require between 0.3 and 0.46 million hectare (mha) of land.[6]

In a land-constrained country where land records remain fragmented and many so-called wastelands support grazing and other livelihood activities, renewable energy (RE) expansion increasingly intersects with competing social and ecological priorities. Addressing these challenges requires governance frameworks that recognise actual land use, improve planning and integrate environmental and social considerations into project development.

Land, social and environmental challenges of RE expansion

Renewable energy expansion delivers significant climate and energy-security benefits, but also gives rise to new social and environmental challenges. Utility-scale solar and wind projects require large, contiguous land parcels for generation, associated infrastructure and transmission, often overlapping with landscapes that support local livelihoods, biodiversity and traditional land uses.

India supports nearly 18 per cent of the world's population while possessing only about 2.4 per cent of the world's land area.[7] As a result, the land is already under immense pressure from agriculture, urbanisation, industrialisation, infrastructure development and conservation activities. With over 65 per cent of India's population dependent on agriculture, livestock rearing, forests and common property resources, renewable energy increasingly competes with existing land uses.[8]

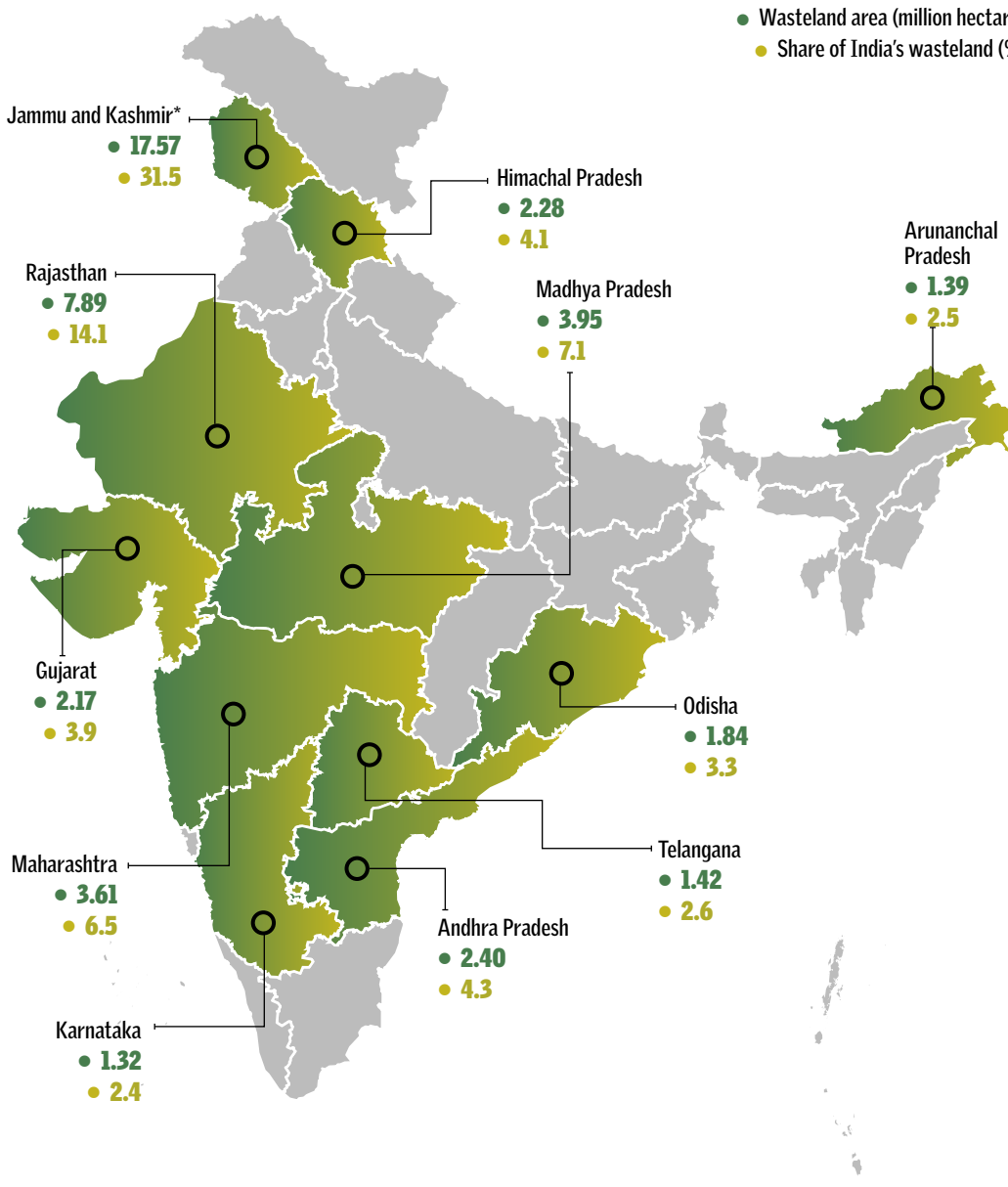
Since land is a state subject, acquisition procedures vary considerably across India. Fragmented holdings, unclear titles and weak land records often delay private land acquisition, encouraging governments to allocate government land and officially classified wastelands for renewable energy projects. State governments are allocating common lands categorised as "government land", "barren land", or "wasteland" for these projects. In several states, including Rajasthan, such lands are allotted under specialised renewable energy land-allotment frameworks rather than through conventional acquisition processes under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (RFCTLARR), 2013.[9]

Although officially classified as government land or wasteland, many of these landscapes function as grazing grounds, seasonal cultivation areas, water-harvesting systems and culturally significant commons. Their allocation for renewable energy projects often overlooks these multiple uses, creating conflicts between administrative classifications and actual land-use practices. For instance, the Orans and Gochar lands of western Rajasthan are recorded in many revenue records as government land, yet they serve as sacred community forests, grazing reserves and traditional water catchments for pastoral communities. Their allocation for solar and wind projects has triggered prolonged disputes over customary rights, biodiversity conservation and cultural heritage.

Similarly, in Gujarat's Khavda region, large tracts of revenue wasteland allocated for RE development have long supported seasonal grazing by Maldhari pastoralists and wildlife habitats, illustrating the disconnect between formal land classifications and their actual ecological and livelihood functions.

These governance challenges illustrate that renewable energy conflicts are not driven by opposition to clean energy itself, but by the way projects are planned, sited and implemented. The following sections examine land governance disputes, distributional justice concerns and environmental impacts.

Map 1: States with the largest wasteland area in India (2015-16)



Source: Wastelands Atlas of India (2019), Department of Land Resources and National Remote Sensing Centre, ISRO

Note: *The Atlas reports Jammu & Kashmir as the undivided state, including the area now administered as Ladakh.

Land classification

Land in India is broadly classified into forest, agricultural, non-agricultural and wasteland categories. The Department of Land Resources further classifies wastelands into 23 sub-categories based on vegetation, soil condition, terrain and usability.

According to the *Wastelands Atlas of India* (2019), wastelands cover 55.77 mha, accounting for 16.96 per cent of India's geographical area. Jammu & Kashmir contains the largest share of the country's wastelands (31.5 per cent), followed by Rajasthan (14.1 per cent), Madhya Pradesh (7.1 per cent), Maharashtra (6.5 per cent), Andhra Pradesh (4.3 per cent) and Himachal Pradesh (4.1 per cent).[10]

These states have also emerged as major RE hubs because they combine extensive solar irradiation, favourable wind resources and the availability of large contiguous land parcels. Utility-scale RE projects have become concentrated in these regions. However, many lands classified administratively as "wastelands" continue to support grazing, seasonal cultivation, collection of minor forest produce and other common livelihood activities. This mismatch between administrative land classification and actual land use has become a recurring source of land-use conflicts, particularly in the development of large solar and wind projects.

Table 1: Renewable energy installed capacity in India's major wasteland states (as of June 30, 2026)

State	Solar (GW)	Wind (GW)	Total RE capacity (GW)
Rajasthan	43.32	5.52	49.49
Gujarat	33.22	16.09	51.54
Madhya Pradesh	6.33	3.69	12.54
Maharashtra	20.31	6.32	33.06
Jammu & Kashmir + Ladakh	0.19	0.00	3.88
Andhra Pradesh	8.07	4.46	16.60

Source: Ministry of New and Renewable Energy (MNRE), State-wise Installed Renewable Power Capacity as on 30 June 2026

Siting criteria and land requirements for solar and wind projects

Site selection is a critical determinant of renewable energy development. While projects are ideally located based on resource availability, land, transmission access, terrain and infrastructure, project planning continues to prioritise technical and financial considerations over social and ecological factors. This can contribute to habitat fragmentation, biodiversity loss, community resistance and project delays.

Utility-scale solar projects typically require four to five acre per MW, meaning a 1-GW project occupies around 4,000-5,000 acre.[11] As India increasingly develops multi-gigawatt solar parks, land requirements extend to tens of thousands of acre. These projects are concentrated in arid and semi-arid regions such as Rajasthan and Gujarat because of high solar irradiation and relatively low rainfall. Unlike agriculture, these developments require fenced project sites, vegetation clearance and restricted public access, often replacing grazing lands and other community uses.

Wind projects generally require around 2.5 acre per MW for turbine foundations, while surrounding land often remains available for agriculture or grazing. Because wind farms are frequently located along coastal regions, ridges and forest fringes, they can fragment habitats and affect ecologically sensitive landscapes despite their smaller direct land footprint.

Beyond generation infrastructure, renewable energy projects require roads, substations, transmission corridors and increasingly battery storage systems. These supporting facilities often extend into agricultural and forested landscapes, expanding the overall environmental and social footprint beyond the project boundary.

Under the EIA Notification, 2006, solar and wind projects fall under the White Category and are exempt from mandatory environmental impact assessments and public hearings, although associated transmission infrastructure requires regulatory approvals. The absence of mandatory environmental and social assessments limits the identification of cumulative ecological impacts, livelihood risks and conflict-sensitive siting options.

Current siting practices largely optimise technical and financial considerations, while giving limited attention to livelihood dependence, customary land use and ecological sensitivity. As a result, conflicts increasingly arise not from renewable energy technologies themselves, but from where and how projects are located.

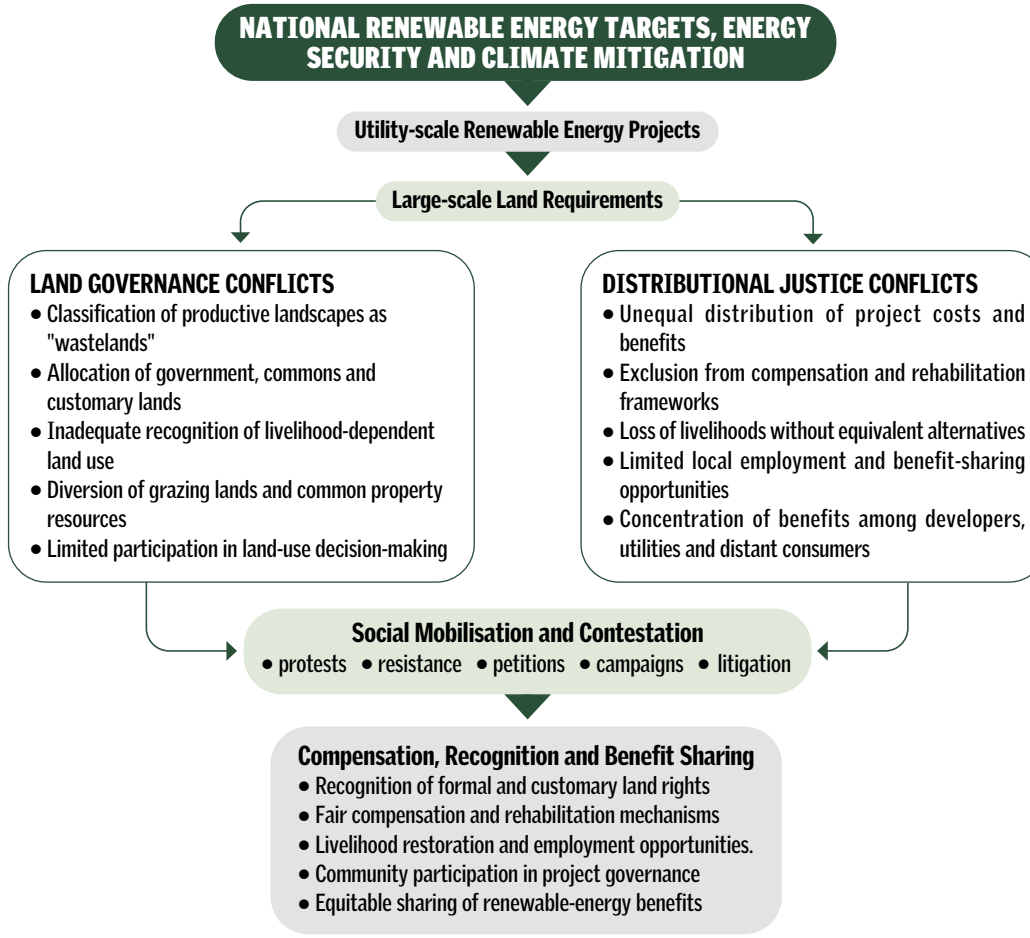
2

SOCIAL CHALLENGES OF RE DEVELOPMENT



Social conflicts surrounding RE projects are driven less by opposition to clean energy than by concerns over land governance, livelihood security, participation in decision-making and the distribution of project benefits. Utility-scale projects are typically planned through techno-economic criteria that give limited attention to local land-use practices and community interests. As a result, conflicts generally emerge around two broad themes: land governance and distributional justice.

Figure 1: Conceptual framework of land governance and distributional justice conflicts in utility-scale RE development



Land governance conflicts

According to Land Conflict Watch, 31 RE projects across India were associated with ongoing social conflicts in 2026, affecting more than 57,000 people and involving nearly 35,900 ha of land.[12] Nearly half of these conflicts relate to common lands, grazing areas and landscapes officially classified as government land or wasteland.

Livelihood and commons-related conflicts (pastoralism)

Renewable energy projects frequently affect communities that depend on common property resources (CPRs) such as grazing lands, village commons, waterbodies and forest-use areas. These resources are central to the livelihoods of pastoral and agro-pastoral communities, particularly in Rajasthan and Gujarat, where livestock rearing relies on extensive grazing networks and seasonal migration routes.

The conversion of commons into renewable energy sites restricts access to grazing areas, fragments livestock movement and reduces the availability of shared natural resources. Since compensation frameworks are largely linked to formal land ownership, users of commons often receive little or no compensation despite experiencing significant livelihood losses.

Cultural and customary landscape conflicts

Renewable energy projects can also generate conflicts when they overlap with landscapes of cultural, religious or customary significance. Across many parts of India, ecological landscapes such as sacred groves, community forests and traditional grazing areas are closely linked to local belief systems and customary institutions. Although these areas may be recorded as government land or wasteland in official records, communities continue to use and protect them for cultural practices, biodiversity conservation and ecosystem management. Such conflicts highlight the limitations of conventional land records in capturing the social and cultural value of these landscapes.

CASE STUDY 1

PHALODI-POKARAN SOLAR PARK, RAJASTHAN

Land, commons and the politics of classification

When India's solar ambition reached the commons

In early 2016, Rajasthan was emerging as the centre of India's rapid solar expansion. Following the development of the Bhadla Solar Park, the Ministry of New and Renewable Energy (MNRE) approved another large project under the Solar Park Scheme. On February 1, 2016, it gave in-principle approval for the 750-MW Phalodi–Pokaran Solar Park.

The project comprised two locations: 450 MW across Ugras, Nagnechinagar and Dandhu villages in Phalodi, Jodhpur district, and 300 MW across Lavan and Purohitsar villages in Pokaran, Jaisalmer district.

The project initially appeared relatively straightforward because most of the identified land belonged to the Rajasthan government and was recorded as



BYELIKOVA_OKSANA, ISTOCKIMAGES

At Phalodi-Pokaran, desert grazing land and livestock share the landscape with solar development projects

government barren land or wasteland. The state, therefore, used the Rajasthan Land Revenue (Allotment of Land for Setting up of Power Plant based on Renewable Energy Sources) Rules, 2007, instead of acquiring private land under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act, 2013.

Building the solar park

To implement the project, the Government of Rajasthan partnered with Essel Infraprojects Limited, an infrastructure development company headquartered in Mumbai, to establish Essel Saurya Urja Company of Rajasthan Limited (ESUCRL). The joint venture was responsible for developing common infrastructure, including internal roads, pooling substations and transmission facilities. Individual solar developers would subsequently lease parcels within the park to establish their generating stations.

During 2016 and 2017, site surveys, transmission planning and infrastructure design progressed. The project formed part of India's strategy to rapidly expand utility-scale solar capacity through large, plug-and-play solar parks. Western Rajasthan was considered suitable because of its high solar irradiation, relatively flat terrain and extensive areas of government land.

The next major step came on March 23, 2018, when the District Collector of Jodhpur issued allotment orders transferring large parcels of government land in Ugras and Nagnechinagar villages to ESUCRL for development of the solar park.

When "wasteland" was not wasteland

For generations, residents of Ugras and Nagnechinagar had used parts of the so-called government land for agriculture, livestock grazing and other community purposes. Villagers also relied on traditional pathways to reach agricultural fields, *dhani*s (small rural settlement), temples, cremation grounds and schools. Government records classified these parcels as barren or wasteland. Local communities regarded many of the same areas as productive commons that supported their livelihoods.

When the matter went to court (see next section), some petitioners stated that their families had cultivated portions of the land continuously for 40-45 years. They also referred to *dhani*s, traditional farm dwellings, and longstanding use of the land for grazing and agriculture. Villagers argued that the allotment process had not adequately considered these existing uses or provided sufficient consultation and verification before the land was transferred for the solar park.

The legal battle begins

The dispute soon reached the Rajasthan High Court. In 2018, several writ petitions, including S B Civil Writ Petition Nos 16304/2018 and 16305/2018, challenged the land allotments. The petitioners argued that the state had failed to recognise their long-standing cultivatory possession and had diverted land without adequately considering livelihood dependence and public use areas.

Their concerns also extended to the proposed boundary walls around the solar park. Villagers argued that fencing could isolate agricultural fields and restrict access to temples, cremation grounds and village roads. Even where particular parcels remained outside the project boundary, they feared that surrounding infrastructure could make them difficult to access.

ESUCRL and the state government defended the allotment on the grounds that:

- the land was government property lawfully allotted under the Rajasthan Land Revenue Rules, 2007;
- the required departmental clearances had been obtained before allotment;
- much of the land was barren and rocky and considered suitable for solar development; and
- the petitioners had not established legally recognised ownership rights over the allotted land.

From single judge to division bench

On November 27, 2019, a single judge bench of the Rajasthan High Court dismissed the writ petitions, effectively upholding the state's allotment decisions.

The villagers appealed, and the matter reached the Division Bench through D B Special Appeal (Writ) Nos 51 and 52 of 2020. As further construction could have created changes that would be difficult to reverse while the appeals were pending, the Division Bench passed a status quo order on February 25, 2020, preventing further development on the disputed Phalodi land.

The High Court's 2021 judgment

On June 29, 2021, the Rajasthan High Court delivered its judgment. The Court did not cancel the Phalodi Solar Park. Instead, it required the state government to examine the actual use of the allotted land and ensure that renewable energy development did not restrict access to agricultural land and public facilities.

The Court directed the government to:

- conduct a detailed survey of the lands allotted to ESUCRL;
- identify any land occupied by public utilities;
- review allotments where surrounding project land prevented the beneficial use of privately held agricultural fields;
- provide approach roads to agricultural lands, *dhani*s and public facilities;
- cancel allotments wherever public utility land had been wrongly transferred; and
- complete the exercise within six weeks.

Resolution and continuing legacy

The court proceedings and subsequent review affected the implementation schedule. Development at the Phalodi site remained stalled from February 2020 while the litigation and land review were underway, whereas the Pokaran component progressed more quickly. According to the Central Electricity Authority, changes to the land configuration were required in accordance with the High Court's directions before fresh allotments could proceed.

Following the review, the District Collector of Phalodi issued revised land allotments on February 23, 2024. By March 2024, around 150 MW of the Phalodi component had been completed, while work on the remaining capacity continued under the revised land configuration.

The Phalodi-Pokaran case shows how a renewable energy project can encounter significant conflict even when private land acquisition is avoided. The dispute arose from the gap between the formal classification of land and the way communities had used it over several decades. Government land recorded as barren or wasteland could still support agriculture, livestock grazing, traditional movement routes and access to community facilities.

Participatory verification of actual land use before allotment can help identify customary uses, access routes, public utilities and common resources at an early stage. Incorporating these factors into project planning can reduce implementation delays while allowing renewable energy development to proceed with greater consideration for local livelihoods and community access.

CASE STUDY 2

THE NEDAN SOLAR PARK DISPUTE, RAJASTHAN

Public utilities, commons and pastoral livelihoods

When government land was not empty land

By 2015, Rajasthan was emerging as a major destination for utility-scale solar development. The state government planned large solar parks across western Rajasthan, using government land to reduce the time and risks associated with land acquisition. One such project was the 1,500-MW Fatehgarh Solar Park, planned across Nedan, Dawara and Rasla villages in Jaisalmer district by Adani Renewable Energy Park Rajasthan Limited (AREPRL), a joint venture of Rajasthan Renewable Energy Corporation Limited and Adani Renewable Energy Park Limited. AREPRL initially sought about 4,041 ha of government land under the Rajasthan Land Revenue Rules, 2007.



DMITRY_CHULOV, ISTOCKPHOTO.COM

Nedan, where a large project abuts traditional grazing land, rural settlements and access routes

The land allocation process soon exposed a problem with treating revenue classification as evidence of actual land use. Before the allotment, district authorities circulated the proposal among government departments and received objections from the Water Resources Department, Forest Department and local officials, along with concerns from residents. Between the initial proposal and final approval, several parcels were removed. Land near settlements in Dawara was excluded, areas adjoining the Great Indian Bustard closure area in Rasla were removed, and land falling within natural river flows in Nedan was taken out. Officials also considered private agricultural holdings, traditional *dhanis* and the absence of approach roads. The proposed area was eventually reduced to around 2,500 ha.

On December 8, 2016, the state issued the demand notice for the land premium. After the required formalities, the District Collector of Jaisalmer issued the allotment order on January 11, 2018, transferring approximately 6,115 *bighas* and 6 *biswas* of government land in Nedan to AREPRL.

Nedan's pastoral landscape depended on more than privately-owned agricultural fields. Villagers used *charagahs*, seasonal waterbodies, village roads and other common resources for grazing, cultivation and everyday movement. After the allotment, residents argued that parts of the allocated area included grazing land, public pathways, waterbodies, graveyards, cremation grounds and other public-use land. Some also claimed long-standing cultivation and residence in *dhanis* without formal ownership titles.

From administrative dispute to legal challenge

In 2018, affected residents approached the Rajasthan High Court through writ petitions, including a case filed by Chanesar Khan, followed by the appeal of Barkat Khan and other villagers. They challenged the January 11, 2018 allotment order, arguing that land serving public and community functions had been treated as available government land without adequately protecting existing rights and access.

AREPRL and the State defended the allotment, saying that the land had been allocated after the required departmental clearances under the 2007 Rules. They maintained that public utility areas such as ponds and graveyards had not been handed over and that the project mainly covered barren and rocky government land.

On November 27, 2019, a single judge bench of the Rajasthan High Court dismissed the writ petitions, holding that several issues involved disputed questions of fact. The villagers appealed. During the appeals in September 2020, the Division Bench examined the original government records and found that officials had themselves



RISHIKA PARDIKAR / CSE

Protests against the proposed solar park development and attempts to dispossess farmers

altered the proposed boundaries after considering objections from departments and local residents. The State subsequently gave an undertaking to maintain status quo on the disputed land.

On June 29, 2021, the Rajasthan High Court delivered its judgment in *Barkat Khan vs State of Rajasthan*, covering the Nedan and Phalodi matters. The Court allowed the solar park to proceed but found that certain public utility lands should not have been included in the allotment. It ordered the immediate cancellation of 1,452.13 *bighas* in Nedan where possession had not yet been handed over to AREPRL. The State was directed to conduct a fresh survey, identify other public utility areas and cancel such allotments where necessary. It was also asked to ensure reasonable access to agricultural fields, village *dhanis* and public facilities, with approach roads identified and recorded in the revenue records.

The judgment allowed the Fatehgarh Solar Park to continue after the disputed parcels were excluded and the land allocation was revised.

CASE STUDY 3

DISPUTE OVER *ORANS*: BAIYA, RAJASTHAN

A project takes shape

By 2024, Rajasthan was already attracting RE investments across its western districts. In this setting, NHPC Limited began advancing plans for a 600-MW solar power project at Baiya village in Jaisalmer district. The project was to be implemented by Adani Solar Energy Barmer One Private Limited and covered approximately 649 ha. The project's Environmental and Social Impact Assessment (ESIA), published in February 2026, described the site as government land suitable for solar development and proposed mitigation measures, including compensatory afforestation where tree removal was required.

For the residents of Baiya, the land identified for the project had a much longer history. At the centre of the dispute was Khasra No 386, covering approximately 2,587 *bighas*. Government records treated the parcel as land available for allocation. Villagers identified it as part of the Rohidalray Oran, a sacred landscape associated with the Rohidalray Temple. *Oran*s are community-conserved areas found across western Rajasthan, where religious traditions and customary institutions have historically helped protect native vegetation, grazing areas, waterbodies and wildlife habitat.



TIMES OF INDIA, TIMES NEWS NETWORK

People stage protest seeking oran, gochar land protection



TEAM ORAN

Activists of Oran Bachao Yatra submit a letter to the Jaisalmer District Collector

Petitioners stated that more than 6,000 mature khejri trees stood within the proposed project area. Khejri is Rajasthan's State Tree and provides fodder, shade, soil enrichment and habitat in the arid landscape. For the residents, protecting the site, therefore, involved the religious significance of the *oran* as well as its ecological functions.

Concerns over tree felling

As preparations for the solar project progressed, villagers became concerned that construction would require extensive tree felling. They argued that removing the khejri trees would affect the ecological character of the area and the customary character of the Rohidalray Oran. By 2025, concerns had begun appearing elsewhere in Jaisalmer, with communities calling for *orans*, grazing areas and associated waterbodies to be identified and recorded before further RE projects were approved. Concerns were raised in litigation concerning Sitodai village, where another solar project was proposed on land claimed to contain *oran* areas.

The dispute reached the Rajasthan High Court when Mukund Singh Bhati and Jujhar Singh filed a public interest litigation. Their petition challenged the treatment of Khasra No 386 as ordinary government land and presented documentary evidence, satellite imagery and other material concerning the site's trees and cultural and ecological significance. The petition also questioned whether customary community interests had received adequate consideration during the land allocation process. The state government disputed the claim that the land was officially recorded as an *oran*. But the government counsel acknowledged before the Court that thousands of trees were present on the site.

Adani Solar stated that the required statutory procedures had been followed and that environmental obligations, including compensatory afforestation, would be implemented according to applicable approvals.

The High Court's intervention

The case came before a Division Bench of the Rajasthan High Court comprising Justice Pushpendra Singh Bhati and Justice Sandeep Shah. Given the possibility of irreversible tree loss while the status of the land was being examined, the Court directed that status quo be maintained. Tree felling on the disputed land was suspended until further orders.

The Court also referred the matter to an expert committee to examine the ecological, cultural and legal status of the site. The committee was asked to inspect the land and submit its findings before the next hearing.

The Baiya proceedings were taking place alongside another development at the national level. On December 18, 2024, the Supreme Court had directed the Rajasthan government and the Union Ministry of Environment, Forest and Climate Change to undertake comprehensive identification and mapping of *orans* through satellite imagery and ground surveys. The Court also directed that eligible *orans* be considered for notification as 'community reserves' under the Wildlife (Protection) Act, 1972; a five-member committee was set up to oversee the exercise.

These directions became relevant to subsequent *oran*-related proceedings before the Rajasthan High Court. The Court sought updates on compliance with the Supreme Court's directions, bringing the recognition and protection of community-conserved landscapes into the wider legal discussion surrounding renewable energy development.

Current status

As of 2026, the Rajasthan High Court's interim order continues to restrain tree felling at the disputed site while the expert committee examines the matter.

The Baiya case shows how a renewable energy project can encounter a land-governance dispute when formal revenue records and customary land-use systems describe the same landscape differently. The project site is associated with ecological functions, religious significance and a history of community stewardship. The litigation has consequently brought the recognition of such landscapes into the renewable energy planning process, alongside questions of land allocation, tree protection and community rights.

CASE STUDY 4

THE ASSAM SOLAR PROJECT, KARBI ANGLONG

Loss of customary land

The Assam government began developing the Mukhya Mantri Soura Shakti Prokolpo to expand utility-scale solar generation and reduce the state's dependence on electricity imports. The flagship project was planned in Karbi Anglong, a Sixth Schedule autonomous tribal area. The proposed Assam Solar Project would have 1,000 MWp (750 MWAC) of solar capacity, battery storage, transmission infrastructure and distribution upgrades. The proposed site around Lahorijan and Khatkhati, near the Assam-Nagaland border, required 2,396 ha, or 18,000 *bighas*, with the Assam Power Distribution Company Limited (APDCL) as the implementing agency.

During 2023 and 2024, preparation moved forward with support from the Karbi Anglong Autonomous Council (KAAC). APDCL launched the procurement on June 24, 2024, when it invited proposals for a Project Management Consultant for the project. On March 21, 2025, it issued bidding documents for a 400/33 kV pooling substation to evacuate power from the proposed plant.

The project's financing plan was taking shape at the same time. In its October 2024 *Report and Recommendation of the President*, the Asian Development Bank (ADB, which was funding the project) described the project as part of Assam's plan to reach 3,000 MW of RE capacity by 2030. The plan included a 500-MW public sector solar facility, a 250-MW public-private partnership, a battery storage pilot and improvements to rural electricity distribution.

Consultation and the first signs of disagreement

An ADB safeguard document recorded a consultation at Khatkhati on January 25, 2024, attended by village representatives and government agencies. The Resettlement and Ethnic Minority Development Plan concluded that the consultation demonstrated "Broad Community Support" and that communities had been informed about the project, its land requirements and anticipated impacts.

Community organisations later disputed that assessment. They said the consultation did not adequately represent all affected villages or involve the customary institutions through which land decisions are traditionally made in Karbi society. Their concern was tied to the nature of landholding in Karbi Anglong. Forests, bamboo groves,



RAHULDSILVA, ISTOCKPHOTO.COM

A herd of wild elephants in a grassland in Karbi Anglong, Assam

shifting cultivation areas, grazing lands and streams are often managed through customary institutions and form part of wider community territories.

By mid-2023, organisations including the Joint Action Committee for Protection of Autonomy (JCCPA) had begun questioning the proposed location. Their position was that communities could support solar development while asking the government to locate projects on genuinely degraded or unused land.

As preparations continued, the opposition became organised. The Karbi Anglong Solar Power Project Affected People's Rights Committee (KASPAPPC) brought together representatives from the affected villages. Community leaders estimated that 23 to 24 villages and around 20,000 people could be affected. They raised concerns about agricultural land, forests, bamboo resources, grazing areas, streams and ancestral territories, and questioned how compensation would address customary land rights that were not represented through individual titles.

FPIC becomes central to the dispute

By this stage, the discussion had moved towards Free, Prior and Informed Consent (FPIC). Community organisations argued that affected villages had not provided free and informed consent and that customary decision-making institutions had not been adequately involved. They maintained that KAAC's institutional approval did not settle the question of consent from communities holding customary rights.

ADB's safeguard documents recorded a different position. They stated that consultations had demonstrated broad community support and that ethnic minority development measures had been incorporated into the project. The difference between these two assessments became central to the dispute.



ANUPAM CHAKRAVARTTY / CSE

At a meeting in Men Tisso village, Karbi Anglong, landowners from the Karbi and Naga communities pledged to resist land acquisition for the proposed project

The dispute reaches the ADB

Community organisations approached the ADB accountability mechanism, raising concerns about customary land rights, livelihoods, cultural heritage and compliance with the bank's safeguard requirements. On February 11, 2025, the ADB Compliance Review Panel (CRP) formally received a complaint concerning the Assam Solar Project and proceeded with its eligibility review.

The dispute was continuing while project procurement was underway. The Government of Assam then requested cancellation of the ADB financing. In May 2025, ADB cancelled its US $434.25 million loan, which had been approved seven months earlier. The cancellation also affected associated technical assistance and procurement activities.

Current status

By 2026, the project remained at the pre-construction stage. APDCL's procurement documents from 2024 and 2025 show that substantial preparation had taken place, while construction had not begun. The questions around customary land rights and community consent remained unresolved.

The subsequent ADB complaint and financing withdrawal added an international safeguard dimension to a conflict that had begun within Karbi Anglong.

Distributional justice conflicts

Land governance determines how RE projects access and use land. Distributional justice focuses on how the costs, benefits and opportunities created by these projects are shared among different stakeholders. Utility-scale RE projects contribute to national climate and energy goals, while the immediate costs of land use change and livelihood disruption are often experienced by communities living around project sites.

Distributional conflicts often emerge around the identification of affected households, compensation, rehabilitation, employment and long-term benefit sharing. Compensation is linked mainly to formal land ownership, excluding cultivators, pastoralists, agricultural labourers and users of common property resources who may depend on land without holding recognised titles, leaving some livelihood impacts outside formal compensation processes. Communities may also raise concerns when commitments relating to employment, infrastructure or local development are not fully implemented.

The following case studies examine how these gaps in compensation, livelihood support and benefit sharing have shaped community experiences of renewable energy projects.

CASE STUDY 1

KURNOOL ULTRA MEGA SOLAR PARK, ANDHRA PRADESH

Compensation and recognition of assigned land cultivators

The Kurnool Ultra Mega Solar Park emerged soon after the Ministry of New and Renewable Energy (MNRE) launched the Solar Park Scheme in 2014. Andhra Pradesh moved quickly to participate, establishing Andhra Pradesh Solar Power Corporation Private Limited (APSPCL) as the implementing agency. In June 2015, the MNRE formally recognised APSPCL as the Solar Power Park Developer for the Kurnool and Ananthapur solar parks. The Kurnool project was planned across Orvakal and Gadivemula *mandals* with a capacity of 1,000 MW, an estimated investment of about ₹7,000 crore and a land requirement of nearly 5,900 acre.

Project preparation had already begun in 2014, when the district administration identified land around Gani, Sakunala and neighbouring villages. Much of the proposed area was government and assigned land. A subsequent assessment recorded about 3,000 acre comprising 120 acre of *patta* land, 25 acre of endowment land and approximately 2,855 acre of assigned land. These assigned lands had been distributed to landless households under government programmes. Families had cultivated the assigned plots for decades, invested in wells and other improvements, and relied on them for household income. Revenue authorities treated the land as government property that could be resumed under applicable rules. Cultivators viewed the same plots through their everyday dependence on agriculture.

The acquisition process accelerated in late 2014 and early 2015. Proceedings under R C No 131/2014 enabled the administration to resume large areas of assigned land, and possession was reportedly taken on January 2, 2015. Several assignees later said that their *Darakastu pattas* had been cancelled or resumed on the basis of alleged violations of assignment conditions. This affected their eligibility for compensation.

As more land was taken over, questions about compensation became increasingly difficult to resolve. Community accounts documented by Land Conflict Watch estimated that nearly 800 cultivators lost access to land, while around 180 received compensation. Revenue officials maintained that compensation could be paid only where legal entitlement was established in the revenue records. Affected cultivators argued that the records did not capture their long-term dependence on the land.



GREENKO GROUP

Kurnool Ultra Mega Solar Park, Andhra Pradesh

The dispute soon reached the courts. In 2016, 22 farmers from Gani village in Gadivemula Mandal approached the Andhra Pradesh High Court. Their petition alleged that the administration had taken possession without following the procedures under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. They also argued that compensation had not been paid before possession was taken. The High Court directed the authorities to maintain status quo for six weeks.

The initial court intervention gave the farmers temporary relief, while the solar park continued to move ahead. Further petitions followed, including *E Lalithamma v State of Andhra Pradesh*, concerning land assigned to the petitioner in 2005 and taken back by the government in 2015 for the solar park. The case raised the question of whether assigned land could be taken back for a public project while denying compensation on the basis of alleged violations of *Darakastu patta* conditions. Similar claims were subsequently raised by other assignees.

Meanwhile, construction proceeded rapidly. APSPCL developed the common infrastructure, while companies including SoftBank Energy, Greenko, Azure Power and Adani established individual generating units within the park. Substantial parts of the project entered commercial operation by 2017, and the park was formally inaugurated by chief minister N Chandrababu Naidu in January 2019.

In August 2019, local MLA Katasani Rambhupal Reddy met APSPCL officials and urged them to address outstanding claims. He pointed to the continuing gap between the operation of the solar park and the unresolved claims of affected cultivators.

Employment also became part of the discussion. Residents had expected the project to generate sustained local employment and wider economic opportunities. Most jobs were concentrated during construction, while the number of long-term operational positions remained limited. For households that had lost agricultural livelihoods, these opportunities provided limited replacement income.

The experience points to a practical issue for future solar parks. Where assigned land, government land and long-term cultivation overlap, revenue records alone may provide an incomplete picture of livelihood dependence. A livelihood-based assessment alongside formal ownership records could help identify affected cultivators earlier and provide a clearer basis for compensation and rehabilitation.

CASE STUDY 2

NP KUNTA SOLAR PARK, ANDHRA PRADESH

Compensation beyond land acquisition

The NP Kunta Solar Park emerged from the Ministry of New and Renewable Energy's Solar Park Scheme, which was launched in December 2014 to support large utility-scale projects through state-led land aggregation and common infrastructure. Andhra Pradesh proposed four solar parks with a combined capacity of 4,000 MW. Among them was the 1,500-MW Ananthapuramu Solar Park, spread across NP Kunta in Anantapur district and Galiveedu in Kadapa district. APSPCL, a joint venture of SECI, APGENCO and NREDCAP, was appointed the state's Solar Park Developer.

Under the project model, APSPCL was responsible for assembling the land and developing roads, water supply and transmission infrastructure before allocating project parcels to developers through competitive bidding. The park subsequently attracted Tata Power Renewable Energy, Azure Power, ACME Solar, FRV Power India and NTPC, with electricity contracted through SECI.

By April 28, 2016, the MNRE reported to the Lok Sabha that the project had already secured land and was progressing. By December 2016, the Detailed Project Report had been completed; 6,692.97 acre had been acquired at NP Kunta and 1,738.40 acre at Galiveedu; internal infrastructure was under construction; and 250 MW had been commissioned. These figures showed how quickly land assembly and construction had progressed.

The land itself had several different legal and livelihood histories. The project covered nearly 11,000 acre across villages including Kothapalli, Veligallu and Thumukunta. The affected parcels included private *patta* land, *Darakastu Patta* (DKT) assigned land and government land cultivated by *S. J. Dhar farmers*. A *Darakastu Patta* holder has been officially assigned a piece of government wasteland for livelihood purposes. On the other hand, an *S. J. Dhar farmer* represents a landless cultivator who actively tills a piece of land but may not hold an individual formal assignment document. These categories were subject to different compensation arrangements, while many families had depended on assigned or government land for cultivation over long periods.

The Environmental and Social Impact Assessment prepared for the project financiers recorded separate compensation packages for private landowners and



COPERNICUS SENTINEL-2, ESA, SENTINTEL HUB

The Ananthapuramu Ultra Mega Solar Park at NP Kunta, Andhra Pradesh (aerial view here) illustrates the extensive land footprint of utility-scale solar development, with large blocks of solar installations

assigned landholders. It also recorded consultations with affected communities and compensation through negotiated settlements. As construction progressed during 2016, farmers began questioning the amounts they had received. Community representatives said that some farmers had expected around ₹2.1 lakh per acre and received less. Discussions around the project had also created expectations of employment, local infrastructure and rehabilitation support.

These concerns gradually became the focus of the dispute. Farmers were seeking clarity on compensation while also asking how the employment, rehabilitation and livelihood commitments associated with the acquisition would be implemented. The issue, therefore, continued after the land had been acquired and construction had begun.

The dispute intensified in 2018, when affected farmers organised demonstrations seeking compensation for 56 Darakastu Patta landholders and 1,156 *S. J. Dhar*

cultivators. Construction activities were reportedly disrupted, and political leaders from opposition parties joined the protests. After repeated representations, outgoing District Collector G Veerapandian forwarded revised compensation proposals to Ajay Jain, Principal Secretary (Energy). Revenue authorities subsequently identified 932 Dhar cultivators as eligible and disbursed approximately ₹9.32 crore. But the settlement process left some claimants outside the approved list, with officials maintaining that additional names had emerged after the original verification exercise.

The dispute continued into 2019, when wider uncertainty emerged across Andhra Pradesh's renewable energy sector following the change in power in the state government. Previously executed renewable energy power purchase agreements came under review, affecting developers operating in the state. At NP Kunta, unresolved compensation issues also continued to affect construction. Land Conflict Watch, an online news platform, reported[13] that work had effectively stalled by June 2019, while official project documents recorded only 250 MW in operation during the early stages of the 1,500-MW project.

The compensation dispute was handled through administrative negotiations involving the district administration, APSPCL and the Energy Department. Environmental and social due diligence reports prepared for financing institutions stated that compensation matters had been addressed through verification of eligible claimants and additional payments. APSPCL and revenue officials reported that compensation issues had been resolved, while community organisations continued to raise concerns about rehabilitation and livelihood restoration.

Land was assembled, infrastructure was built and generation began while questions over compensation and rehabilitation were still being raised. The 2018 verification exercise resulted in payments to 932 Dhar cultivators, while some claims remained disputed. By 2019, these local concerns had become part of a wider period of uncertainty for renewable energy projects in Andhra Pradesh.

The case points to the importance of following land acquisition with sustained rehabilitation and livelihood support. Compensation arrangements, employment commitments and other assurances need to be documented during acquisition and tracked through project implementation. This gives affected households a clear mechanism for raising claims after construction begins and gives project authorities a defined process for resolving them.

CASE STUDY 3

CHARANKA SOLAR PARK, GUJARAT

Unequal distribution of benefits

The Charanka Solar Park emerged from Gujarat's early push towards large-scale solar power generation. In January 2009, Gujarat became the first Indian state to adopt a dedicated solar power policy, nearly a year before the Jawaharlal Nehru National Solar Mission. The policy offered incentives for private investment and introduced a model in which the government would aggregate land, develop common infrastructure and allocate plots to multiple developers. Charanka became the first major demonstration of this approach.

The government selected Charanka village in Santalpur taluka of Patan district, close to the Little Rann of Kutch and the Pakistan border. Government records classified much of the area as wasteland, while its high solar irradiation and low population density made it attractive for large-scale development. The Gujarat Power Corporation Limited (GPCL) became the nodal agency, developing the site and allocating plots to private companies. SunEdison, Lanco Solar, Solar



SOURCE: GOOGLE EARTH

Satellite view of India's first solar park at Charanka: Installations now occupy large stretches of Charanka's landscape, limiting traditional access for commons-based livelihoods

Semiconductor, Alex Astral Power, Emami, IndoSolar and other companies subsequently established projects within the park. By April 2012, around 214 MW had been commissioned.

The government promoted Charanka as a regional development project alongside its electricity-generation role. Officials expected the investment to bring employment, better roads, improved electricity infrastructure and new economic activity to a remote part of Gujarat. These expectations shaped how villagers understood the project. Research found that many residents initially welcomed solar development, viewing it as an opportunity for economic advancement.[14]

Land development accelerated during 2010 and 2011. Much of the site consisted of government land, which reduced the need for acquisition of privately-owned agricultural holdings. On the ground, however, these areas had several uses. The commons provided seasonal livestock grazing grounds for the Rabari pastoral community and local farmers, while landless households collected *Prosopis juliflora*, locally called *gando baval*, and converted it into charcoal for sale. These activities were absent from formal land records, although they constituted a part of the local economy.



SAUR NEWS BUREAU

Charanka Solar Park, Gujarat: Expansive rows of solar panels across a flat, dry landscape

Because much of the project occupied government land, the acquisition process generated relatively few formal disputes. Private landowners received compensation where their land was acquired, and there was no major litigation over the establishment of the park. The more difficult questions emerged after construction, when residents began comparing the employment and development expectations associated with the project with what they experienced locally.

During construction, the park created temporary employment in civil works, transportation, fencing and installation. After commissioning, the number of permanent jobs was considerably smaller. Technical positions were often filled by workers from outside the area, while local employment was concentrated in security, grass cutting and panel cleaning. For villagers who had expected continuing employment, the transition from construction to operations, therefore, brought a significant reduction in available opportunities.

The impact was particularly significant for the Rabari pastoralists. Their livestock depended on seasonal access to the surrounding commons. As solar installations were fenced, grazing areas became smaller and herders had to travel farther or reduce their herd sizes. Livestock remained an important source of household income, making the loss of grazing access a livelihood issue. Since pastoralists generally did not hold formal ownership rights over the commons, the loss of this access did not result in direct compensation.

Landless households faced a similar change. Before the solar park, families collected *gando baval* from the commons and sold charcoal as a supplementary source of income. Once access to the project area was restricted, this livelihood opportunity disappeared. Their dependence on the commons had not been formally recognised during project planning, leaving these households without compensation or a comparable livelihood alternative.

Over time, differences also emerged in who could take advantage of the new economic opportunities. Households with larger landholdings, higher education or stronger local connections were better positioned to secure contracts, employment or other project-related opportunities. Smaller farmers, pastoralists and landless households had fewer resources with which to participate. Research found that economically stronger groups captured a greater share of the emerging opportunities, while vulnerable households faced greater livelihood losses.[15]

Infrastructure produced a similar mix of expectations and outcomes. Roads and electricity infrastructure improved around the project area, but interviews with

villagers indicated that many residents viewed these improvements as primarily serving the solar park's operational needs. Expectations concerning drinking water, schools, healthcare and irrigation were only partly met. The scale of investment in electricity generation, therefore, created expectations of corresponding improvements in local public services.

Charanka did not develop into a prolonged court dispute. Community dissatisfaction was expressed through local discussions, negotiations and subsequent academic research. The issues largely concerned employment, access to common resources and the distribution of economic gains. Existing acquisition procedures provided limited avenues for addressing these wider questions because many affected households did not hold formal rights over the resources on which their livelihoods depended.

At the village level, however, pastoralists and landless households carried livelihood costs associated with losing access to commons, while the longer-term employment and public-service benefits were more limited than many residents had expected.

The Charanka experience suggests that benefit sharing needs to begin with a proper understanding of how project land is used. Grazing, collection of biomass and other informal activities can have real economic value even when they leave little trace in revenue records. Recognising these uses during project planning, providing livelihood alternatives and creating mechanisms for local communities to participate in project-related economic opportunities can make benefit sharing more equitable.

CASE STUDY 4

REWA ULTRA MEGA SOLAR PROJECT, MADHYA PRADESH

Employment expectations and benefit sharing

The Rewa Ultra Mega Solar Project began taking shape in 2014, when the Madhya Pradesh government started planning a large solar park in Gurh tehsil of Rewa district. The project later aligned with MNRE's Solar Park Scheme. In 2015, the state established the Rewa Ultra Mega Solar Limited (RUMSL) as a joint venture between Madhya Pradesh Urja Vikas Nigam Limited and the Solar Energy



ACME SOLAR

Rewa Ultra Mega Solar Project, Madhya Pradesh: A wide aerial image that conveys the scale of the solar park

Corporation of India. RUMSL was given responsibility for land assembly, project structuring, market consultations, bidding and common infrastructure.

The project was planned across approximately 1,500 hectare (ha) and divided into three 250-MW units. Environmental and social assessments were completed before tendering, with the World Bank and International Finance Corporation supporting the transaction structure. Twenty national and international companies participated in the bidding process. After the reverse auction, Mahindra Renewables Private Limited, ACME Jaipur Solar Power Private Limited and Arinsun Clean Energy Private Limited were selected to develop the three units. The project achieved a first-year tariff of ₹2.97 per kWh, without viability gap funding.

Land assembly and expectations

RUMSL assembled the project land through a combination of government revenue land and private purchases under Madhya Pradesh's mutual consent policy. About 1,255.68 ha came from government revenue land and approximately 300 ha were purchased from private landowners through negotiated agreements. The World Bank later highlighted this approach because land was assembled before tenders were invited, reducing acquisition-related risks during project implementation.

During consultations, villagers associated the project with a wider set of economic opportunities. They expected employment, better roads, improved public services and new local businesses. The scale of the proposed investment, estimated at around ₹4,500 crore, reinforced these expectations. For families giving up private land and households dependent on surrounding commons, the project was seen as part of the future development of the area.

Construction moved ahead during 2016-2018. The World Bank approved financing for shared infrastructure in March 2017, followed by a loan agreement with the Government of India in November 2017. The first generating units began producing electricity in June 2018, commercial operations started in July 2018, and the full 750-MW capacity was commissioned by January 3, 2020. Around 76 per cent of the electricity was supplied to Madhya Pradesh's distribution companies and 24 per cent to the Delhi Metro Rail Corporation (DMRC). Rewa became the first renewable energy project in India to supply power to DMRC, adding to its national profile.

The project received the World Bank Group President's Award for Innovation and Excellence and recognition from the Global Infrastructure Facility. Its bidding structure, payment security mechanism and contracting arrangements became reference points for later solar projects.

Employment becomes the main concern

The social concerns became more visible after construction was completed. During construction, local residents found temporary work in civil works and other project activities. Once the plant became operational, the number of available positions fell sharply. According to Land Conflict Watch[16], families whose land had been acquired believed they had been assured employment for one member of each affected household. Many later reported that permanent jobs had not materialised. Long-term local employment was concentrated mainly in security, housekeeping and maintenance, while technical positions were generally filled by skilled workers from outside the area.

The expectation was that the project would create a continuing source of local economic opportunity. As the plant entered regular operation, the gap between these expectations and the available jobs became a recurring source of dissatisfaction. The benefits of the project were increasingly perceived as flowing towards developers, electricity consumers and urban institutions, while local employment gains remained limited.

Access to land and local livelihoods

The project's physical footprint also affected movement around the site. Land Conflict Watch reported[17] that the boundary wall restricted traditional routes used by villagers and pastoralists. In some cases, journeys that had previously taken two to three kilometre increased to 14 to 15 km because residents had to travel around the fenced solar park. Pastoralists also reported reduced access to grazing areas. These impacts had been identified during the project's environmental and social assessment, which noted potential disruption to grazing systems and food networks dependent on the surrounding land.

These changes added another dimension to the employment concerns. Households were adjusting to changes in agricultural access, grazing routes and other established patterns of rural life while the permanent employment opportunities associated with the solar plant remained limited.

A conflict handled outside the courts

The Rewa dispute did not develop into prolonged litigation over land acquisition or compensation. Land Conflict Watch classifies it as "Out of Court", with communities relying on representations, local negotiations and public advocacy. There are no reported High Court or Supreme Court judgments in which affected villagers challenged the acquisition or sought judicial enforcement of employment commitments.

Employment opportunities, local development and benefit sharing had largely emerged through consultations, public assurances and community expectations. These commitments did not necessarily take the form of enforceable contractual obligations. This left communities with limited formal mechanisms for pursuing employment or benefit-sharing claims once the plant was operational.

The Rewa project remains an important example of what a well-prepared solar park can achieve in procurement, financing and project development. Its experience also shows that these measures do not determine how host communities assess the project after commissioning. For many residents, employment, livelihood security and access to local resources formed part of the project's expected benefits. Land transactions addressed the immediate transfer of property, while longer-term economic participation remained less clearly defined.

For future solar parks, Rewa points towards a broader approach to benefit sharing. Employment commitments need clear definitions, eligibility criteria and monitoring

arrangements. Local infrastructure and livelihood measures also need identifiable responsibilities and timelines.

The four case studies show that distributional conflicts often continue beyond the initial land transaction. They are shaped by how affected communities are identified, how compensation and rehabilitation are delivered, and how local people participate in the longer-term benefits of renewable energy projects. Across the four projects, concerns around compensation, livelihood restoration, employment and benefit sharing continued into the implementation and operational stages.

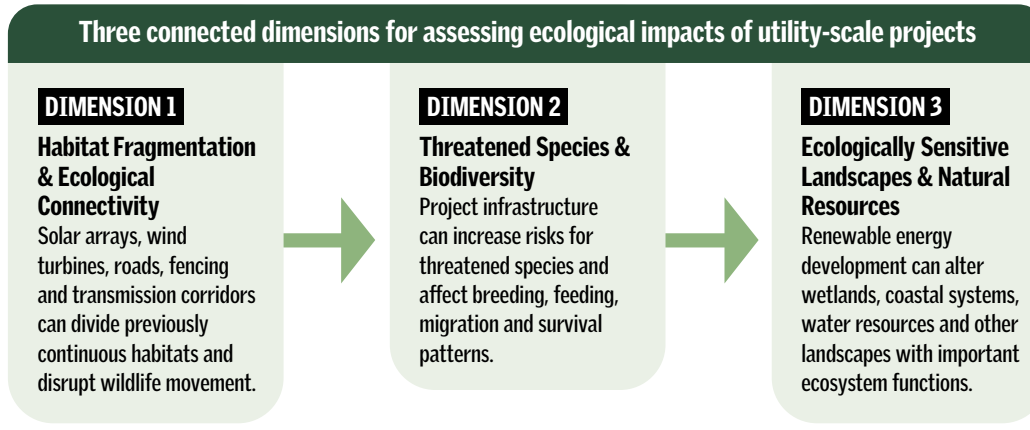
3

ENVIRONMENTAL CHALLENGES OF RE DEVELOPMENT



Renewable energy expansion is essential for decarbonising India's power sector and reducing dependence on fossil fuels, but large-scale deployment also changes natural landscapes and ecological processes. Utility-scale solar and wind projects are increasingly being developed across grasslands, wetlands, coastal ecosystems, scrublands and other environmentally sensitive areas. Their infrastructure can affect habitat continuity, wildlife movement, water systems and ecosystem services that support local communities and biodiversity. These impacts can become significant when project siting, land-use planning and environmental assessment do not adequately account for ecological sensitivity and cumulative impacts.

Figure 2: Environmental conflicts in RE development



Habitat fragmentation and ecological connectivity

Renewable energy infrastructure can fragment habitats by introducing solar arrays, wind turbines, access roads, substations and transmission corridors into otherwise continuous landscapes. These structures can restrict wildlife movement, break ecological corridors and alter the functioning of surrounding ecosystems. The effects are particularly visible in western India, where large renewable energy projects are being developed across the Thar Desert and Kutch landscapes. Land classified as barren, wasteland or scrubland in administrative records can therefore have significant ecological value, making landscape-level assessment and careful project siting important during renewable energy planning.

CASE STUDY 1

KHAVDA RE PARK: GUJARAT

Habitat fragmentation and ecological connectivity

The Gujarat government announced plans for a large hybrid renewable energy park in the Khavda region of Kutch in late 2020. The project was planned with an eventual capacity of 30 GW of solar and wind power and was presented as a major contribution to India's target of 500 GW of non-fossil fuel capacity by 2030. Located near the India-Pakistan border in the Great Rann of Kutch, the site offered strong solar irradiation, high wind speeds and extensive government land.

The Gujarat government formally approved the project in December 2020 and designated Gujarat Industries Power Company Limited (GIPCL) as the nodal agency for common infrastructure, including substations, internal roads and transmission facilities. The project was structured as an Ultra Mega Renewable Energy Power Project under MNRE's Solar Park Scheme, allowing multiple developers to establish individual projects within the larger park. Over the following years, companies including Adani Green Energy, NTPC Renewable Energy, GSECL, NHPC, NLC India, SJVN Green Energy, JSW Neo Energy, SAEL Industries, KPI Green Energy and ENGIE secured project parcels.

Development and commissioning proceeded in phases from 2024 onwards.

The availability of government land and existing transmission infrastructure was also presented as an advantage. Much of the landscape was described as sparsely populated or wasteland, making it appear suitable for large-scale renewable energy development.

The ecological character of the landscape raised a different set of questions. Khavda forms part of the wider Greater Rann of Kutch ecosystem and is closely connected with the Banni Grasslands, Chhari Dhand Conservation Reserve and seasonal wetlands. These wetlands lie along the Central Asian Flyway and provide feeding and resting areas for migratory flamingos, cranes, pelicans, storks and other waterbirds. The wider grassland landscape also supports species such as the Great Indian Bustard, Lesser Florican, Indian wolf, caracal, striped hyena, desert fox and chinkara.



X/@INDUMAKALKTCH1

Khavda Renewable Energy Park, Gujarat: The Great Indian Bustard in its natural habitat

As project planning progressed, environmental concerns focused increasingly on the cumulative footprint of the park. Solar arrays, wind turbines, roads, substations, fencing and transmission lines would occupy a landscape that had previously remained largely continuous. Grassland species depend on open areas for movement, feeding and breeding. The ecological concern, therefore, extended beyond vegetation clearance to the fragmentation of habitat and loss of connectivity.

Transmission infrastructure became particularly important because of the presence of the Great Indian Bustard (GIB). The species has relatively poor frontal vision and is vulnerable to collisions with overhead power lines. Research by the Wildlife Institute of India[18] has identified power-line collisions as an important source of mortality for the remaining population. As renewable energy projects expanded across Rajasthan and Gujarat, conservationists raised concerns about the cumulative effect of transmission networks across GIB habitat.

The legal proceedings that affected renewable energy development in the region began before most of the Khavda construction activity. In 2019, conservationist M K Ranjitsinh and others approached the Supreme Court under Article 32, seeking stronger protection for the Great Indian Bustard and Lesser Florican from overhead transmission lines in Rajasthan and Gujarat.

On April 19, 2021, the Supreme Court directed that overhead power lines in priority GIB habitats should be placed underground wherever technically feasible and required bird diverters on existing lines. The order had implications for transmission planning around Khavda because proposed power evacuation routes passed through the same wider ecological landscape.

The 2021 direction created practical concerns for transmission utilities and renewable energy developers. Undergrounding high-voltage lines across large distances was considered technically difficult and expensive, with potential implications for project timelines. Conservation organisations continued to argue that transmission planning needed to account for cumulative impacts on grassland habitats.

The Supreme Court revisited the matter on March 21, 2024 after the Union government sought modification of the earlier directions. The Court constituted a seven-member expert committee with representatives from the power sector, wildlife conservation, transmission planning and environmental science. The committee was asked to identify priority conservation areas, examine the feasibility of underground transmission and develop a framework for managing the relationship between renewable energy infrastructure and GIB conservation.

Over the following year, the committee assessed transmission requirements and conservation priorities. Its recommendations included delineating priority areas for GIB conservation, developing dedicated transmission corridors, installing scientifically validated bird diverters, selectively undergrounding lines where feasible and strengthening biodiversity monitoring. This shifted the discussion towards landscape-level planning rather than treating each transmission line as a separate project.

On December 19, 2025, the Supreme Court accepted much of the committee's framework. The Court expanded priority conservation areas in Rajasthan and Gujarat and called for transmission planning that reduced unnecessary proliferation of overhead lines in sensitive habitats. The judgment also emphasised coordinated infrastructure planning across renewable energy development and biodiversity conservation.

In January 2026, MNRE issued directions treating delays experienced by several renewable energy projects in Rajasthan and Gujarat, including projects associated with Khavda, as force majeure for extending commissioning timelines while transmission approvals were being clarified.

THE GREAT INDIAN BUSTARD: HABITAT LOSS AND TRANSMISSION RISK

The Great Indian Bustard (GIB) has become one of India's most important biodiversity conflicts linked to renewable energy development. Fewer than 150 individuals are estimated to remain in the wild, with most found across the Thar Desert of Rajasthan and parts of Gujarat.

Overhead transmission lines emerged as a major concern because GIBs have limited frontal vision and can fail to detect wires during flight. In 2021, the Supreme Court directed the undergrounding of power lines in priority GIB habitats. Its recommendations were considered in the Court's 2025 judgment, which adopted a more targeted, risk-based approach to power infrastructure in GIB habitats.

The revised framework identified priority conservation areas, called for restoration of critical grassland habitats and strengthened long-term monitoring of GIB populations. It recommended immediate undergrounding or rerouting of 79.2 km of critical 33 kV transmission lines and undergrounding of 64.9 km of 66 kV lines. For existing and future high-voltage lines, the framework recommended dedicated transmission corridors and rerouting wherever feasible. Bird diverters were recommended where undergrounding could not be practically implemented.

Species-specific risk assessment, careful routing of transmission corridors, habitat restoration and long-term population monitoring can help reduce conflicts between renewable energy expansion and conservation priorities.

Khavda continues to expand, with multiple phases under construction and commissioning. Its central issue is the compatibility of extensive renewable energy and transmission infrastructure with an ecologically connected grassland landscape. The experience has strengthened the case for landscape-level biodiversity assessment, strategic transmission planning, species-specific mitigation and long-term ecological monitoring from the early stages of project development.

Disturbance of ecologically sensitive landscapes

Beyond impacts on wildlife habitats, renewable energy projects can also alter wetlands, coastal ecosystems and water-stressed landscapes. Large-scale solar developments can modify natural drainage patterns, affect groundwater availability and change ecosystem functions through extensive land conversion, fencing, roads and other supporting infrastructure. These concerns become particularly important when projects are located near Ramsar wetlands, within coastal regulation zones or across semi-arid regions already experiencing water and ecological stress. The following cases illustrate how these landscape-level impacts can emerge during both project development and operation.

CASE STUDY 1

SAMBHAR SOLAR PROJECT, RAJASTHAN

Renewable energy and wetland protection

In the early 2010s, Rajasthan was emerging as a major destination for utility-scale solar development because of its high solar irradiation, large areas of government-controlled land and relatively low population density. Sambhar Lake, located about 75 km southwest of Jaipur across Jaipur, Nagaur and Ajmer districts, soon became part of this expansion. The site offered strong solar resources and extensive land, but it was also part of one of India's most important wetland ecosystems.

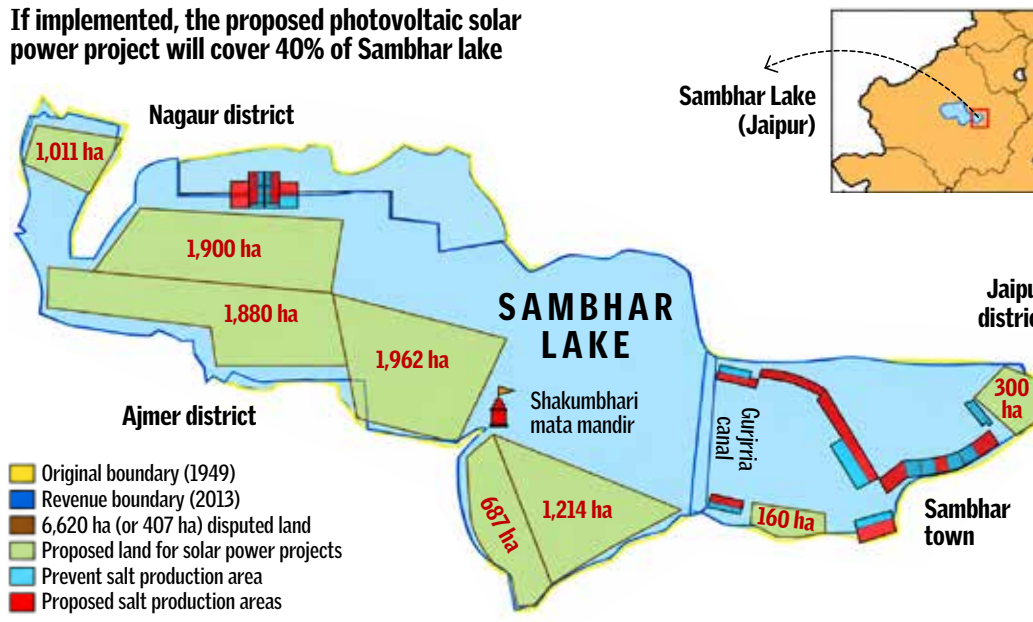
The Sambhar Ultra Mega Solar Power Project entered the public domain in September 2013, when the Government of India announced a proposed 4,000 MW project over approximately 9,300 ha belonging to Sambhar Salts Limited, a subsidiary of Hindustan Salts Limited. At the time, it was presented as the world's largest single-location solar project. Government estimates put annual generation at around 6,000 to 6,400 million units, making the project an important part of India's expanding solar programme.



F9PHOTOS, ISTOCKPHOTO.COM

Sambhar Solar Project, Rajasthan: Flamingos on the wetland

Map 2: Proposed solar power project area within Sambhar Lake



Map not to scale

Source: Down To Earth. (2014). Solar threat to Sambhar, by Ankur Paliwal

The institutional arrangements were formalised on January 29, 2014, when six public sector enterprises signed an MoU in New Delhi. The consortium comprised Bharat Heavy Electricals Limited, Solar Energy Corporation of India, Hindustan Salts Limited, Power Grid Corporation of India, Satluj Jal Vidyut Nigam and Rajasthan Electronics & Instruments Limited. BHEL was expected to provide engineering and equipment, Power Grid to develop evacuation infrastructure, SECI to facilitate power sale arrangements and HSL to make land available through Sambhar Salts. SJVN and REIL were to support implementation and operations.

The land was largely under government control and associated with salt production, while the flat terrain, strong solar radiation and access to transmission infrastructure supported large-scale development. Government communication presented the project as an opportunity for investment, employment and regional development.

The ecological character of the site soon became central to the discussion. Sambhar Lake is India's largest inland saline wetland and has been a Ramsar Site since 1990.

It lies along the Central Asian Flyway and supports large seasonal populations of greater and lesser flamingos, pied avocets, black-winged stilts, pelicans, cranes, ducks and other migratory birds. The wetland also performs important ecological functions related to saline hydrology and groundwater recharge.

Environmental concerns focused on the wider footprint required to support a 4,000 MW project. Solar modules would occupy a large area, while roads, substations, fencing and transmission corridors would further divide the landscape. Scientists and environmental organisations pointed out that the wetland ecosystem extended beyond the visible water surface into mudflats, salt pans and open habitats used by birds for feeding, breeding and resting. Changes to drainage and movement across these areas could affect the functioning of the wider wetland.

By the second half of 2014, the project was facing growing uncertainty. The Rajasthan government reportedly expressed reservations about locating such a large solar installation close to the Ramsar wetland. Discussions followed on shifting the project to Kharaghoda in Gujarat, another saline landscape with strong solar potential. The original 4,000 MW proposal subsequently lost momentum.

From 2017 onwards, the Rajasthan High Court began monitoring the condition of Sambhar Lake through public interest litigation and *suo moto* proceedings. The proceedings covered illegal salt extraction, groundwater depletion, encroachments, wetland degradation and weaknesses in environmental governance. These proceedings later became relevant when new renewable energy proposals were brought forward in the surrounding area.

A smaller project brought the issue back before the Court in August 2023. Hindustan Salts Limited, through Sambhar Salts Limited, entered into an agreement with SJVN Green Energy Limited for a 100-MW solar project on land near Sambhar Lake. The revised proposal was substantially smaller than the earlier 4,000-MW project and was intended to avoid the core wetland while using land associated with the salt works. The agreement nevertheless came under judicial scrutiny because it had been executed while the High Court was already dealing with proceedings concerning Sambhar Lake.

The Court was informed that the 2023 MoU had not been disclosed during the ongoing proceedings. This raised questions about the transparency of the public sector entities involved and whether the proposed development had been adequately brought within the Court's consideration of the lake's protection. In January 2026,

the Rajasthan High Court initiated *suo moto* contempt proceedings against senior officials of Hindustan Salts Limited, Sambhar Salts Limited and SJVN Green Energy Limited.

The Court then examined technical and environmental material relating to the proposed 100-MW project. Reports from experts, environmental authorities and an Additional District Judge appointed to examine the site helped establish whether the proposed project was located within the notified wetland or on adjacent land.

On April 28, 2026, the Rajasthan High Court concluded that the land proposed for the 100-MW project was outside the notified wetland boundary. The Court, therefore, did not impose an absolute prohibition on the project. It allowed development subject to safeguards designed to protect the surrounding ecosystem. These included maintaining sufficient clearance below solar structures for wildlife movement, protecting natural drainage and hydrological flows, undertaking compensatory plantation where trees were removed and implementing measures to reduce disturbance to migratory birds.

The Court also allowed the contractual arrangements between Hindustan Salts Limited, Sambhar Salts Limited and SJVN Green Energy to remain valid despite delays arising from the proceedings. The outcome effectively created a different development pathway from the original 4,000-MW proposal. A smaller project could proceed on land outside the notified wetland, provided that ecological safeguards were incorporated into its design and implementation.

The Sambhar case, therefore, developed through several stages: a 4,000-MW proposal in 2013, institutional arrangements in January 2014, environmental reservations later that year, prolonged judicial monitoring of the wetland from 2017, a new 100-MW proposal in August 2023 and renewed judicial scrutiny in 2026. The conflict centred on the location and ecological consequences of renewable energy infrastructure within a sensitive wetland landscape.

The eventual approval of the smaller project shows how environmental scrutiny can influence the scale, location and design of renewable energy infrastructure. Sambhar also demonstrates why project-level assessment needs to consider the wider ecological system, including wetlands, drainage patterns, bird habitats and surrounding landscapes.

CASE STUDY 2

DHOLERA SOLAR PARK, GUJARAT

Coastal wetlands and environmental safeguards

The Dholera Solar Park emerged from the larger plan to develop the Dholera Special Investment Region under the Delhi-Mumbai Industrial Corridor. The Gujarat government established the region as a greenfield industrial city, covering about 920 sq km along the Gulf of Khambhat. As plans for manufacturing and logistics infrastructure progressed, the government also proposed a large solar park to supply clean electricity to the emerging industrial hub.

The institutional structure was developed through Dholera Industrial City Development Limited, created by the Government of Gujarat and the Delhi-Mumbai Industrial Corridor Development Corporation. Dholera Special Investment Regional Development Authority was responsible for securing land and statutory approvals, while Gujarat Power Corporation Limited was identified as the agency for developing the solar park. Under the proposed arrangement, land would be obtained and leased to GPCL, which would develop common infrastructure and subsequently allocate plots to solar developers through competitive bidding.



JAYANTIBHAI MOVALIYA, ISTOCKPHOTO.COM

Coastal mudflats and tidal wetlands of Gujarat

Site selection initially appeared straightforward from an engineering perspective. Project documents highlighted high solar radiation, flat terrain, limited vegetation, proximity to transmission infrastructure and water availability for panel cleaning. The proposed park was planned with a capacity of 4,400 MW across 8,594.95 hectares, placing it among the largest solar parks proposed at the time.

The environmental appraisal changed the nature of the discussion. The site lies along the Gulf of Khambhat, where the landscape includes intertidal mudflats, salt marshes, tidal creeks and saline coastal wetlands. Coastal Regulation Zone mapping showed that approximately 7,949 ha, or 92.5 per cent of the proposed project area, fell within CRZ-I B, the category covering ecologically sensitive intertidal areas. Only about 436 ha lay outside the CRZ.

The first detailed regulatory examination took place at the 207th meeting of the Expert Appraisal Committee for Coastal Regulation Zone projects on January 25, 2019. The Committee recognised the project's strategic importance but sought more information on migratory bird habitats, drainage patterns, coastal geomorphology, tidal hydrology, shoreline stability and sea-level rise. It also considered the cumulative effects of roads, substations and extensive fencing. The proximity of Velavadar Blackbuck National Park, about four km from the nearest proposed solar plot, added another ecological consideration.

The Committee consequently adopted a phased approach. Its consideration was limited initially to the first 1,000 MW, while the remaining 3,400 MW required further scientific assessment. The project proponents were asked to undertake studies on migratory birds, sea-level rise, coastal erosion, geomorphological processes, drainage behaviour and cumulative ecological impacts.

Between 2019 and 2021, the project team commissioned the additional studies. These included assessments of bird migration, coastal geomorphology and hydrodynamic behaviour. The studies examined tidal processes, shoreline changes and sea-level rise and identified areas where development should be avoided because of ecological or hydrological importance.

The revised proposal returned to the EAC at its 267th meeting in July 2021. The Committee considered the additional scientific evidence, including the migratory bird assessment prepared by GUIDE and the coastal processes study undertaken by the Tamil Nadu-based Indomer Coastal Hydraulics Pvt Ltd. These studies provided a stronger basis for understanding the relationship between the proposed infrastructure and the surrounding coastal system.

The EAC still sought further verification before moving towards final approval. It constituted a sub-committee comprising environmental scientists, coastal experts, EAC members, MoEFCC representatives and the Gujarat Ecology Commission. The group was asked to inspect the site and examine the proposed safeguards. The EAC also required a comprehensive migratory bird conservation and habitat restoration plan and additional protection for areas identified as ecologically sensitive.

The project was considered again at the 280th EAC meeting in November 2021. After reviewing field observations and the revised technical studies, the Committee concluded that the project could proceed subject to environmental safeguards.

Approximately 629 ha were designated as permanent no-development buffer areas. Additional conditions covered environmental monitoring, protection of natural drainage, restrictions on groundwater extraction within CRZ areas, siting of construction camps outside sensitive coastal zones and long-term ecological monitoring. The Committee also emphasised that the project should proceed without significant damage to the coastal ecosystem.

Scientific studies, site inspection and regulatory review shaped the project's subsequent design and safeguards.

As development progressed, the initial capacity moved towards implementation while later phases remained subject to the conditions established through the appraisal process. The Dholera experience demonstrates the value of assessing coastal renewable energy projects through a wider ecological lens. Tidal systems, wetland habitats, drainage patterns, coastal geomorphology and sea-level rise all need to be considered alongside conventional project parameters such as solar resource, land availability and transmission access.

CASE STUDY 3

KAMUTHI SOLAR PROJECT, TAMIL NADU

Water stress and solar operations

Tamil Nadu's Solar Energy Policy, introduced in 2012, set a target of 3,000 MW of solar capacity by 2015 and encouraged large-scale private investment. The policy helped create the conditions for Adani Power to develop a major solar project near Kamuthi in Ramanathapuram district, about 90 km from Madurai. The project



V BHAGYA SUBHASHINI, SWARAJYA

The Kamuthi Solar project in Tamil Nadu

was subsequently developed through Adani's renewable energy operations and became one of India's largest single-location solar plants.

The project was formally announced in March 2015, when Adani signed agreements with TANGEDCO for a 648-MW photovoltaic plant. The investment was estimated at about ₹4,550 crore, with the project spread across nearly 2,500 acre, or 1,012 ha, in several villages of Kamuthi taluk. Construction began in February 2016 and progressed rapidly. More than 8,500 workers installed around 2.5 million solar modules, supported by 576 inverters, 154 transformers, nearly 6,000 km of electrical cable and a dedicated 400-kV substation. The plant was completed in about eight months and inaugurated in September 2016.

Landowners who sold or leased land also expected the project to create a continuing economic relationship with the surrounding villages. These expectations became important when the project moved from construction into regular operation.

Concerns over land and common resources emerged during this period. Investigations later documented by Land Conflict Watch reported[19] that about 4,000 acre had been enclosed through project fencing. Villagers said that the fencing affected access to traditional waterbodies, including *kanmais*, *ooranis* and seasonal

Figure 3: Satellite imagery of the Kamuthi landscape (2014-2021)
– showing the transition from a predominantly vegetated and agricultural landscape to large-scale solar development and increasing aridity



Source: Google Earth imagery

streams, as well as grazing areas. Compensation addressed privately acquired land, while households dependent on common resources did not necessarily receive compensation because they did not hold formal ownership rights over those resources.

The issue was particularly relevant in Ramanathapuram, where agriculture depends heavily on traditional tanks and shared water resources. Roads, fencing and project infrastructure changed how people moved through the landscape and accessed these resources.

Employment became another concern after construction ended. The large construction workforce created temporary employment, while the operational plant required considerably fewer workers. Villagers interviewed by Land Conflict Watch reported that they had expected longer-term employment opportunities, particularly for younger members of households associated with the project. By 2018, concerns had emerged that the permanent economic opportunities available locally were smaller than expected.

The most significant conflict emerged after commissioning, when attention shifted from land to water. Solar panels in the dry Ramanathapuram climate require regular cleaning because dust accumulation can reduce generation. During 2017, villagers began reporting that large quantities of groundwater were being transported to the project for panel cleaning.

A report published by *The New Indian Express* in June 2017[20] stated that contractors were extracting approximately 200,000 litre of groundwater per day from borewells near the Gundar riverbed, about five km from the project. Around 40 tractor tankers, each carrying between 6,000 and 8,000 litre, were reportedly making repeated trips to the plant. Revenue officials quoted in the report stated that commercial groundwater extraction from the locations had not been formally permitted.

The location of the extraction became central to the community response. Ramanathapuram is a water-stressed district with irregular rainfall, saline groundwater and substantial dependence on traditional irrigation tanks. During dry periods, villages have to buy drinking water.

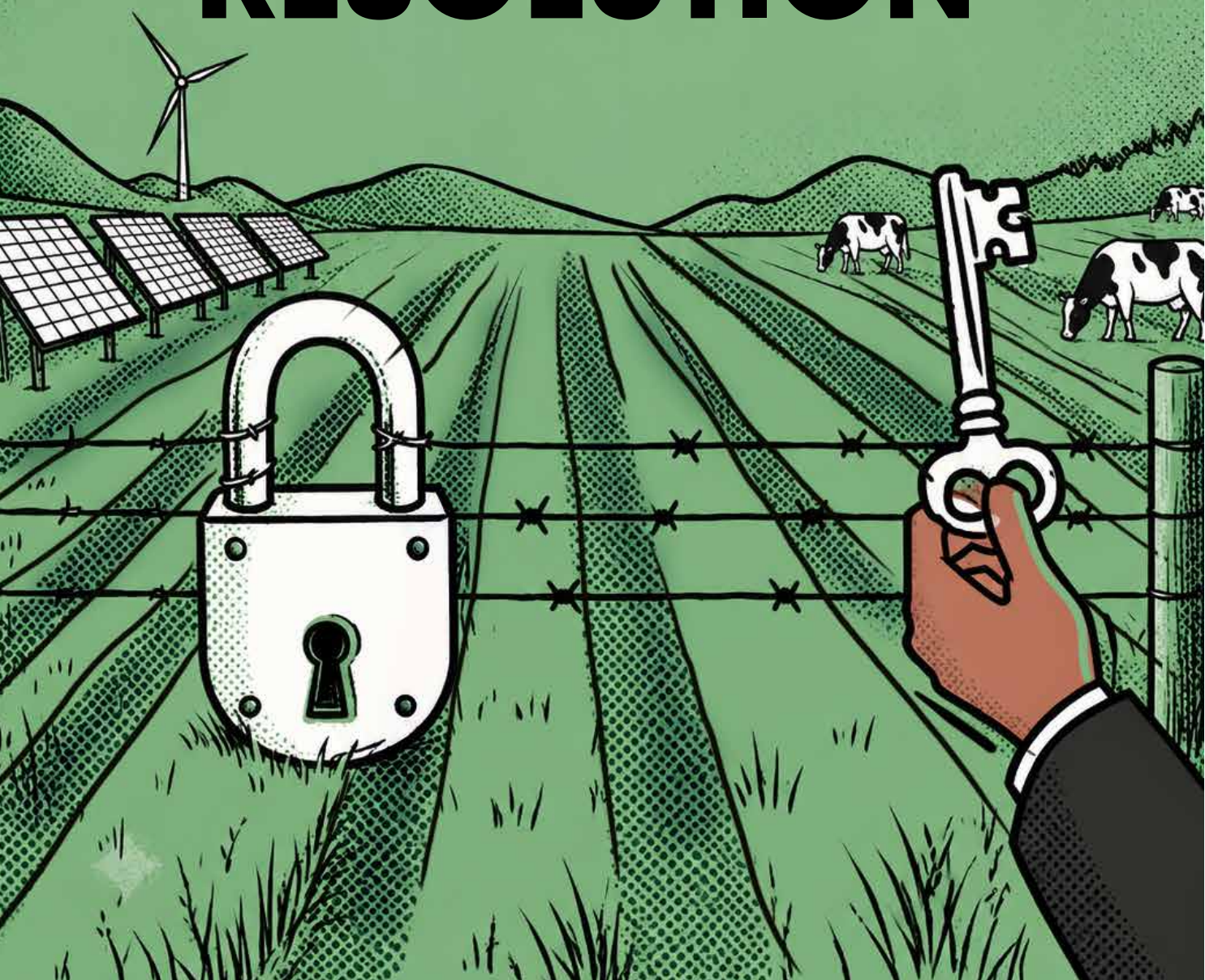
The dispute remained largely within administrative channels. Following complaints from residents and media reports, district authorities reportedly directed that groundwater extraction from the original source should stop. The project operator

subsequently shifted towards using brackish groundwater available within the project site, treated through reverse osmosis, and introduced robotic panel-cleaning systems to reduce freshwater requirements.

The case also highlights the importance of assessing common resources during project planning. Formal land acquisition generally identifies private ownership, while rural livelihoods can depend on shared tanks, ponds, grazing areas and drainage channels that fall outside individual land titles. In a water-stressed region such as Ramanathapuram, these resources form part of the local livelihood system and need to be considered alongside the project's land and infrastructure requirements.

The Kamuthi case ultimately became a question of how a large RE project manages its relationship with a water-stressed landscape over its operating life. The experience points towards the need for water-use assessment before commissioning, monitoring of groundwater extraction, protection of common water resources and adoption of low-water or dry-cleaning technologies in regions facing recurring water stress.

4 INNOVATIONS FOR CONFLICT RESOLUTION



The experience of RE development across India shows that conflicts over land, livelihoods and environmental impacts can be addressed through better project planning and governance. Utility-scale solar and wind projects have faced concerns around land acquisition, common property resources and ecological impacts, prompting developers and governments to reconsider conventional approaches to project development.

International financiers such as the International Finance Corporation (IFC), World Bank and Asian Development Bank have reinforced this approach through requirements for environmental and social management systems, stakeholder consultation and grievance redress mechanisms. Research on India's energy transition also increasingly recognises social acceptance as an important part of long-term project viability, alongside technical and financial considerations.

Several projects demonstrate how conflict mitigation can be incorporated into project planning from the outset. These approaches include long-term land leasing instead of compulsory acquisition, installing solar panels over existing canals and reservoirs, combining agricultural production with solar generation through agrivoltaics, and creating mechanisms for local communities to share in project-related benefits.

Land governance innovations

Land governance has become a major challenge in India's renewable energy transition. Much of the land identified for these projects already supports farming, grazing, pastoral activities or other community uses. Areas recorded as "wasteland" in revenue records may function as village grazing commons (*gochars*), sacred groves (*orans*), seasonal agricultural land or pastoral landscapes that support rural livelihoods. Differences between formal land records and customary use can, therefore, create disputes even after developers receive the required statutory approvals.

The issue is particularly visible in Rajasthan and Gujarat, where RE projects have overlapped with grazing commons and culturally important landscapes. Research published in *Energy Research & Social Science*[21] highlights the limited availability of genuinely unused land for RE development and shows how different land-tenure systems shape the distribution of costs and benefits. Farmers with formal land titles may receive compensation or lease payments, while pastoralists, landless households and users of common property resources can lose access to land without receiving comparable economic benefits.

These recurring disputes have encouraged governments and developers to reconsider conventional approaches to land acquisition. Long-term leasing, dual-use infrastructure and multi-functional land-use models offer ways to accommodate renewable energy while retaining some existing economic uses of land. Such approaches shift attention towards better land governance, early recognition of customary use and project designs that reduce displacement.

The following four examples illustrate these approaches. The Pavagada Solar Park demonstrates how long-term leasing can allow farmers to retain land ownership while making large parcels available for solar development. Punjab's canal-top solar programme uses existing irrigation infrastructure, reducing the need for additional agricultural land. Agrivoltaic systems combine crop cultivation with solar generation on the same land parcel. Floating solar projects use reservoirs and other water bodies for electricity generation, reducing pressure on terrestrial land.

CASE STUDY 1

PAVAGADA SOLAR PROJECT, KARNATAKA

Land leasing instead of land acquisition

The Pavagada Solar Park, officially known as Shakti Sthala, was conceived in 2015 in Pavagada taluk of Tumakuru district, Karnataka. Developed by Karnataka Solar Power Development Corporation Limited (KSPDCL), a joint venture of KREDL and SECI, the 2,050-MW park was eventually commissioned in phases and became fully operational in December 2019.

Pavagada was a difficult location for conventional agriculture. The taluk had experienced recurrent drought, declining groundwater levels and low farm productivity. Rain-fed cultivation produced uncertain returns, with farmers reportedly earning around ₹15,000-25,000 per acre annually, depending on rainfall. When the solar park was proposed, the prospect of losing agricultural land through compulsory acquisition created concern among landowning families.

KSPDCL responded by adopting a voluntary leasing model. Following consultations during 2015-16, around 2,300 landowners agreed to lease nearly 13,000 acre for 28 years. Farmers retained ownership while giving KSPDCL development rights, allowing the corporation to assemble contiguous parcels and subsequently sub-lease them to solar developers. The agreement provided landowners with an annual payment of ₹21,000 per acre, with a 5 per cent increase every two years. For farmers



SOMINI SENGUPTA, THE NEW YORK TIMES

A view of the Pavagada Solar Park in Karnataka, with solar panels alongside agricultural land

dependent on uncertain rainfall, the lease created a predictable income while retaining ownership of the underlying land.

KSPDCL dealt with the aggregation and leasing process, allowing individual developers to access large contiguous parcels without negotiating separately with thousands of landowners. Since the farmers retained legal title, the project avoided permanent transfer of ownership and reduced the scope for disputes associated with compulsory acquisition.

The project also introduced measures intended to extend benefits beyond lease income. A Local Area Development Fund was established through contributions from project developers to support village infrastructure, including roads, drinking water, schools, sanitation and health facilities. The Shakti Sthala Farmers' Welfare Association provided a platform for land-leasing farmers to participate in discussions concerning local development expenditure.

The leasing model, however, did not benefit everyone who depended on the landscape. Assessments by the World Resources Institute[22] and independent researchers found that landowners received regular rental income, while landless agricultural workers, tenant farmers and pastoral communities had fewer direct

economic benefits. Some households also lost employment and access to common resources as agricultural activity declined and the solar park occupied large areas. Researchers found that some farmers considered their bargaining position during lease negotiations weak and believed that higher lease payments could have been secured.

The model changed the relationship between farmers and project developers by separating land ownership from long-term project use. It also reduced the need for compulsory acquisition and provided landowners with a continuing income stream. The experience shows that leasing arrangements need to be accompanied by measures for landless workers, tenants and common-resource users whose livelihoods depend on the same landscape. For large RE projects, this broader approach can make land governance more responsive to the different groups affected by project development.

CASE STUDY 2

CANAL-TOP SOLAR, PUNJAB

Using existing irrigation infrastructure

One practical way to reduce land-related conflicts in RE development is to use existing infrastructure rather than acquire additional land. Canal-top solar follows this approach by installing photovoltaic panels above irrigation canals, allowing electricity generation without converting agricultural land or common property resources.

Punjab's canal-top solar programme began under MNRE's Pilot-cum-Demonstration Scheme, through which 20 MW of canal-top solar capacity was sanctioned in December 2014. The Punjab Energy Development Agency (PEDA) implemented the programme under the state's New and Renewable Sources of Energy Policy, 2012. PEDA adopted a Build-Own-Operate (BOO) model under which private developers financed, constructed and operated the plants and supplied electricity to the Punjab State Power Corporation Limited (PSPCL). The approach made use of Punjab's canal network, which extends for more than 10,000 km. PEDA estimates that the network has a technical potential of more than 1,500 MW for canal-top solar.

Following competitive bidding in 2016, four projects with a combined capacity of 20 MW were awarded. SAM Solar developed two 2.5 MW projects over the



PUNJAB ENERGY DEVELOPMENT AGENCY (PEDA)

Canal-top solar in Punjab, with panels spanning the canal

Sidhwan Branch Canal near Doraha in Ludhiana and the Ghaggar Branch Canal near Nidampur in Sangrur, while other projects were developed over canals in Patiala district. The Punjab installations presented a significant engineering challenge because the canals were between 28 and 40 metre wide. Reinforced concrete piles were installed along the canal banks, with steel tension-cable and space-frame structures supporting the solar modules above the water. Construction was coordinated with the annual canal maintenance shutdowns, generally lasting 10-15 days, allowing structural work to take place without interrupting irrigation.

The projects demonstrated several benefits beyond avoiding land acquisition. The 20-MW programme is estimated to have saved around 110 acre of agricultural land that would otherwise have been required for ground-mounted solar installations. The panels also provide shade over the canals, reducing water evaporation, while the cooler environment above flowing water can improve module performance.

The canal-top model also reduced the scope for the land-related disputes commonly associated with large solar parks. The Punjab projects did not involve acquisition of agricultural holdings for the solar arrays, and there have been no major reported farmer protests or land-related litigation associated with the programme. This makes infrastructure co-location particularly relevant for states where competition between renewable energy and agricultural land is becoming increasingly important.

The programme has since moved beyond its initial pilot. PEDA reported 20 MW commissioned and 50 MW under implementation by 2025, while in September 2025 it invited expressions of interest for another 40 MW of canal-top solar capacity under the BOO model. The expansion indicates continued interest in using existing infrastructure for renewable energy, although canal-top systems generally involve higher structural and installation costs than conventional ground-mounted projects.

Canal-top solar cannot be applied across all locations because its feasibility depends on canal width, structural conditions, water flow, access and the economics of construction. By placing renewable energy infrastructure over an existing public asset, the approach can reduce pressure on agricultural and common land while allowing irrigation and electricity generation to operate within the same physical space.

Table 3: Canal-top solar – innovation and outcomes

Innovation	Outcome
Existing irrigation canal used for solar installation	No new land acquisition
Suspended cable-based structure	Canal operation remained uninterrupted
Solar installed over existing infrastructure	~100–110 acres of agricultural land saved (20 MW programme)
No conversion of farmland	No reported land acquisition disputes
No reported land acquisition disputes	Lower potential for land-related social conflict
Dual use of infrastructure	Electricity generation + irrigation from the same corridor
Panels over water	Reduced evaporation and improved module cooling

CASE STUDY 3

AGRIVOLTAIC SOLAR SYSTEMS

Agrivoltaics or AgriPV combines solar electricity generation with agricultural production on the same land. By allowing crops, livestock and solar infrastructure to share the same parcel, AgriPV can reduce pressure to convert productive farmland exclusively for energy generation. Assessments by The Energy and Resources Institute (TERI) and the Energy Transitions Commission indicate that India has substantial technical potential for such dual-use systems.[23]

A useful example is the Indra Solar Farm at Khargapur in Tikamgarh district, Madhya Pradesh, developed by Khare Energy Private Limited. The first phase



CONNY POKORNY, ISTOCK IMAGES

Agrivoltaic solar systems allow crops to grow beneath elevated panels

of the 2-MW project was commissioned in November 2022 under PM-KUSUM Component A. The project uses elevated photovoltaic structures approximately four-five metre high, along with polyhouse-mounted and bifacial panels. The height allows tractors, farm machinery, livestock and workers to move below the panels while cultivation continues.

The project combines electricity generation with crop cultivation, horticulture and livestock rearing. Wheat, maize, chilli, green gram, brinjal, sorghum and other seasonal crops are grown beneath and between the solar structures. More than 70 goats and cattle graze within the site, helping manage vegetation. Animal manure is used in vermicomposting, creating an additional nutrient cycle within the farm. Electricity is sold to the state distribution utility under a 25-year power purchase agreement, giving the project a long-term revenue stream alongside agricultural production.

Field evidence is beginning to show wider benefits. A TERI baseline assessment published in March 2026[24] found that partial shading from the elevated panels reduced evapotranspiration by about 17 per cent and irrigation requirements by approximately 25 per cent. Crop performance varied by type, with shade-tolerant crops performing better under the panels. The assessment also found improvements in wheat grain weight under the system. The combined value of electricity, agricultural output and water savings improved farm resilience and household income.

AgriPV, therefore, offers a way of using the same land for two productive purposes. Farmers can continue agricultural activities while participating in renewable energy generation, reducing the pressure to acquire additional agricultural land for solar parks. The model also creates scope for diversified farm income and more efficient use of water and land.

Wider adoption will depend on suitable site conditions, crop selection, technical standards, financing and policy support. Elevated structures require greater investment than conventional ground-mounted systems, which can affect project economics. TERI's 2026 assessment and the Agrisolar Best Practice Guidelines indicate that appropriate policy and financing mechanisms can help overcome these barriers. For India, AgriPV offers a practical land-governance model that brings energy generation, agricultural production and water management onto the same land parcel.

CASE STUDY 4

FLOATING SOLAR INFRASTRUCTURE

Floating solar photovoltaics (FPV) offer another approach to reducing land-use pressure from utility-scale renewable energy. Instead of using agricultural or common land, FPV systems are installed on reservoirs, dams and other inland waterbodies. This allows electricity generation within existing water infrastructure while preserving terrestrial land for agriculture and other uses. Floating systems can also benefit from the cooling effect of water, which can improve module performance, while shading the water surface can reduce evaporation.

India's most prominent large-scale example is the 600-MW Omkareshwar Floating Solar Park in Khandwa district, Madhya Pradesh. The project was approved in September 2020 and is being developed by Rewa Ultra Mega Solar Limited (RUMSL), a joint venture of SECI and Madhya Pradesh Urja Vikas Nigam Limited. It occupies the Omkareshwar reservoir on the Narmada river, between the Indira Sagar and Omkareshwar hydroelectric projects. Using an existing reservoir and associated transmission infrastructure reduces the need for new terrestrial land and allows the solar park to benefit from an established power evacuation system.



X.COM/JOSHIPRALHAD, UNION MINISTER OF NEW AND RENEWABLE ENERGY

Floating Solar Power Project at Omkareshwar, Madhya Pradesh, harnessing reservoir space to generate clean electricity while reducing pressure on land resources

The project is being developed in phases by several companies. AMP Energy commissioned 100 MW in June 2024, followed by SJVN Green Energy's 90 MW in August 2024 and NHDC's 88 MW in October 2024. In November 2024, Tata Power Renewable Energy commissioned another 126 MW, taking operational capacity within the park to more than 400 MW. Further phases remain under development. The floating arrays use photovoltaic modules mounted on interconnected HDPE pontoons anchored to the reservoir, with electricity transferred to the grid through the project's transmission infrastructure.

Moving solar infrastructure on to water, however, can shift the nature of land-use conflicts rather than remove them completely. At Omkareshwar, around 300 fisherfolk from six villages raised concerns over the project, arguing that floating panels would restrict access to fishing areas that had traditionally supported their livelihoods. Many of these communities had already lost agricultural land during construction of the Omkareshwar reservoir and subsequently became dependent on fisheries. The proposed solar park, therefore, raised concerns about another change in access to the reservoir.

The dispute reached the Madhya Pradesh High Court in 2024, where the concerns of fishing communities were brought before the Court and RUMSL was asked to respond. The case highlighted an important dimension of floating solar development: reservoirs are working landscapes that support fisheries, navigation and other local economic activities. Their value cannot be assessed solely in terms of available water surface.

The technology can substantially reduce pressure on agricultural land and avoid many disputes associated with terrestrial land acquisition. Its successful deployment also requires early assessment of fishing zones, navigation routes, water-based livelihoods and community access. For future FPV projects, mapping these uses and developing appropriate access and benefit-sharing arrangements will be important for ensuring that shifting infrastructure from land to water does not create a new set of livelihood conflicts.

Water stewardship

Water has become an increasingly important dimension of RE development in India. Solar and wind projects generally require less operational water than thermal power plants, yet many large renewable energy parks are located in arid and semi-arid regions such as Rajasthan, Gujarat and parts of Karnataka, where groundwater resources are already under pressure. Solar panels require periodic cleaning to

remove dust and sand deposits, particularly in dry environments where soiling can reduce generation. This creates a potential competition for water in areas where communities already face declining groundwater levels and seasonal shortages.

These concerns have encouraged some renewable energy developers to look beyond reducing water consumption within the project itself. Increasingly, projects are incorporating water stewardship measures that combine traditional water conservation practices with technologies that reduce freshwater use. Such approaches can help improve water security in project-hosting areas while addressing the operational needs of RE infrastructure.

CASE STUDY 1

REVIVING TRADITIONAL WATER SYSTEMS – ReNew

In Thar Desert of western Rajasthan, where rainfall is limited and groundwater is often saline, communities have traditionally depended on rainwater harvesting systems such as *tankas*, household underground storage tanks, and *naadis*, community ponds. Over time, many of these structures deteriorated because of silt accumulation, limited maintenance and changes in settlement patterns. Their declining capacity increased dependence on groundwater and other water sources.

Around 2015, ReNew, a RE company based in Gurugram, began a community water stewardship programme around its wind and solar assets in Jaisalmer district in partnership with the rural development organisation GRAVIS. The programme focused on restoring existing water systems and improving their quality. Household *tankas* were constructed or rehabilitated, community *naadis* were desilted, and biosand filters were introduced to improve the quality of harvested rainwater. Village development committees and local water management committees were also established to oversee maintenance and keep the systems under community management.

Across successive phases, ReNew reported the construction of more than 100 household *tankas*, restoration of several community ponds and the creation of more than 18 million litre of water conservation capacity. The company's sustainability reports state that the interventions have benefited more than 14,500 residents across villages in Jaisalmer.[25]



CSE PHOTO LIBRARY

A traditional water-storage and rainwater harvesting system in an arid village

Restored *naadis* provide water for households and livestock, while improved rainwater harvesting can reduce dependence on groundwater during prolonged dry periods. The use of locally familiar structures and community-managed maintenance also makes the approach relevant to other water-stressed desert and semi-arid regions. For renewable energy developers, such interventions provide a way to connect project investments with a resource that is central to the resilience of host communities.

CASE STUDY 2

DRYCLEANING OF SOLAR PANELS – ADANI GREEN ENERGY

Water stewardship can also focus on reducing the amount of freshwater required for renewable energy operations. Solar parks in arid regions require regular panel cleaning because dust accumulation can reduce generation. Conventional cleaning methods can require substantial quantities of water, creating additional pressure in areas where communities already face water shortages.

Adani Green Energy Limited (AGEL) has responded by deploying AI-enabled robotic dry-cleaning systems across its utility-scale solar parks, including the Khavda Renewable Energy Park in Gujarat. The autonomous robots use rotating microfibre brushes to remove dust from the panels without routine water use.

AGEL reported that robotic cleaning across 4,760 MW of operational capacity saved approximately 347 million litre of water annually during FY 2023-24. Its subsequent sustainability disclosures reported annual water savings of around 546 million litre following wider deployment. The company has also combined these measures with rainwater harvesting, rejuvenation of 85 village ponds, groundwater recharge and atmospheric water generation. AGEL reports that these interventions supported water-positive certification across its operational portfolio, based on an independent assessment.[26]

Together, the ReNew and AGEL examples address two sides of water stewardship. ReNew's programme focuses on strengthening water availability for communities by restoring traditional water systems, while AGEL's drycleaning technology reduces freshwater demand within project operations. In water-stressed regions, such measures can reduce pressure on local resources while improving the resilience of communities and renewable energy projects.



SUNNYBOTICS, INC

A robotic cleaning unit moves across a solar array

Local livelihoods and skills for a just energy transition

Large-scale renewable energy projects are often presented as sources of rural employment, yet the benefits created during construction and operation are not always distributed evenly. Project development can also affect agriculture, pastoralism and other livelihood activities that depend on local land and natural resources. Compensation for land does not fully address these changes, particularly for landless workers, tenants and informal workers whose livelihoods depend on access to local resources rather than formal land ownership.

This has encouraged RE companies to look beyond project construction and create opportunities for local participation in the emerging green economy. Skills training, local employment and support for small enterprises can help communities build new sources of income as traditional livelihoods change.

CASE STUDY 1

PROJECT SURYA, GUJARAT

Skills transition for salt pan workers

Project Surya is a useful example of how renewable energy development can be linked with longer-term livelihood opportunities for communities whose traditional occupations are vulnerable to economic and environmental change.

Launched on June 30, 2022, Project Surya was developed by ReNew in partnership with the United Nations Environment Programme (UNEP) and the Self-Employed Women's Association (SEWA) for the Agariya community of Gujarat's Little Rann of Kutch. The community depends heavily on seasonal salt production, with workers spending much of the year in remote salt pans under difficult climatic conditions. Women involved in salt production often have limited access to formal employment, skills training and basic services, while incomes from seasonal work remain uncertain.

The programme introduced training linked to the RE sector. Women received practical instruction in solar photovoltaic installation, operation and maintenance, solar pump servicing, workplace safety and basic electrical systems. Training also covered financial literacy, entrepreneurship and digital skills. ReNew provided technical expertise and exposure to renewable energy operations, SEWA supported community mobilisation and implementation, and UNEP provided programme



DIMPLE BHATI, ISTOCK IMAGES

Project Surya, Gujarat: A woman solar technician working on a solar installation

oversight. The National Skill Development Corporation also supported the initiative by connecting the training with recognised skill-development frameworks.

The programme was designed around livelihood diversification. By acquiring technical skills, women from the salt-producing community could pursue employment in renewable energy operations and related activities while developing an alternative source of income. ReNew reported that 575 women had completed training by FY 2024-25, with participants subsequently joining manufacturing facilities and renewable energy operations. Its social impact assessment reported that 78 per cent of women assessed experienced a significant increase in monthly income following employment or placement opportunities. ReNew continues to work towards its original target of training 1,000 women.

Construction-related employment is usually temporary, while technical skills can provide opportunities over a much longer period. Training local residents can also help developers build a workforce familiar with the communities and operating environment around their projects.

Project Surya, therefore, provides an example of benefit sharing through skills and employment. It connects renewable energy investment with livelihood diversification and women's participation in the emerging green economy. The World Economic Forum has highlighted the initiative as an example of a people-positive energy transition, reflecting its focus on combining clean energy deployment with local economic opportunity.[27]

Community infrastructure and service delivery

Renewable energy projects are often located in remote rural areas where access to reliable electricity, quality education and basic public infrastructure remains limited. Compensation for land addresses specific economic losses associated with acquisition, while longer-term development needs such as schools, healthcare and digital connectivity often require separate interventions.

Support for schools, healthcare services, drinking water and digital infrastructure can improve everyday living conditions while creating a more visible connection between renewable energy investment and local development. These interventions can also strengthen relationships with host communities by directing a share of project-related social investment towards locally identified needs. In this way, RE projects can contribute to rural development alongside electricity generation and create a broader basis for community participation and acceptance.

CASE STUDY 1

LIGHTING LIVES

Solar-powered digital education

One established example is ReNew's Lighting Lives programme, developed through the company's corporate social responsibility initiatives to address energy access and digital learning in rural government schools. The programme focuses on schools that receive less than three hours of electricity a day, where unreliable power affects classroom teaching, computer use and access to digital educational resources. The intervention combines solar electricity with digital infrastructure to improve the overall learning environment.

Under the programme, schools are equipped with off-grid or rooftop solar systems to provide a reliable electricity supply. Digital learning laboratories are then established with desktop computers, interactive smart panels and other educational

equipment. The programme also includes environmental awareness activities that introduce students to renewable energy and climate change and encourage them to act as “green ambassadors” in their communities.

According to ReNew’s latest sustainability disclosures, Lighting Lives has electrified 32 schools, established 37 digital computer laboratories and directly benefited around 10,000 students. Across its wider CSR programmes, the company works in more than 740 villages across 11 states, reaching more than 1.7 million people through education, healthcare, livelihoods and environmental initiatives. One example is New ki Dhani village in Jodhpur district, Rajasthan, where ReNew installed a 20-kW off-grid rooftop solar system and a digital laboratory with 15 computers and an interactive LED panel. The intervention provided reliable electricity to a government school that had previously experienced frequent outages and benefited around 450 students and 15 staff members.

It nevertheless demonstrates how community investments can extend the benefits of renewable energy into areas such as education and digital access. Reliable electricity allows schools to use digital learning tools, supports classroom activities and strengthens access to educational resources.



HANDINHAND INDIA

Children using computers powered by solar in a school

The programme also illustrates a broader approach to community engagement in RE development. Investments in local education and digital infrastructure can complement measures related to land, livelihoods and environmental protection. When combined with these measures, community development programmes can strengthen relationships between developers and host communities and contribute to the wider development benefits associated with the clean energy transition.

Waste management and resource recovery

The rapid expansion of renewable energy is creating a new environmental challenge around the management of end-of-life solar modules, wind turbine blades, batteries and other equipment. Solar PV modules typically operate for 20-25 years, which means that India's early utility-scale projects will increasingly begin reaching the end of their useful life.

The Government of India has started incorporating circular economy principles into renewable energy governance. Estimates from Down To Earth[28] suggest that cumulative solar PV waste in India could reach around 200 kilotonne by 2030 and increase substantially as installed capacity expands. The E-Waste (Management) Rules, 2022 brought solar photovoltaic panels within the Extended



BILANOL, ISTOCK IMAGES

Photovoltaic solar panels damaged by a thunderstorm: Management of damaged and end-of-life equipment is a major environmental challenge

Producer Responsibility framework, requiring producers to take responsibility for environmentally sound management of end-of-life equipment. In March 2026, the government also reiterated the need to strengthen domestic recycling capacity and develop a circular economy for the solar sector.

A significant step towards building this ecosystem came in April 2025, when the National Institute of Solar Energy (NISE) signed a MoU with Attero, an electronic waste and lithium-ion battery recycling company. The partnership focuses on developing solar panel recycling technologies, conducting pilot testing with end-of-life modules and establishing a dedicated research facility for solar panels and batteries. It also aims to support technical standards and policy recommendations for renewable energy waste management. The collaboration brings together NISE's technical capabilities and Attero's experience in commercial recycling and resource recovery.

Renewable energy developers are also incorporating waste management into their environmental management systems. Large companies report practices such as segregation of hazardous and non-hazardous waste, recycling of metals and electronic equipment through authorised recyclers, and controlled disposal of used transformer oil, lubricants, batteries and other equipment. These measures are becoming increasingly relevant as India's installed renewable energy base expands and the first generation of utility-scale projects approaches retirement.

Waste management, therefore, needs to be considered across the entire project lifecycle, from procurement and construction to operation, refurbishment and eventual decommissioning. Early planning for collection, recycling and material recovery can reduce future environmental risks while retaining valuable materials within the economy. For India's renewable energy transition, developing a reliable circular economy around solar modules, batteries and other equipment will be an important part of responsible and resource-efficient growth.

5

THE WAY AHEAD



India's renewable energy expansion has entered a phase where the quality of deployment matters alongside the pace of capacity addition. The case studies in this report show how large-scale projects can affect land access, rural livelihoods, water resources and ecologically sensitive landscapes. Groundwater stress in arid solar belts, habitat fragmentation affecting the Great Indian Bustard, and disputes over *orans*, *gochars* and other common resources illustrate the local pressures that can accompany rapid infrastructure expansion.

The cases examined in this report also provide practical examples of how these pressures can be addressed. Voluntary land leasing at Pavagada, canal-top and floating solar, agrivoltaic systems, restoration of traditional water systems, dry panel cleaning, local skills development and investments in rural education demonstrate that project design and community engagement can influence outcomes significantly.

The priority now is to move such approaches from individual projects into mainstream renewable energy planning. This requires action across five areas: environmental and social accountability, inclusive siting, project design, benefit sharing and end-of-life management.

Institutionalise environmental and social accountability

Environmental and social accountability in India's renewable energy sector is currently stronger in projects backed by international finance. Institutions such as the World Bank, IFC and ADB require developers to undertake environmental and social assessments covering land acquisition, biodiversity, water resources, socio-economic conditions, stakeholder consultation and grievance redressal.

India can build on these practices by introducing a proportionate Environmental and Social Impact Assessment framework for utility-scale renewable energy projects above a defined capacity threshold, irrespective of the source of financing. The assessment framework should reflect the specific characteristics of renewable energy projects and focus on four areas: water use, land-use transformation, local socio-economic conditions and biodiversity.

The assessment should lead directly to an Environmental and Social Management Plan with defined mitigation measures, responsibilities, timelines and monitoring indicators. This would allow potential problems to be identified during planning and siting, when changes to project design remain possible.

Adopt inclusive siting criteria

Many land disputes examined in this report began with a gap between formal land classification and actual land use. Revenue records may identify an area as wasteland or government land even where it supports grazing, seasonal cultivation, pastoral movement, water harvesting or religious practices. Renewable energy planning, therefore, needs to consider how land functions at the community level alongside its legal classification.

States should develop community-verified GIS maps that distinguish genuinely available land from Gochars, Orans, grazing routes, agricultural areas, water systems and ecologically sensitive landscapes. These maps can form part of renewable energy land banks and should be available to developers before projects are tendered or land is allocated.

Access should be treated as an important part of land planning. Solar parks, fencing and associated infrastructure can cut traditional routes to grazing areas, water bodies and agricultural fields. Land allotment and lease agreements should, therefore, include provisions for right-of-way, access corridors and continued access to community resources where required.

Multi-use land models should also receive greater attention. Agrivoltaics can combine electricity generation with agriculture, while canal-top and floating solar can use existing infrastructure and water bodies. In the wind sector, repowering can increase generation at established sites and make greater use of existing transmission infrastructure.

Pursue transformative project design

The spatial footprint of renewable energy varies significantly by deployment model. Future planning should therefore assess alternatives before defaulting to large greenfield projects.

Rooftop solar can increase distributed generation through existing built environments. Canal-top and floating solar can use existing public infrastructure and reservoirs, reducing pressure on agricultural land. Distributed renewable energy systems, including mini-grids, micro-grids and solar irrigation pumps, can bring generation closer to consumers and reduce the need for long transmission corridors.

These models can complement, rather than replace, utility-scale renewable energy. Their relative land requirements, transmission needs, water use, ecological impacts and local economic benefits should be considered during energy planning.

Table 4: Comparison of spatial footprints of alternative RE deployment models

Parameter	Utility-scale solar park	Canal-top/Floating solar	Rooftop solar/DRE
Land requirement	Large greenfield footprint	Uses existing canals and water bodies	Uses existing buildings or local sites
Land impact	Potentially high	Minimal terrestrial land requirement	Minimal new land requirement
Main co-benefit	Large-scale generation	Dual use of existing infrastructure; reduced evaporation	Local generation, energy access and household participation
Key constraint	Land acquisition and transmission footprint	Site-specific engineering and water-use considerations	Distributed implementation and financing
Conflict-reduction potential	Moderate	High	High

Institutionalise benefit sharing

The experience of Kurnool, NP Kunta, Charanka and Rewa shows that compensation alone does not determine how communities assess a renewable energy project. Landless workers, tenants, pastoralists and users of common resources may experience livelihood impacts without receiving comparable economic benefits.

Long-term land leasing provides one useful model because landowners retain ownership while receiving regular income. For large projects, this can be complemented by a formal community benefit mechanism.

A Community Benefit Fund could be established for renewable energy projects above a defined capacity, with contributions linked to installed capacity or project revenue. The fund could operate over the full project life and support locally identified priorities such as drinking water, healthcare, roads, education and livelihood development. Gram Panchayats and district authorities could jointly oversee the fund, with public disclosure of allocations and expenditure.

Local employment and skills development should form another part of the framework. Developers could establish clear targets for local hiring and provide training for construction, electrical work, operations and maintenance. Project Surya demonstrates how renewable energy skills can create longer-term livelihood opportunities for communities whose traditional occupations are under pressure.

CSR investments can complement these mechanisms by prioritising host villages and supporting needs such as digital classrooms, solar irrigation, drinking water systems and healthcare facilities.

Establish end-of-life lifecycle traceability

The renewable energy transition is also creating a future waste-management challenge. Solar modules, batteries, inverters, wind turbine components and other equipment will increasingly reach the end of their useful lives as India's RE fleet matures.

India should establish a digital traceability system covering renewable energy equipment across its lifecycle. Each module, battery, inverter and major turbine component could be linked to information on its manufacturer, installation date, ownership, refurbishment history and final recycling or disposal pathway.

This system can be integrated with the Extended Producer Responsibility framework and CPCB platforms. It would improve collection and recycling, reduce informal dismantling and support recovery of valuable materials such as aluminium, copper, glass, silicon and other resources.

The cases in this report show that renewable energy conflicts are closely connected to the way projects are planned, located and governed. Land classification, water availability, biodiversity, access to common resources and local livelihood conditions can shape the experience of a project long after the initial land transaction has been completed.

A more inclusive RE transition, therefore, needs to begin at the planning stage.

The priority is to make these approaches part of normal renewable energy planning rather than relying on individual projects to develop their own responses. This would allow India to continue expanding renewable energy capacity while giving greater attention to the communities, ecosystems and natural resources that support the transition.

References

1 Press Information Bureau, Government of India. (2026, March 25). Cabinet approves India's Nationally Determined Contribution (2031–2035) to be communicated to the United Nations Framework Convention on Climate Change. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2245209&reg=48&lang=2

2 Press Information Bureau, Government of India. (2026, April 8). India ranks third globally in renewable energy installed capacity: Shri Pralhad Joshi. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2250039&reg=48&lang=2

3 Press Information Bureau, Government of India. (2026, August 9). India achieves landmark 300 GW non-fossil fuel power capacity. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2296782&reg=48&lang=2

4 Press Information Bureau, Government of India. (2026, July 22). India's installed wind power capacity reaches 57,443 MW as on June 30, 2026. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2287725&reg=48&lang=2

5 Central Electricity Regulatory Commission. (2025, November). Staff paper on proposal for allocation of connectivity granted (on LOA route) where the signing of the PPA/PSA is getting delayed. https://cercind.gov.in/2025/staff-paper/SP-251125.pdf

6 Down To Earth. (2025, January 17). The 500 GW switchover. https://www.downtoearth.org.in/energy/the-500-gw-switch-over

7 IC Centre for Governance. (2019). The Journal of Governance: Special issue on environment. https://moef.gov.in/uploads/2019/10/SpecialEdition_Journal-of-Governance.pdf

8 Aslam, M., & Fazal, S. (2025). Transforming India—An Appraisal of Agricultural Land Use in Uttar Pradesh: A Regional Analysis. *Journal of Land and Rural Studies*, *13*(1), 46-66.

9 Grover, S., & Swami, N. (2024). Voices from the ground: People's perspectives on large-scale renewables. Centre for Energy, Environment & People. https://ceep.co.in/storage/publication/1751357724.pdf

10 Department of Land Resources, Ministry of Rural Development, Government of India, & National Remote Sensing Centre, Indian Space Research Organisation. (2019). Wastelands atlas of India–2019: Change analysis based on temporal satellite data of 2008–09 and 2015–16. https://dolr.gov.in/en/wasteland-atlas-of-india-2019/

11 Solar Energy Corporation of India. (n.d.). Frequently asked questions. https://www.seci.co.in/upload/static/files/FAQ(1).pdf

12 Asian NGO Coalition for Agrarian Reform and Rural Development. (n.d.). Land beneath the panel: A study examining renewable energy land-use conflicts to foster a just energy transition. Land Conflict Watch. https://www.landconflictwatch.org/publication/land-beneath-the-panel-

13 Land Conflict Watch. (n.d.). Ananthapuramu solar power park oustees demand higher compensation for their land. https://www.landconflictwatch.org/conflicts/ananthapuramu-solar-power-park-oustees-demand-higher-compensation-for-their-land

14 Yenneti, K., & Day, R. (2016). Distributional justice in solar energy development in India: The case of Charanka solar park. Journal of Rural Studies, 46, 35–46. https://doi.org/10.1016/j.jrurstud.2016.05.009

15 Yenneti, K., & Day, R. (2015). Procedural (in)justice in the implementation of solar energy: The case of Charanaka solar park, Gujarat, India. Energy Policy, 86, 664–673. https://doi.org/10.1016/j.enpol.2015.08.019
16 Land Conflict Watch. (2023, August). Job assurance and land use changes in Madhya Pradesh's Rewa solar project. https://land-conflict-watch.webflow.io/conflicts/rewa-ultra-mega-solar-project-fails-to-create-employment-for-locals
17 Land Conflict Watch. (2023, August). Job assurance and land use changes in Madhya Pradesh's Rewa solar project. https://land-conflict-watch.webflow.io/conflicts/rewa-ultra-mega-solar-project-fails-to-create-employment-for-locals
18 Land Conflict Watch. (2024, February). Adani's Kamuthi solar power plant casts shadow on livelihood of locals. https://land-conflict-watch.webflow.io/conflicts/adani-s-kamuthi-solar-power-plant-casts-shadow-on-livelihood-of-locals
19 Land Conflict Watch. (2024, February). Adani's Kamuthi solar power plant casts shadow on livelihood of locals. https://land-conflict-watch.webflow.io/conflicts/adani-s-kamuthi-solar-power-plant-casts-shadow-on-livelihood-of-locals
20 Rajasekaran, R. K. (2017, June 6). Adani solar plant guzzles illegal fresh water in drought-hit Tamil Nadu. The New Indian Express. https://www.newindianexpress.com/states/tamil-nadu/2017/Jun/06/adani-solar-plant-guzzles-illegal-fresh-water-in-drought-hit-tamil-nadu-1613326.html
21 Khar, S., & Iychettira, K. (2026). No empty land: Comparing distributional outcomes of solar parks across land tenure regimes in India. Energy Research & Social Science, 132, Article 104544. https://doi.org/10.1016/j.erss.2026.104544
22 Poojary, V., Hingne, A., Narayan, U., Kelkar, U., & Chattaraj, S. (2024). Just transition insights from India's 2050 MW Pavagada Solar Park. WRI India.
23 Energy Transitions Commission, & The Energy and Resources Institute. (2026). Unlocking solar at scale: How agrivoltaics overcome land constraints in India's energy transition. https://www.energy-transitions.org/publications/unlocking-solar-at-scale-agripv/
24 Mallik, H., Bhar, I., Choudhury, P., & Vaidya, P. (2026). Responsible Agri-PV baseline assessment report: Khare Energy Plant, Madhya Pradesh. The Energy and Resources Institute. https://www.teriin.org/policy-brief/responsible-agri-pv-baseline-assessment-report-khare-energy-plant-madhya-pradesh
25 ReNew. (n.d.). Harnessing traditional knowledge for water security. https://www.renew.com/foucuesd-initiative/harnessing-traditional-knowledge-for-water-security
26 Adani Green Energy Limited. (2024, July 25). Adani Green Energy announces strong Q1 FY25 results with EBITDA of Rs. 2,374 crore, up by 23%. https://www.adanigreenenergy.com/newsroom/media-releases/adani-green-energy-announces-strong-q1-fy25-results-with-ebitda-of-rs-2374-crore-up-by-23-percentage
27 Dosanjh, M. K., Fruergaard, W., Bohle Zeller, R., De Las Morenas Moneo, E., & Nigam Sinha, V. (2023, January 5). Speeding up renewable energy: Bottlenecks and how you resolve them. World Economic Forum. https://www.weforum.org/stories/forum-institutional/speeding-up-sustainable-energy-bottlenecks-and-how-you-resolve-them-davos2023/
28 Das, B. (2023, August 23). India faces stiff challenge with management of 187,200 tonnes of solar PV waste. Down To Earth. https://www.downtoearth.org.in/waste/india-faces-stiff-challenge-with-management-of-187-200-tonnes-of-solar-pv-waste-91317

India's renewable energy transition is advancing rapidly, but its success depends on how projects affect the people and landscapes around them. *Powering Progress, Protecting People* examines the social and environmental conflicts emerging from large-scale renewable energy development, with case studies spanning Rajasthan, Gujarat, Andhra Pradesh, Madhya Pradesh, Assam and other states. It traces how land classified as wasteland or government land often supports grazing, agriculture, water systems and culturally significant commons, while compensation and employment opportunities remain unevenly distributed. The report also examines environmental pressures on wildlife habitats, wetlands, coastal ecosystems and water resources. Drawing on experiences from projects across India, it identifies practical approaches to reduce conflict, including inclusive land-use planning, agrivoltaics, canal-top and floating solar, water stewardship, local skills development and community benefit sharing. It concludes with five policy priorities to strengthen environmental and social accountability and ensure that renewable energy expansion advances climate goals while protecting livelihoods and community interests.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phone: 91-11-40616000 Fax: 91-11-29955879
E-mail: cse@cseindia.org Website: www.cseindia.org