CEEW
THE COUNCIL

How a Green Economy can Deliver Jobs, Growth and Sustainability in Odisha

Report | January 2025

Suggested citation: Jain, Abhishek, Gunjan Jhunjhunwala, et al. 2025. *How a Green Economy can Deliver Jobs, Growth and Sustainability in Odisha.* New Delhi: Council on Energy, Environment and Water.

Disclaimer: The views expressed in this study are those of the authors and do not necessarily reflect the views and policies of the Council on Energy, Environment and Water.

Cover image: Alamy Stock Photo.

Peer reviewers (overall) Dr Amrita Goldar, Senior Fellow, ICRIER; Pranab R. Choudhury, Director and Co-founder, Landstack; Dhruba Purkhayasta, Director - Growth and Institutional Advancement, CEEW; Dr Vaibhav Chaturvedi, Senior Fellow, CEEW

Peer reviewers (sectoral) **Energy transition:** Harsh Thacker, Director - Global Consulting & R&D services; Chaitanya Kanuri, Associate Director - Electric Mobility, Sustainable Cities and Transport, WRI India; Ananth Aravamudan, Chief of Programs and Strategy, Villgro; Dr Rahul Jain, Deputy Program Manager, Renewable Energy, Centre for Science and Environment; Nisheeth Srivastava, Senior Sector Specialist - Energy, KfW Development bank; Martand Shardul, Policy Director - GWEC; Anjali Lathigara, Lead Market Intelligence - APAC region, GWEC; Dhruv Rajeev, former Senior Analyst at CSTEP; Dr Debajit Palit, Professor, NTPC School of Business; Sumeet Mazumdar, CEO, Federation of Indian Small Hydropower (FISH); Saptak Ghosh, Senior Policy Specialist, CSTEP; Rishabh Jain, Senior Programme Lead, CEEW; Dhruv Warrior, former Programme Associate, CEEW; Seshadri Raghavan, Programme Lead, CEEW; Bhawna Tyagi, Programme Lead, CEEW; Disha Agarwal, Senior Programme Lead, CEEW; Himanshu Anand, former Programme Associate, CEEW; Karan Kothadiya, Programme Associate, CEEW; Arjun Dutt, Senior Programme Lead, CEEW; Pankaj Kargeti, Engagement Lead, CEEW; Nilanshu Ghosh, former Research Analyst, CEEW

Circular economy: Sourabh Manuja, former Waste Management Advisor, GIZ; Satish Sinha, Associate Director, Toxics Link; Dr Parveen Kumar, Program Head - Sustainable Batteries, WRI; Jai Kumar Gaurav, Senior Advisor - Climate Change and Circular Economy, GIZ; Dr Subhasis Pradhan, Assistant Professor, Department of Civil Engineering, BITS Pilani; Lubna Anantakrishnan, Managing Trustee, Kashtakari Panchayat; Priyanka Singh, Programme Lead, CEEW; Sonal Kumar, Programme Lead, CEEW; Dhruv Warrior, former Programme Associate, CEEW; Seshadri Raghavan, Programme Lead, CEEW

Bioeconomy and nature-based solutions: Dr Ashwini Chhatre, Associate Professor, Economics and Public Policy, ISB; Dr Ayyandar Arunachalam, Director, ICAR - CAFRI; Dr Tanweer Alam, Director, IIP; Dr Madhu Puttegowda, Associate Professor, Malnad College of Engineering; Dr G N Hariharan, Executive Director, MSSRF; Arun Kumar Bansal, Board Member PEFC International, Former Addl DG Forests; Dr Anup Prakash Upadhyay, Associate Professor, Indian Institute of Forest Management; Dr Virendra Kumar Vijay, Professor, Indian Institute of Technology; Deebeeprasad Mishra, CEO, SEPL, India; Dr Shanti Kumar Sharma, Assistant Director General, HRM, ICAR, Delhi; Abhiram Seth, Managing Director, Aquaagri Processing Pvt Ltd; Dr Joy Rajbanshi, Programme Lead, CEEW; Karan Singhal, former Programme Associate, CEEW; Sijo Abraham, Programme Associate, CEEW; Sabarish Elango, Programme Associate, CEEW; Dr Chandan Jha, Programme Lead, CEEW; Vishwas Chitale, Senior Programme Lead, CEEW; Shreya Wadhawan, Programme Associate, CEEW; Dr Suparana Katyaini, Programme Lead, CEEW; Ritika Dube, Consultant, CEEW

Publication team: Alina Sen (CEEW); The Clean Copy; MADRE Designs; and FRIENDS Digital Colour Solutions.

Organisation: The **Council on Energy, Environment and Water** (CEEW) — a homegrown institution with headquarters in New Delhi — is among the world's leading climate think tanks. The Council is also often ranked among the world's best-managed and independent think tanks. It uses data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research and strives to impact sustainable development at scale in India and the Global South. In over fourteen years of operation, CEEW has impacted over 400 million lives and engaged with over 20 state governments. Follow us on LinkedIn and X (formerly Twitter) for the latest updates.

COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)
ISID Campus, 4 Vasant Kunj Institutional Area
New Delhi – 110070, India
+91 11 4073 3300

info@ceew.in | ceew.in | @CEEWIndia | ceewindia

CEEW
THE COUNCIL

How a Green Economy can Deliver Jobs, Growth and Sustainability in Odisha

Report leads

Abhishek Jain and Gunjan Jhunjhunwala

Core team

Wase Khalid, Aaditya Malhotra, and Urwa Tul Wusqa

Research team

Nicole Almeida, Parineet Kaur Chowdhury, Nikhitha Jagadeesh, Aishwarya Jain, Aishwarya Joshi, Apoorve Khandelwal, Neeraj Kuldeep, Shruti Nambiar, Shruti Prakash, Theres Thomas, and Akanksha Tyagi

Report
January 2025
ceew.in

MOHAN CHARAN MAJHI
CHIEF MINISTER, ODISHA

LOKASEVA BHAVAN
BHUBANESWAR

FOREWORD

Odisha stands at a pivotal moment in its development journey. Our economy is projected to grow at about 8.5 per cent annually, faster than the national average. We aim to create many more jobs for our youth and women as Odisha embarks on its vision, '*Viksit Odisha, 2036* for *Viksit Bharat, 2047*. In this journey, we also need to diversify and transform our economy to become more future- relevant, resilient, and resource-efficient to ensure well-being and prosperity for all communities.

A green economic paradigm, as outlined in this ground-breaking report by the Council on Energy, Environment and Water (CEEW), offers a unique pathway for Odisha to diversify and transform its economy. By broadening the imagination of "green" beyond renewable energy to include other aspects of energy transition such as circular economy, bioeconomy and nature-based solutions, we can unlock many more economic and employment opportunities. With a thrust on local value addition, it could also help Odisha catapult its economy from primary sectors to more secondary and tertiary sectors – generating higher incomes and better quality of life for our citizens.

Alongside, our industrial base would help us make big strides in supporting India's energy transition and circular economy ambitions. Odisha can become a regional leader in showcasing a successful circular model as the world moves from traditional mining to urban mining.

Phone : Office : 0674-2531100, 2531500, 2535100 (Fax)

3199 / 24 . 09 . 2025

Continuation Sheet

This report on *"How a Green Economy Can Deliver Jobs, Growth and Sustainability in Odisha"* helps us imagine the potential of expanding our green economy initiatives in our state. It also outlines institutional mechanisms necessary to develop a multi-sector green economy, converging with existing schemes and programmes and integrating various aspects of our development agenda.

I am happy to learn that Secretaries and Senior Government officials have supported this important initiative and CEEW Team. Together, we can lead Odisha into a sustainable future, ensuring that our next phase of development is people-centric and environmentally resilient.

(MOHAN CHARAN MAJHI)

ମନୋଜ ଆହୁଜା, ଭା.ପ୍ର.ସେ.
ମୁଖ୍ୟ ଶାସନ ସଚିବ, ଓଡିଶା
MANOJ AHUJA, IAS
CHIEF SECRETARY, ODISHA

ଦୂରଭାଷ: ୦୬୭୪-୨୫୩୪୩୦୦ / ୨୫୩୬୬୦୦ (O)
Tel. : 0674-2534300 / 2536700 (O)
ଫ୍ୟାକ୍ସ : ୦୬୭୪-୨୫୩୬୬୬୦
Fax : 0674-2536660
ଇ-ମେଲ / E-mail : csori@nic.in
ପତ୍ର ସଂଖ୍ୟା / Letter No.:
ତାରିଖ/Date:

MESSAGE

Odisha's transition to a green economy is inevitable. A multi-sectoral green economy that is resilient to climate change will help safeguard against future economic vulnerabilities and create millions of jobs. This report by Council on Energy, Environment and Water (CEEW) showcases the estimated size of a green economy in Odisha and serves as a comprehensive guide for all key stakeholders, including policymakers, administrators, industry and civil society organizations (CSOs) to come together to realise its potential. By adopting the green economy paradigm, Odisha will position itself as an important hub for green jobs and investments, attracting sustainable industries and setting a benchmark for other states.

(Manoj Ahuja)

ମୁଖ୍ୟ ଶାସନ ସଚିବଙ୍କ କାର୍ଯ୍ୟାଳୟ, ଓଡ଼ିଶା, ସାଧାରଣ ପ୍ରଶାସନ ଓ ସାଧାରଣ ଅଭିଯୋଗ ବିଭାଗ, ଲୋକ ସେବା ଭବନ, ଭୁବନେଶ୍ୱର-୭୫୧୦୦୧
Office of the Chief Secretary, Odisha, GA & PG Department, Lok Seva Bhavan, Bhubaneswar-751001

ANU GARG, IAS
Development Commissioner
-cum-Additional Chief Secretary
Government of Odisha

D.O. No. _____/DCACS

Date :

MESSAGE

"The Green Odisha Initiative" Report is a call to action for all sectors of the economy. From micro-enterprises to large industries, across coastal and inland districts, there is significant potential to generate green jobs, attract investments, and support the development of emerging, future-relevant livelihood sectors. The Common Results Framework (CRF), as outlined in this report by Council on Energy, Environment and Water (CEEW), gives a structured approach to systematically track progress and ensure that every Departmental initiative is aligned with the state's green economy objectives.

Planning and Convergence Department will act as the Secretariat to facilitate coordination among Government Departments and Agencies so that the state's green economy goals are integrated with all sectors and programmes. The report is the culmination of a year long engagement and interaction between the CEEW Team and the Secretaries of related Departments which was coordinated by the Planning & Convergence Department.

(Anu Garg)

Tel: 0674-2536882, 2322617 (O)
E-mail: dcplg@nic.in

A circular economy focuses on the reuse and regeneration of materials, transforming waste into wealth and creating a greener economy.

Image: iStock

About CEEW

INTEGRATED | INTERNATIONAL | INDEPENDENT

The **Council on Energy, Environment and Water (CEEW)** — a homegrown institution with headquarters in New Delhi — is **among the world's leading climate think tanks**, often ranked among the **world's best-managed and independent think tanks**. We use data, integrated analysis, and strategic outreach to explain — and change — the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research and strives to **impact sustainable development at scale** in India and the Global South.

In numbers

14 years of operation
11 Union ministries
20 State governments
330+ people
500+ research projects
600+ seminars & conferences
10,000+ media mentions
400+ mn lives impacted
2070 India's net zero target informed

Leadership

Board
Mr Jamshyd N. Godrej (Chairperson)
Dr Janmejaya Sinha
Mr Montek Singh Ahluwalia
Dr Naushad Forbes
Mr S. Ramadorai
Dr Suresh Prabhu
Ms Vinita Bali

CEO
Dr Arunabha Ghosh

Clean electricity penetration

- Informed **PMO**: 100 GW solar, 175 GW RE target; Surya Ghar Yojana (10 mn homes)
- Informed ***Ujjwala*** & ***Saubhagya***: 125+ mn people electrified, 100+ mn households got LPG
- Supporting **rooftop solar deployment** in Madhya Pradesh, Uttarakhand & Rajasthan
- Training **30,000+** ***Vidyut Sakhis*** in Uttar Pradesh
- **Net-zero roadmaps** for six states
- Power markets and pathways beyond 2030

Sustainable livelihoods & green economy

- **Jobs, Growth and Sustainability**, first economy recovery report during CoViD-19
- First (& ongoing) mapping of clean energy jobs (3.4 mn FTE employment by 2030)
- **Powering Livelihoods:** USD 5+ mn to support rural startups; 19,000+ livelihoods; 10,000+ tech deployed
- **Green economy** ecosystem in Odisha
- Enabled world's first policy framework on distributed renewables for livelihoods
- Clean Energy Access Network impacting >200 enterprises

Global impact

- Strategic Partner to **India's G20 Presidency**
- Conceptualised **International Solar Alliance**
- Supported **Paris Agreement**, Kigali Amendment
- **"Think tank of the Global South"** for Stockholm+50
- **India's first report on global governance**
- UNSG's **High-Level Expert Group on Net Zero**
- Global Commission on the **Economics of Water**
- Co-created **Our Common Air** global commission
- Climate finance definitions & taxonomy; GIFT City as sustainable finance hub

Low-carbon industrialisation & circularity

- Co-chaired Science, Technology & Innovation Policy
- Supporting **National Green Hydrogen Mission**; **Green Steel Mission**
- Informing Indian **carbon market** design
- Net-zero routes: steel, cement, fertiliser, aluminium
- **Green industrial policies:** Gujarat, Tamil Nadu
- **Database** of industrial emissions in India
- Natural-gas-based furnace for MSMEs

Fuels of the future

- Supporting India's **Critical Minerals Mission**
- Driving **circular economy** for solar, solid waste & wastewater
- Identifying & supporting **value chains for clean tech manufacturing**
- Supporting manufacturing of **advanced cell chemistry batteries**
- QUAD collaboration on critical minerals

Quality of life of citizens

- **Clean air action** in Delhi, Maharashtra & Punjab
- Commission for Air Quality Management
- National **Water Resources** Framework
- Supporting **National Mission for Clean Ganga**
- Developing first **Climate Resilience Atlas**
- Supporting XVI Finance Commission with disaster risk index for Indian states
- **Heat-cum-humidity action plans** for 300+ cities
- **Flood-risk management action** plans for five cities
- **Sustainable mobility** in Kerala, Punjab (1,100 e-autos) & Uttar Pradesh (300+ e-buses)
- Natural farming in Andhra Pradesh & Rajasthan
- Co-authored **India Cooling Action Plan**
- QUAD agreement on clean cooling
- Co-authored **Mission LiFE**

Building capabilities

Green financial intermediation for investments, insurance, & carbon markets	Generative AI for energy transition & climate resilience	Planetary tipping points & impact on India's development

> The importance of institutions — for public policy research, advisory and action — is not to claim a monopoly over truth. Their importance lies in rebuilding trust.

Acknowledgment

We would like to express our heartfelt gratitude to the Government of Odisha for their invaluable and consistent support towards this initiative. Special thanks to Shri. Manoj Ahuja (Chief Secretary), Shri. Pradip Kumar Jena (ex-Chief Secretary), Smt. Anu Garg (Additional Chief Secretary cum Development Commissioner) and Smt. Chithra Arumugam (Special Secretary, Planning and Convergence Department) for their constructive feedback and for believing in the promise and potential of a green economy for the state.

Our technical advisory group members, Dr Souvik Chakraborty (Senior Research Fellow, University of Massachusetts) and Dr Rohit Azad (Faculty at Jawaharlal Nehru University) have been critical in ensuring rigour in research methodology, and Dr Arabinda Mishra (Chairperson, Development and Environment Futures Trust) in helping us understand the state context of Odisha better. Mr Devjit Mitra (Director, Socratus Foundation) and the Socratus Foundation have been instrumental in shaping the institutional mechanism recommendations.

We extend our deepest appreciation to our peer reviewers, whose insights and expertise significantly enhanced the credibility and reliability of our assessment. Our special thanks go to Dr Amrita Goldar, Senior Fellow at ICRIER and Mr Pranab R. Choudhury, Director and Co-founder of Landstack, for serving as external reviewers. Thanks also to our internal reviewers, Dr Dhruba Purkhayasta, Director - Growth and Institutional Advancement at CEEW, and Dr Vaibhav Chaturvedi, Senior Fellow at CEEW. This report greatly benefited from thorough reviews by experts across the three sectors of energy transition, circular economy, nature-based solutions and bio-economy. We thank you for sharing your expertise with us and giving us your precious time.

We undertook approximately 100+ consultations to better understand the value chains and their potential. Our gratitude to each and every one who gave us their precious time and supported our research.

Several of our former colleagues have played an important role in the development of this work. We thank Aravind Harikumar, Arvind Poswal, Atish Padhy, Sakshi Kumare, Aparajita Nair Dmonty, Ujjawal Kumar, and Arijit Sarkar—and our current colleague, Vanya Pandey, for their invaluable support during various research stages across different sectors.

This acknowledgment would be incomplete without our gratitude to Ms Seema Paul, Program Director, Sequoia Climate Foundation (SCF) and the entire SCF team for their generous financial support and flexible learning approach. When donors turn to learning partners, the output is significantly enriched.

Thank you all for your generosity and support in this endeavour.

The authors

Contents

A green economic paradigm can help states achieve responsible growth, resilient jobs and a regenerative environment.

Image: iStock

Executive summary

India is one of the fastest-growing economies in the world and is home to the world's largest population. With reasonably young demographics, India needs jobs-intensive economic growth and not merely economic growth. Simultaneously, India needs to achieve an ambitious climate target to be net zero by 2070 while making its economy resilient to the impacts of climate change. **India's economic development strategy needs a concomitant focus on jobs, growth, sustainability and resilience. Adopting a green economy paradigm could help India meet these four strategic outcomes, unlocking tens of millions of jobs while fostering a low-carbon and resilient economy.**

Adopting a green economy paradigm could help India unlock tens of millions of jobs while fostering a low-carbon and resilient economy

Box ES1 **A green economy paradigm for India**

A green economy paradigm for India must

- **mainstream sectors and value chains** in the economy that further job-intensive economic growth while regenerating/safeguarding the natural capital;
- **enhance economic resilience** by investing in sectors that would be relevant and thriving in a low-carbon and climate-changed world;
- **expand the 'greening' of the economy** beyond the green energy transition to other sustainability-oriented sectors, such as bio-economy, including the use of biomaterials and nature-based solutions, the circular economy, and beyond; and
- **build the capacity and skills** of the (future) workforce to actively transform the economy from an extractive to a regenerative one.

The case for a green economy in Odisha

As India embarks on a green economy paradigm, its real implementation will happen in the Indian states. To understand the relevance of a green economy at a state level, we focus on Odisha, a state that has pioneered several positive climate action initiatives. Odisha was the first to draft a state action plan on climate change, adopt climate budgeting initiatives and institutionalise the state disaster management authority. The state also boasts ecological diversity, from dense forests to a long coastline, a thriving industrial base, and significant dependence on conventional extractive economic sectors. The state also needs economic diversification, given the vulnerability of its current economic sectors to a low-carbon transition as well as emerging climate impacts.

A green economy paradigm can unlock much needed jobs and further economic opportunities in the state while attracting fresh investments. Besides, it would help Odisha to:

Diversify its economy into future-relevant sectors, ensuring long-term economic resilience;

Reduce youth out-migration by creating new economic opportunities within the state;

Transition from an economy dependent on primary production to one with value-added sectors; and

Position itself as a green investment destination, attracting new-age investments and talent.

We estimate the jobs, market and investment (J-M-I) opportunities, should Odisha adopt a green economy paradigm. The report also elaborates on what it would take for Odisha to adopt and implement such an economic paradigm.

For the assessment, we considered various emerging green sectors of the economy, namely, the green energy transition (ET), the circular economy (CE), and the bio-economy and nature-based solutions (BE and NbS). These green economic sectors were selected considering:

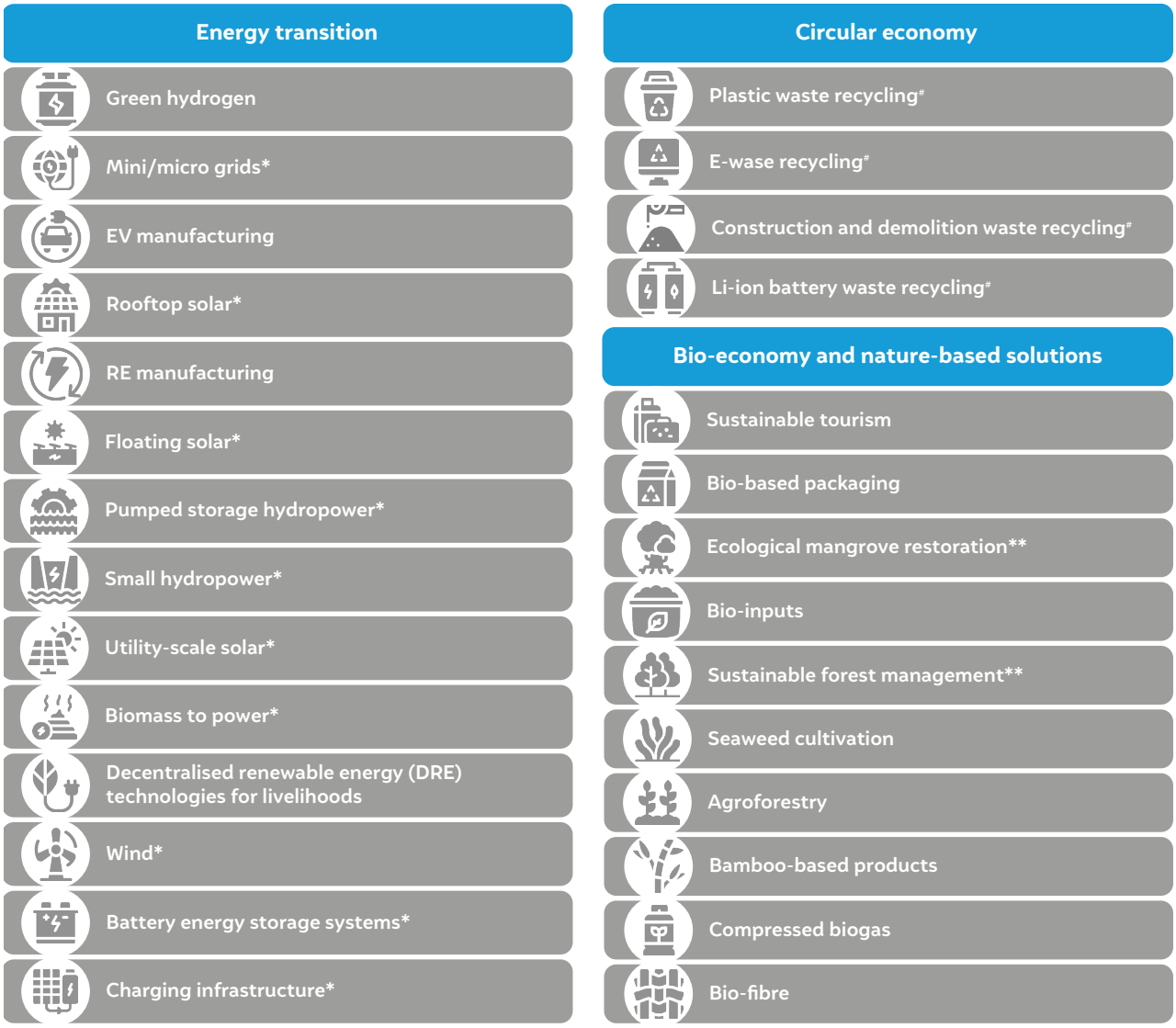
- the growing interest of the Indian private sector-from corporates to start-ups-in these sectors;
- emerging supportive government policies;
- the need to expand the spectrum of emerging climate solutions, including but also beyond the ET; and
- the need to further economic activity across all levels of the economy – from microenterprises to large industries and from primary sectors to tertiary ones.

Across these sectors, we identified and shortlisted 28 value chains based on (i) their suitability to Odisha's geographic and natural resource context; (ii) inputs received from the state officials; and (iii) their commercial maturity (within or outside Odisha). These value chains range from battery manufacturing to sustainable packaging to ecological mangrove restoration (EMR). A detailed list is provided in Figure ES1.

It is worth noting that the three green economic sectors and their value chains do not constitute an exhaustive list — many more green economic opportunities are likely to emerge in the coming times. We selected these diverse value chains and sectors to broaden the discourse on the green economy and its economic potential in India. Currently, many of these emerging green opportunities are not on the radar of policymakers, economists, industrialists, financiers, and civil society actors. This first-of-its-kind report would help broaden their imagination and understanding of the possibilities that the green economy paradigm can offer.

Odisha is a pioneer of several positive climate action initiatives and has a real opportunity to also be the first state to adopt a comprehensive green economy paradigm

Figure ES1 Green economy value chains are diverse in nature and extend beyond renewable energy



Source: Authors' analysis

Note: *Only deployment of the value chain has been factored in estimations. The rest of the value chains in the ET sector factor in estimations for manufacturing. #Only recycling of waste products is included in the value chain.

**Only restoration related activities – nursery management, plantation and maintenance activities – have been included in the value chain

We estimate that if Odisha actively adopts and scales up these value chains by 2030, the state can:

Create ~10 lakh full time equivalent (FTE) jobs

Contribute INR 2 lakh crore (USD 23.7 billion*) to the state GDP

Attract INR 3.5 lakh crore (USD 41.8 billion) in investments

It would mean that Odisha can add about 23 per cent to its state GDP and about 20 per cent to its current investment figures.

* All INR to USD conversions are at the rate of 1 USD = 83 INR

These estimates are based on a bottom-up sizing of the potential of each of the selected 28 value chains in Odisha. The sizing of the potential employs rigorous analysis using data from the literature and stakeholder interviews with enterprises, sector experts, and relevant state government departments for each respective value chain. We conducted 110+ private sector consultations, about 25 consultations with different state agencies or departments in Odisha, and were guided by leading experts in the research process.

Next, we present a breakdown of these aggregate potential numbers across the three sectors (refer to Figure ES2) and their subsequent value chains (refer to Figure, ES3, ES4, ES5). It is noteworthy that the jobs-to-investment ratio varies greatly across sectors and across value chains. The number of FTE jobs per INR Cr of investment is about 12 to 9 times higher for CE and BE+NbS, respectively, as compared to ET[1] — further emphasising the need to broaden our green economic transition beyond only green energy transition, given the jobs-intensive growth that India needs.

Figure ES2 A green economy paradigm can unlock huge opportunities for jobs and economic diversification in Odisha

	Energy transition	Circular economy	Bio-economy and nature-based solutions
No. of value chains	14	4	10
Job potential*	4 lakh+	29,700+	5.6 lakh+
Market opportunity**	INR 1.6 lakh crore+	INR 9,500 crore+	INR 25,900 crore+
Investment opportunity	INR 2.8 lakh crore+	INR 2,500 crore+	INR 63,500 crore+#
Jobs per crore of investment	1.4##	11.9	8.9

Source: Authors' analysis

Note: *Only considers direct jobs. **Does not include carbon revenue and final product revenue of many VCs (such as agroforestry). #Includes public outlay for NbS. ##The investment opportunity in ET is high because of a high initial capex requirement.

**Job potential and investment opportunity have been estimated till 2030 while market opportunity has been estimated in 2030.

Figure ES3 Energy transition can generate more than four lakh jobs and INR one and a half lakh crore in market opportunity with an investment of less than INR three lakh crore

Value chain	Jobs ('000)	Market (INR '000 cr)	Investment (INR '000 cr)
RE manufacturing	93	44	65
Mini/micro grid	82	0.8	21
Green hydrogen and electrolyser	65	40	57
DRE technologies for livelihoods	44	5.7	0.1
EV manufacturing	31	53	25
Rooftop solar	26	0.4	4.5
Floating solar	17	3.2	31
Battery energy storage systems	16	0.6	4.5
Biomass to power	13	2.3	1.4
Utility-scale solar	6.9	2.7	40
Charging infra	5	0.3	1.6
Pumped storage hydropower	3.3	6.2	19
Wind	0.6	0.5	6.9
Small hydropower	0.5	0.7	1.4
Total	**401**	**161**	**281**

Source: Authors' analysis

Note: RE, renewable energy; GH2, green hydrogen; BESS, battery energy storage systems; DRE, decentralised renewable energy; PSH, pumped storage hydropower; EV, electric vehicle

1 For example, plastic waste recycling can create more than 10 jobs per crore INR of investment, whereas electric vehicle (EV) manufacturing will create about 1 job per crore of investment.

Figure ES4 Circular economy can generate 30 thousand jobs and INR 10 thousand crore in market opportunity with an investment of less than INR three thousand crore

Value chain	Jobs* ('000)	Market (INR '000 cr)	Investment (INR '000 cr)
Plastic waste recycling	23	8.4	2
E-waste recycling	5.5	1.1	0.4
Construction and demolition waste recycling	1.5	0.1	0.1
Li-ion battery waste recycling	0.2	0.1	0.1
Total	**30**	**10**	**2.6**

Source: Authors' analysis

* Represent direct jobs created from recycling operations and do not include other roles within a company like finance, administration, sales and marketing.

Figure ES5 Bio-economy and nature-based solutions can generate more than five lakh jobs and INR 26 thousand crore in market opportunity with an investment of around 64 thousand crore

Value chain	Jobs ('000)	Market (INR '000 cr)	Investment (INR '000 cr)
Sustainable forest management	244	3.3	14
Seaweed cultivation	108	0.8	1.1
Agroforestry	136	4.9	29
Bamboo-based products	29	6.4	9.5
Compressed biogas	21	1	0.2
Bio-fibre	11	2.4	2.5

Value chain	Jobs ('000)	Market (INR '000 cr)	Investment (INR '000 cr)
Sustainable tourism	7.5	4.8	1.8
Bio-based packaging*	2.9	2.2	4.8
Mangrove restoration	2.2	0.01	0.1
Bio-inputs	2.1	0.1	0.01
Total	**565**	**26**	**64**

Source: Authors' analysis

* These numbers are based on an assumption that 50 per cent of the available biomass is utilised for bioplastic and 50 per cent for bio-based packaging paper. Range of estimates for each product is shown in Chapter 3.

Catalysing a green economy in Odisha

The jobs, market, and investment (J-M-I) estimations build the case for promoting these value chains, but the next big question is, what should be the approach to realising this potential? We tackle this question at two fundamental levels: (i) efforts to implement and scale each value chain and (ii) efforts across the value chains at an economic paradigm level.

At the value chain level, we answer a range of important questions to move forward in supporting these value chains:[2]

- What are the key barriers limiting the emergence and scale-up of the value chain? What could be the mitigation strategies to overcome these barriers?
- What are the roles and responsibilities of different state departments in promoting and supporting each value chain? Who could be the lead and allied departments for each value chain?

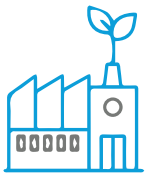
2 These are discussed in detail for each value chain in the main report.

- What are the key risks in scaling the respective value chain? What could be the associated mitigation strategies?
- What are the prevailing successful on-ground examples for each value chain? What can we learn from them?

At the economy-wide level, to realise the immense potential of a green economy in Odisha, **we propose an implementation plan called the Green Odisha Initiative** (GrOI). It weaves in and builds upon the state's ongoing isolated efforts to develop green value chains and offers a state-wide and economy-wide coherent approach.

- **A whole-of-government approach**
  - The GrOI will function as an overarching initiative of the state government, directly under the leadership of the chief minister. Its secretariat will be hosted at the Planning and Convergence Department (P&CD), which oversees interdepartmental planning and coordination.
  - A Common Results Framework (CRF)[3] is to be designed to ensure convergence of the prevailing schemes and programmes across various departments, leveraging them to promote the green economy. This step is essential for budgetary allocations and for regularly monitoring the progress of the initiative. The CRF will also propose department-level goals and targets.
  - A committee of select department secretaries, chaired by the chief secretary, will be established to oversee the formulation and implementation of the initiative.
  - A subcommittee, consisting of state officials at the director level of the respective departments, will be formed to support the secretary-level committee in ensuring active collaboration and coordination between departments in implementing the GrOI.

- **A whole-of-economy approach**
  - The GrOI aims to catalyse all sectors and segments of the economy – from primary to tertiary, micro, small, and medium enterprises (MSMEs) to large industries, and manufacturing to services – by greening existing business activities and promoting new green activities and value chains.
  - Once the CRF is operationalised, it will enable the state to estimate how much of the budget is aligned with advancing the green economy in the state. The government can then set progressively increasing targets to expand this share of the budget over time.
  - The GrOI will catalyse active policy signalling from the state government to direct private-sector investment towards Odisha's green sectors. This includes creating a more conducive and supportive policy environment for green enterprises, providing favourable incentives where needed, and implementing regulations to scale up green value chains. Additionally, it may also include an ecosystem development approach around value chains as well as cross-cutting support via areas such as skill development for green sectors.



Currently, many of the emerging green opportunities are not on the radar of policymakers, economists, industrialists, financiers, and civil society actors

3 Refer to Chapter 4 of the main report.

- **A whole-of-state approach**

  - The GrOI's on-ground implementation should be pan-Odisha, ensuring that all geographical regions across the state begin evolving and aligning their economic activities with more future-relevant economic sectors.
  - Local contexts, such as biological resources and locational advantages, will naturally influence the kinds of green value chains that can be developed in different regions. For example, the seaweed value chain would be dominant in the coastal districts, while certain CE value chains may be dominant in more urbanised parts of the state.

The private sector and civil society must complement the endeavours of the government with regard to the GrOI through the implementation of technology, innovation, investments, skills development, community engagement, local institutional capacity building, and other similar measures.

Image: iStock

By 2030, Odisha can create 10 lakh full-time equivalent (FTE) jobs, directly contribute INR 2 lakh crore (USD 23.7 billion) to the state GDP, and attract INR 3.5 lakh crore (USD 41.8 billion) in investments

Conclusion

A green economy has the potential to unlock vast economic and job opportunities, especially as we broaden the imagination beyond just the energy transition. Many of these emerging opportunities need public support and the private sector's attention today so that the jobs for our youth and our economy can thrive and become resilient in a low-carbon and climate-changed future. Not investing in a green economy now may mean losing out in the global competitive landscape as the demand for green products and services will skyrocket in the coming years

This report is one of the first to estimate, characterise, and showcase a pathway for realising these opportunities at a state level in India. While the scope and potential of the green economy could be even greater, it will require coordinated efforts from the state, markets, and civil society to translate this opportunity into a tangible reality for millions on the ground.

With a short cultivation period, seaweed farming can improve livelihood opportunities for fishing communities, especially women.

Image: Alamy

1. Introduction

India is the fastest-growing major economy in the world, with a gross domestic product (GDP) growth rate of 8.2 per cent in the fiscal year 2023–24. Comprising a population with a median age of just over 28 years, India possesses significant economic and demographic potential (PIB 2024). By 2030, its working-age population is expected to number more than a billion people, with its demographic peak occurring only after 2040 (EY India 2023; Malin and Tyagi 2023). However, to adequately realise its demographic dividend, India must create about 80 lakh jobs annually (Ministry of Finance 2024). With an overall unemployment rate of 6.8 per cent, the International Labour Organization (ILO) estimates that India's youth population accounts for 83 per cent of those unemployed (Fernandes 2024). Therefore, India needs job-intensive economic growth to create equitable economic opportunities for its population. Simultaneously, India has committed to achieving net zero by 2070, with imminent and ambitious decarbonisation targets set for 2030 (PIB 2023a). To concurrently achieve both priorities of job creation and low-carbon development, it is critical to build a green economy paradigm that generates jobs, furthers economic prosperity, and fosters climate and environmental action.

It is critical to build a green economy paradigm that generates jobs, furthers economic prosperity, and fosters climate and environmental action

1.1 What is a green economy?

The extant literature provides varied definitions and characteristics of a green economy. The United Nations Environment Programme propounds the key characteristics as being *"low carbon, resource efficient and socially inclusive"* while also generating income growth and job opportunities through an increase in public and private investments (UNEP n.d.). The Green Economy Coalition propounds similar characteristics of a green economy; it says that a *"green economy is one that provides prosperity for all within the ecological limits of the planet"* (Green Economy Coalition 2020). The Global Green Growth Index, similarly, is an attempt to quantitatively assess the performance of 157 countries along four green growth dimensions: *"efficient and sustainable resource use, natural capital protection, green economic opportunities and social inclusion"* (Global Green Growth Institute n.d.). The ILO particularly emphasises the green jobs that are generated through a green economy, as *"green jobs are decent jobs that contribute to preserve or restore the environment"* (ILO n.d.). The common thread in each of these understandings is that a green economy is climate-positive and sustainable while also being job-intensive.

In this study, *we define the green economy as one that protects the environment and stays within the ecological boundaries of nature while promoting job-intensive economic prosperity*. A job-intensive green economy paradigm is particularly crucial for a country like India to align its environmental and climate-action objectives with that of sustainable economic development.

To offer shape to this definition, in the context of India, it is necessary to answer a range of questions:

- Which sectors and value chains constitute a green economy?
- Is a green economy equivalent to a green energy transition (ET)?
- What is the potential of the green economy – in terms of generating jobs, economic growth, and investments?
- How can we mainstream the green economy paradigm?

This report aims to answer these questions and initiate a broader dialogue to evolve the Indian economy along a greener trajectory. In doing so, we explicitly broaden the imagination and scope of a green economy beyond just the green ET to include other climate-positive sectors, such as the circular economy (CE), bio-economy (BE), and nature-based solutions (NbS). Together, these areas expand the vast span of emerging green opportunities.

With a combination of progressive economic policies and abundant natural resources, Odisha has the capacity to become the first state in India to mainstream a green economy paradigm

1.2 A green economy paradigm for Odisha

As India embarks on a green economy paradigm, its real implementation will happen at the subnational level- its states. To understand the relevance of a green economy at a state level, we focus on Odisha, a state that has pioneered several positive climate action initiatives. Odisha was the first to draft a state action plan on climate change, adopt climate budgeting initiatives and institutionalise the state disaster management authority. The state also boasts of ecological diversity from dense forests to a long coastline, hilly regions, central plateau, and floodplains which provide an opportunity to examine diverse green economic sectors and value chains in a single state. These advantages, combined with a thriving industrial base, significant dependence on conventional extractive economic sectors and a range of supportive policies for green sectors warrant Odisha to explore the possibilities of a green economy.

Odisha is a pioneer in India for action against climate change. It was the first Indian state to (i) adopt a State Action Plan on Climate Change, (ii) formalise a climate budget, and (iii) secure funding from the UN Green Climate Fund (Government of Odisha: Forest, Environment and Climate Change Department n.d.). Encouragingly, in recent years, the state has surpassed the national average in GDP growth, the Human Development Index (HDI), and the Multidimensional Poverty Index (MPI) – all key indicators of a resilient economic trajectory (PTI 2023; The New Indian Express 2019; NITI Aayog 2023). Additionally, it has a strong industrial base with the presence of large steel, aluminium, coal, and other industries.

In adopting a green economy paradigm, Odisha can leverage its thriving industrial ecosystem, abundant bioresources, and rich natural ecosystems to diversify its economy and expand job and livelihood opportunities. The state's combination of policies holds significant potential to accelerate green economic development. This policy support will help attract the private investments required to promote the green economy in Odisha. An illustrative example of three such policy instruments is given here:

- *Industrial Policy Resolution 2022 Odisha*: Since its adoption, the Industrial Policy Resolution (IPR) has significantly improved the ease of doing business, enhanced the quality of governance infrastructure, streamlined regulatory compliance, and provided incentives for several industries to flourish in Odisha. The resolution classifies industrial sectors eligible for special incentives into two categories – priority sectors and thrust sectors – each with its own set of incentives and regulations. A few green economic sectors and value chains are placed within the ambit of thrust sectors, including green energy equipment and green hydrogen (GH_2). The IPR can be further utilised to include many more green sectors, thus attracting investments from the private sector (Government of Odisha: Industries Department n.d.).

- *Odisha Renewable Energy Policy, 2022*: The state's renewable energy (RE) policy provides numerous incentives and benefits to industrial RE developers in an effort to attract them into the state. The policy has a huge scope and covers almost all the value chains included within the ET vertical of the Green Odisha Initiative (GrOI). Some of the incentives and benefits that the policy provides include the following:
  - progressive waiver of inter-state transmission system (ISTS) charges and other similar charges;
  - exemption of 50 paise per unit of electricity duty;
  - subsidies for consumers of electricity that is generated using RE sources; and
  - prioritisation of land availability for RE projects from industrial land banks (Government of Odisha: Industries Department n.d.).
- *Odisha MSME Development Policy–2022*: Odisha's MSME policy provides several incentives and benefits to companies that fall within its ambit to promote industrial growth equitably across its districts. These include land subsidies, exemptions on certain duties, fixed capital subsidies, interest subsidies, and several others. Currently, the policy identifies eight focus sectors, none of which are green economic sectors. By extending its focus to include green sectors, the existing provisions of the MSME policy can be used to direct investments towards green value chains in the state (Government of Odisha: Micro, Small & Medium Enterprises Department n.d.).

We have selected three emerging green economic sectors to explore Odisha's green economic potential. These sectors comprise 28 unique value chains, each with varying potential to generate jobs, market, and investment opportunities

With a combination of progressive economic policies and abundant natural resources, Odisha has the capacity to become the first state in India to mainstream a green economy paradigm. However, certain additional efforts can help Odisha accelerate this transition. These are as follows:

- Converge economic development and climate action in the same direction
- Become an attractive destination in India for green investments
- Enhance value addition in the state
- Diversify the state's economy to include emerging green sectors

1.3 Scope for a green economy in Odisha

We have selected three emerging green economic sectors to explore Odisha's green economic potential.[4] These sectors comprise 28 unique value chains, each with varying potential to generate jobs, market, and investment opportunities. This list is inexhaustive, and more sectors and value chains may be included as the green economy begins to take shape in the state. The three sectors that we have identified are as follows:

- **Energy transition**: The ET sector is often considered the foundational pillar of a green economy. This sector includes key technologies necessary for transitioning to a non-fossil-fuel-based economy, such as the deployment of renewable technologies like solar and wind, and the manufacturing of components critical to the RE ecosystem. It also includes technologies, products, and services for decarbonisation, such as electric vehicles (EVs) and GH2. We have identified 14 value chains within ET as greening energy sources could unlock substantial job and market potential.

4 The methodology chapter of this report discusses our selection criteria. As the green economy efforts in the state progress, it is possible for the state to expand these sectors and value chains.

- **Circular economy**: *The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting."* (Ellen Macarthur Foundation n.d.). The Indian economy is projected to generate 165 million tonnes of waste from different streams by 2030 (International Trade Administration 2023). To achieve an environmentally sustainable economy, it is crucial to find methods to recover resources from waste and reintegrate them back into the economy. Based on the state's priorities, we have included four green value chains in the CE in our analysis. However, there is scope to include additional value chains in the future.
- **Bio-economy and nature-based solutions**: Arguably, the most innovative way to create economic value from a green transition is by sustainably leveraging natural resources. BE is defined as an efficient approach to converting and utilising biological resources into economic goods, thereby scaling revenue creation towards realising a sustainable economy (BIRAC 2021). It encompasses a wide range of value chains, including bio-inputs, biogas, bio-fibre, and bio-packaging. While BE is a product-based framing of industry, NbS involve actions that focus on the protection, restoration, or sustainable management of natural ecosystems, generating income and job opportunities for local communities (IUCN 2020). Under the combined sector of BE and NbS, we have identified 10 value chains, such as ecological mangrove restoration, bio-fibres, and sustainable tourism, which could contribute to the green transition paradigm in Odisha.

To realise the green economy paradigm, we have proposed an implementation plan called the Green Odisha Initiative. This initiative will adopt a whole-of-government approach to mainstream the green economy in Odisha

This report is the first step towards mainstreaming a green economy in Odisha, and it consists of four chapters.

- In Chapter 2, we discuss the methodology used to
  - identify these three green economic sectors and the value chains within them;
  - estimate the job potential, market opportunity, and investment opportunity of each value chain; and
  - propose an institutional mechanism to implement and develop the value chains in Odisha, and limitations to our methods.
- Chapter 3 consists of a brief overview of each value chain, covering
  - the jobs, market, and investment potential of each value chain;
  - the roles and responsibilities of relevant government departments to scale them up;
  - the risks and challenges scaling up may present, and mitigation strategies to tackle them;
  - the rationale for the private and public sectors to invest in these value chains; and
  - a case study demonstrating success from the ground.
- To realise the green economy paradigm, we have proposed an implementation plan called the GrOI. This initiative will adopt a whole-of-government approach to mainstream the green economy in Odisha. Details of the initiative are shared in Chapter 4 of this report, where we have included suggestions for
  - implementing an institutional mechanism;
  - a common results framework (CRF); and
  - the roles and responsibilities of the private sector and civil society in making the green economy a reality.
- Detailed dossiers that provide crucial knowledge (J-M-I potential, challenges and mitigation, mapping of lead and allied departments, risks to scale) on each value chain identified under the initiative have been designed and attached as additional documents to Chapter 3 of this report. These dossiers will be useful to assist government officials, policymakers, and academics interested in scaling up the green economy in Odisha.

2. Research methodology

Image: CEEW

Members of the CEEW team at the State Secretariat in Odisha. Government consultations were crucial to the development of this study.

This chapter discusses the methodology used to estimate the opportunity size of a green economy in Odisha and our recommendations for implementation routes. It also details the methods employed to identify key green economic sectors relevant to Odisha, pinpoint green value chains within these sectors, and assess the challenges, mitigation strategies, and risks associated with scaling such green value chains.

We adopted a 'five-step approach' to quantify, characterise, and propose an institutional mechanism for realising a green economy in Odisha. Table 2.1 discusses the overarching set of methods leveraged for the study.

Table 2.1 The five steps and rationale to estimate and implement a green economy

Sequential steps	Key question answered	Activities
Identify key green economic sectors relevant to the state.	Which emerging green sectors can Odisha leverage to further jobs, growth, and sustainability?	Identify economic sectors that are green or have the potential for greening.
Selection of value chains under each sector.	Which emerging value chains can Odisha prioritise across the selected green sectors to foster a green economic transition? Which green value chains hold the most potential for scaling up?	Identify a long list of value chains across the three economic sectors. Define and use guiding principles for shortlisting value chains. Delineate segments/activities within the shortlisted green value chains for which jobs and market size will be estimated. Undertake stakeholder consultations to finalise the list of value chains.
Estimate the size of the job, market, and investment opportunities for each value chain.	If Odisha could embrace the green economic sectors, how big would the jobs, market, and investment opportunities be? Are there successful examples of these value chains on the ground?	Establish guiding principles for jobs and market estimation. Leverage secondary data from industry and academic research and publications for estimations. Undertake stakeholder consultations to get data on FTE job factors and demand for jobs and market estimations.
Identify the associated challenges, risks, and mitigation strategies in scaling each of the value chains.	What are the key risks in scaling the value chains? What could be the mitigation strategies? What are the major challenges in scaling the value chains? What could be the mitigation strategies? What could be the role of various government departments and the private sector?	Leverage secondary data from industry and academic research and publications and undertake stakeholder consultations to map challenges. Undertake stakeholder consultations to identify their mitigation strategies. Identify the roles of different stakeholders in mitigating the challenges. Leverage secondary data from industry and academic research and publications to outline the risks associated with scaling. Undertake stakeholder consultations to map the risks associated with scaling a value chain and possible mitigation strategies.
Propose an institutional mechanism to implement a green economy in Odisha.	What is a suitable institutional mechanism to implement the green economy?	Identify the lead and supporting departments for each green value chain. Assess the need for any additional institutional body (and its form) to mainstream a green economy paradigm and its form. Develop a common results framework to map value chain outcomes, outputs, and activities to existing government schemes to enable budgetary convergence and regular monitoring of progress.

Source: Authors' analysis

2.1 Identifying key green economic sectors relevant to Odisha

We selected the green economic sectors considering the following: (i) the growing interest from the private sector in India, ranging from large industries to start-ups, in these sectors; (ii) evolving government policies; (iii) the need to expand climate solutions beyond the ET; (iv) the need to further economic activity across all levels of the economy – from microenterprises to large industries, and from primary to tertiary sectors.

Based on these considerations, we identified three emerging green sectors of the economy: (i) the green ET (henceforth ET); (ii) the CE; and (iii) BE and NbS.

We adopted five key parameters to identify value chains: policy support, natural endowment, supply-side feasibility, the presence of an ecosystem of related goods, and global momentum

2.2 Selecting value chains in each sector

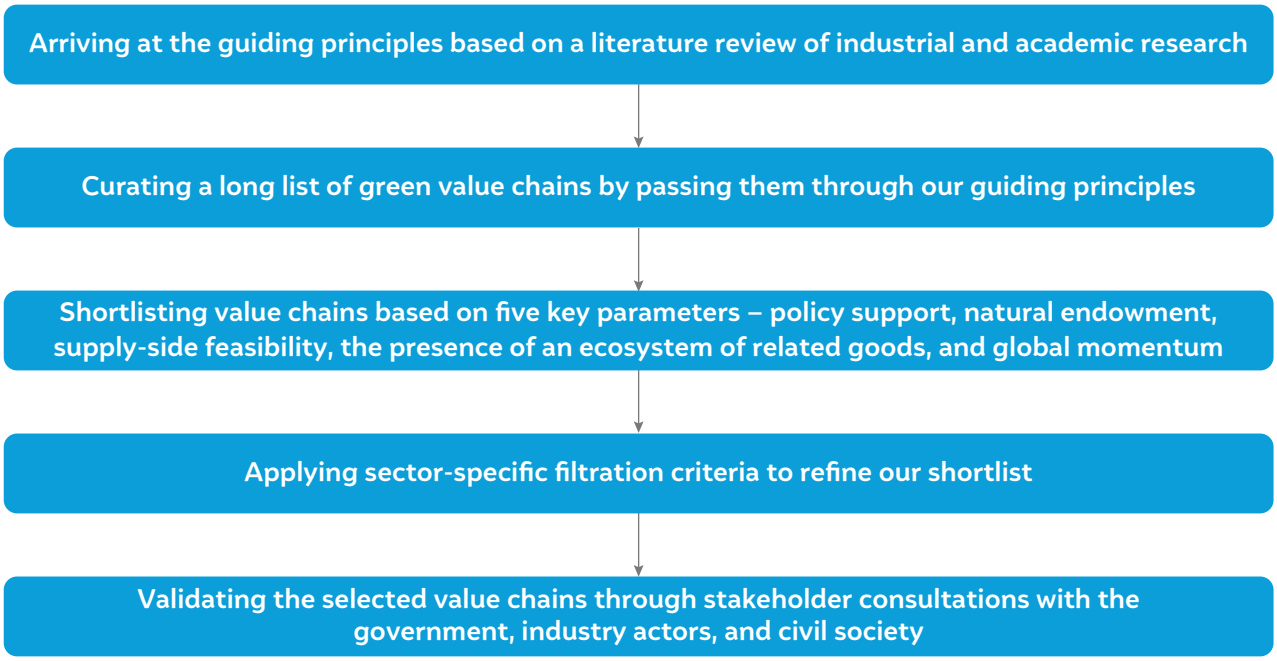
We compiled a comprehensive list of green value chains across the three identified green economic sectors using the following set of guiding principles, informed by our analysis of the existing literature from industry, academic research, and relevant publications:

- **Suitability for Odisha's geographical and resource contexts:** The value chains should be well-suited to Odisha's geography and resources, aiming to create jobs and livelihoods, diversify economic activities, and avoid depleting natural assets.
- **Prioritisation of established value chains:** Focus on value chains that have been proven to be successful, scalable, and replicable and that have been prioritised by the government.
- **Inclusion of emerging high-potential value chains:** Consider value chains with high potential that are less explored or new to Odisha but have been successfully commercialised elsewhere.
- **Avoidance of long-term ecological damage:** Exclude value chains that are likely to cause long-term ecological harm.

After curating a long list of value chains using the guiding principles, we evaluated them based on five key parameters to create an initial shortlist. These parameters included policy support, natural endowment, supply-side feasibility, the presence of an ecosystem of related goods, and global momentum. Additionally, we applied sector-specific filtering criteria to refine our shortlist, recognising that each sector is at a different stage of development and has unique characteristics. For example, in more mature value chains, such as those in the ET sector, we prioritised those with strong policy support, government interest, and established national or sub-national targets. Conversely, for emerging value chains, we focused on those with significant stakeholder engagement and private-sector interest. Further details on these sector-specific filtering criteria are provided in Annexure A.

Finally, we conducted stakeholder convenings and consultations to ascertain that the filtered list of value chains is relevant in Odisha. As part of the stakeholder convening, we hosted a closed-door roundtable with experts from eight civil society organisations (CSOs) in the state, each with many years of experience across various sectors. Through this, we mapped their perceptions on the relevance of the filtered value chains for the state of Odisha. We also held more than 22 rounds of consultations with state officials across several departments. An indicative list of the departments consulted is provided in Annexure B, and the process used to select value chains is illustrated in Figure 2.1.

Figure 2.1 The process we used to select green value chains



Source: Authors' analysis

2.3 Estimating the size of the job, market, and investment opportunities for each value chain

The study focuses on estimating the job, market, and investment (J-M-I) potential of the selected green economic value chains, as determined by the process discussed above in section 2.2. Some key features that inform these estimates are outlined in Box 2.1.

Box 2.1 **Key characteristics of jobs, market, and investment estimated as part of the study**

We account for and estimate **only direct job roles**. Indirect and induced job opportunities created will be discussed wherever possible but are not estimated, to avoid double counting. Furthermore, we calculate cumulative jobs and investment till 2030 (accounting for the seven year period — 2024-30) and market opportunities in 2030.

To determine the J-M-I potential, we adopted a tailored approach for each value chain to ensure robustness, particularly when dealing with both established and emerging sectors. Key factors in formulating these estimates included job factor estimations, industry consultations, and benchmarks from leading regions. We also ensured that projections were aligned with industry norms while allowing flexibility for sectors with varying working patterns or evolving dynamics. In addition, detailed approaches to each value chain estimation are discussed in the document here.

While we employed a nuanced methodology for J-M-I estimations, we also set common considerations applicable to all value chains. These are detailed below:

A. Considerations for jobs estimations

- We estimate jobs to be FTE.

Box 2.2 Formula for FTE job estimation

An FTE job is estimated as the ratio of time an employee spends on a specific task or project during a given year to the standard total working hours for that industry (A. Tyagi et al. 2023).

- For established sectors, we relied on existing FTE job factors (for instance, several value chains within the ET).
- For emerging sectors, we conducted consultations and focus group discussions with industry players to determine the FTE job factors.
- The number of working days for an FTE job may vary by industry. For most value chains, the range is typically between 220 and 300 days. However, for certain value chains within the BE and NbS sectors, the number of working days ranges from 100 to 180 days.
- We estimate jobs till 2030.
- We considered only direct job opportunities to avoid double counting.[5]

B. Considerations for market potential estimation

- We evaluated the business-as-usual (BAU), policy targets, and technical potential of value chains to project an ambitious target for each.
- In addition, the ambitious targets were also benchmarked against the targets of leading states or comparable international geographies.
- Wherever the benchmark did not exist or where Odisha was already ahead of the other states, we undertook consultations with industry experts to estimate the ambitious targets.
- Market size was estimated based on the ambitious targets set for different value chains.
- We estimate market potential in 2030.

2.4 Identifying the associated challenges, risks, and mitigation strategies in scaling each of the value chains

We leveraged an extensive literature review – academic papers, reports, policy documents, and so on as well as stakeholder consultations with government and industry players – to identify the major challenges hindering the scale-up of respective green value chains, the risks in scaling value chains, and the measures that can be used to mitigate these.

When mapping the challenges, we ensured they aligned with the appropriate mitigation strategies. Additionally, we developed a set of categories for mapping challenges, including limited access to affordable financing, lack of investor interest, inadequate policy support, absence of proof of concept and low confidence in viability, and psychological barriers. For instance, to address the challenge of improper maintenance of rooftop solar (RTS) systems, we mapped out the roles of private entities, including developers and channel partners/vendors, alongside government departments. These stakeholders must ensure the development of standard operating procedures (SOPs), provide consumer training, and implement other suitable mechanisms to support the proper maintenance of RTS systems.

Scaling some green value chains carries the risk of negatively impacting biodiversity and causing environmental degradation if resources are overexploited for economic gains or if interventions are not well planned and implemented. For example, inadequately poorly

5 In some cases, indirect jobs in one value chain can be direct jobs in another value chain. In such cases, if we account for indirect jobs, we will end up with double counting.

planned and implemented floating solar can negatively affect marine aquaculture and biodiversity, cause water quality disruptions, and interfere with local transportation and fishing activities. Similarly, scaling biomass-based value chains could lead to an increase in demand for crop residue, potentially driving stakeholders to shift to crops that provide high-volume residue or even use forested land for cultivation. In this study, we have identified these risks and provided some suggestive measures to address them, though we have not outlined comprehensive mitigation strategies for each risk.

The immense potential for a green economy needs a robust and effective institutional mechanism to realise it

2.5 An institutional mechanism for implementing a green economy in the state

The immense potential for a green economy needs a robust and effective institutional mechanism to realise it. Given the need for a whole-of-economy and a whole-of-government approach, it was important for us to identify an institutional mechanism that enables multi-department convergence and coordination.

We first undertook a mandate mapping exercise for each department, to identify the department that could serve as the lead for the promotion of a value chain and all the other departments that will have an allied role. It involved reviewing their core mandate, schemes and policies implemented by them and any recent announcements made by the state government that further signalled their departmental mandate and priorities. Subsequently, the consultations with the state's Chief Secretary and other Principal Secretaries led to the emergence of the idea of developing a secretary-level committee and officers' level sub-committees to oversee the implementation of the Green Odisha Initiative and enable cross-department collaboration. It also emerged from the consultation that there is a need to have secretariat support for the initiative as a Programme Management Unit (PMU) to be housed under the Planning and Convergence Department (P&CD). The PMU would provide secretariat support to the Committee of the Secretaries.

To enable convergence of the existing schemes and programmes towards the Green Odisha Initiative, we looked at the previous examples of useful guiding frameworks enabling such convergence. Based on the past experiences of a common results framework (CRF) for enabling nutrition-related outcomes in the state, our collaborators, Socratus Foundation[6], co-developed a CRF for Green Odisha Initiative.

Further description of the CRF and the roles of the committee and subcommittees can be found in section 4.1 and section 4.2 of this report.

2.6 Limitations

- Since many of the value chains are in their early stages, we had to rely heavily on secondary data and stakeholder interactions for our estimations.
- While our report does not prescribe the specific standards and regulations each sector or value chain should adopt to mitigate risks, it highlights these risks to emphasise the importance of managing them effectively.
- Although we consulted with state departments to understand their priorities and reviewed their mandates, we did not conduct a comprehensive institutional assessment of these departments, which would have included factors such as departmental capacities, vacancy rates, institutional structures (sub-departments and divisions), and operational modes (such as special structures for specific schemes), among others.
- Since we did not conduct an in-depth institutional review of government departments, we do not address implementation challenges. However, these challenges may be included in the Common Results Framework (CRF) by the committee overseeing each value chain.

6 The Socratus Foundation for Collective Wisdom is a think tank based out of Bengaluru with extensive experience of working with state governments in India.

3. Green economic value chains

As mentioned earlier in this report, we have identified three green economic sectors and 28 green value chains within them to mainstream a green economy in Odisha. Here is a brief overview of the three green sectors and the value chains we have selected within each of them:

Energy transition

ET involves adopting essential technologies to shift towards a non-fossil-fuel-based economy. We have identified 14 value chains within ET, including the deployment of RE sources like solar and wind, as well as the manufacturing of critical components needed for these sources. It also encompasses technologies, products, and services aimed at decarbonisation, such as EVs and GH2. Transitioning to greener energy sources has the potential to create significant job opportunities and unlock new markets.

Circular economy

The CE is a system in which materials are never wasted (Ellen MacArthur Foundation n.d.) and natural resources are restored. In this model, products and materials are cycled through processes such as maintenance, reuse, refurbishment, remanufacturing, recycling, and composting. We have identified four key value chains within CE – construction and demolition (C&D) waste, lithium-ion battery (LIB) waste, plastic waste, and electrical and electronic equipment waste (e-waste).

Bio-economy and nature-based solutions

BE is described as an efficient method of transforming and utilising biological resources to generate economic goods, thus fostering revenue growth towards realising a sustainable economy. It encompasses a broad range of value chains, including bio-inputs, biogas, bio-fibres, and bio-packaging. While the BE focuses on product-based industry framing, NbS involve actions like protecting, restoring, or sustainably managing natural ecosystems to create income and job opportunities for local communities. It encompasses value chains such as agroforestry, ecological mangrove restoration, seaweed cultivation, sustainable forest management, and sustainable tourism. Within this combined sector, we have identified 10 value chains, which could contribute to Odisha's green transition.

3.1. Energy transition

The ET sector is a key emerging green sector that can play a substantial role in driving Odisha's economic growth, promoting job-intensive development, ensuring future employment security, and enhancing economic resilience.

Importance of the ET sector for Odisha

India has set an ambitious target of achieving 500 GW of RE by 2030. The ET sector could unlock several new economic opportunities that would facilitate this significant shift. The most promising value chains for Odisha in this sector include the following:

Deployment of RE technologies

utility-scale solar, RTS, floating solar, mini-grids, wind, biomass, and small hydropower (SHP).

Storage technology deployment

pumped storage hydropower and battery energy storage systems (BESS).

Component manufacturing

solar modules, wind components, and batteries.

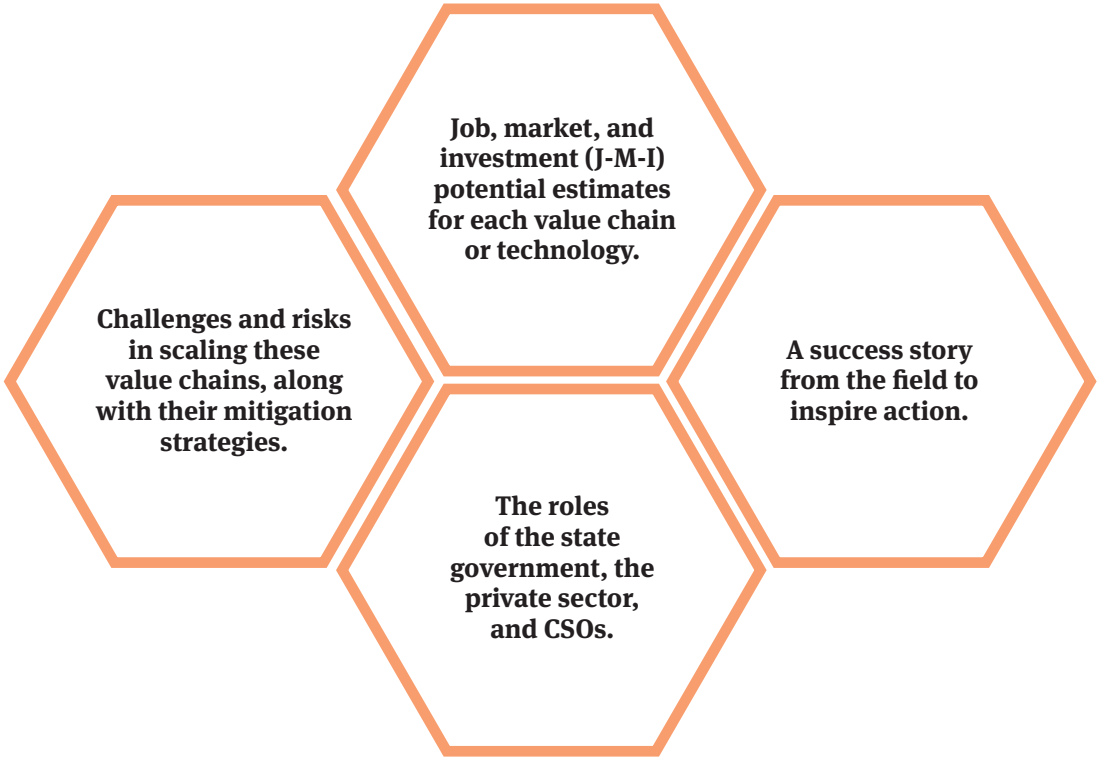
Industrial decarbonisation

GH2 deployment; electrolyser manufacturing; production of two-, three-, and four-wheelers; and the rollout of charging stations.

Decentralised RE for powering livelihoods

decentralised renewable energy (DRE)-powered applications such as bulk milk chillers, cold storage, dryers, grain milling machines, and looms.

For each value chain, we discuss



3.1.1. **Battery energy storage systems**

BESS enables the storage of energy in batteries for later use. Deployment of BESS along with renewable energy (RE) ensures that the excess power generated by RE is stored and used later, thus making RE a reliable source of power and mitigating the impact of its intermittent nature.

Opportunities for 2030

16,000 FTE jobs
against 4,700 MW of BESS deployment and 700 MW battery manufacturing capacity deployment

INR ~600 crore (USD 72 million)**
the estimated market opportunity.

INR ~4,500 crore (USD 540 million)***
the estimated investment opportunity

*Source: *Authors' analysis of A. Tyagi et al. (2023). **Authors' analysis of BloomberNEF (2023). ***Authors' analysis of Warrior et al. (2023)*

Image: Alamy.com (for illustrative purposes only)

Why should Odisha invest in BESS?

To solve the intermittency and variability issues associated with RE.

To reduce the reliance on coal, especially during peak hours.

To prevent failures typically faced by distribution transformers (DT) due to overloading, thereby increasing DT life and deferring large investments on DT augmentation.

To release system congestion by supporting the distribution transformer during peak hours, thus avoiding outages.

To provide better reliability and quality power 24x7 to consumers.

Inspiration from a success story

Tata AutoComp, a vehicle component manufacturer since 1995, has partnered with a Chinese battery manufacturer, Gotion to establish a 9-GWh BESS manufacturing plant (Colthrope 2023). Through such partnerships, the company aims to strengthen its research and development (R&D) in areas such as cell chemistries, recycling, and so on. Key partners include organisations such as the Indian Space Research Organisation (ISRO), the Council of Scientific and Industrial Research–Central Electrochemical Research Institute, and the Centre for Materials for Electronics Technology (C-MET).

Departments that could support in scaling BESS

Department of Energy

Science & Technology Department

Source: Authors' analysis

Overcoming challenges to scale BESS

Technological/technical challenge/s	Proposed interventions
Lack of cost-effective solutions to mitigate the high upfront investment required for setting up Battery Energy Storage Systems (BESS)	The **Department of Energy (DoE)** should facilitate the deployment of BESS by pooling land for developers, ensuring that the time and costs associated with the process are minimised. This would ease the burden on developers and accelerate deployment. The **Industries Department** should enhance the investment climate by providing plug-and-play facilities to battery manufacturers, improving the ease of doing business in the state and encouraging investments in the sector. The **Science and Technology Department (S&TD)** should establish a centre for excellence for research on storage technologies, and various battery chemistries, etc., aimed at achieving greater cost competitiveness through R&D in storage technologies. The **DoE** should also plan to incorporate BESS in grid planning and provide support for ancillary services to signal the state's commitment to BESS deployment. This would convey to investors that the state is serious about the deployment of BESS.

Supply chain-related challenge/s	Proposed interventions
High dependencies on import of input materials and lack of long-term solutions to address import dependencies	The **S&TD**, in collaboration with industry players and international and national institutions, should set up centres of excellence that support material innovations in battery technologies, such as the replacement of critical minerals, when possible. **Industry and private players** should work towards establishing businesses to mine materials from battery waste for reuse in manufacturing (Warrior et al. 2023).
Skill-related challenge/s	**Proposed interventions**
Unavailability of critical talent	The **Odisha Skill Development Authority (OSDA)** should address current skill shortages, particularly in battery manufacturing, by facilitating targeted training programmes. This would involve close collaboration with the private sector to develop a relevant curriculum. Additionally, the OSDA may partner with universities to establish centres of excellence focused on critical technologies for the green transition, such as technologies related to batteries.
Regulatory challenge/s	**Proposed interventions**
Lack of technical and safety standards that are specific to tropical climates	The **DoE** should spearhead efforts along with the **Bureau of Energy Efficiency (BEE)** to institutionalise safety standards for BESS, such as ensuring humidity-free systems during summers and tailoring standards to other typical weather conditions seen in different parts of Odisha and India (WBSCD and IESA 2023).

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of BESS

Post-use batteries and their improper disposal pose environmental risks due to the constituent chemicals leaching into soil and water. While the Battery Waste Management Rules, 2022 exist, a system of responsible recycling industry with processes for monitoring through inspections is required.

3.1.2. **Public charging stations for electric vehicles**

Public charging stations (PCSs) supply electric current to recharge vehicle battery packs in public spaces such as malls, offices, highways, and so on. These facilities are typically provided and operated by public authorities, utilities, charging station operators, fleet operators, and location owners. There are more than 198 PCSs in Odisha (BEE 2024).

Opportunities for 2030[7]

~5,000* FTE jobs
against the deployment of 50,000 chargers

INR ~300 crore (USD 35 million)**
the estimated market opportunity.

INR ~1,600 crore (USD 190 million)***
the estimated investment opportunity

*Source: *Authors' analysis. **Authors' analysis of Niti Aayog, Mop, DST, BEE, WRI (2021) and OERC (2023) ***Authors' analysis of Pulse Energy (2024)*

7 Does not include battery swapping.

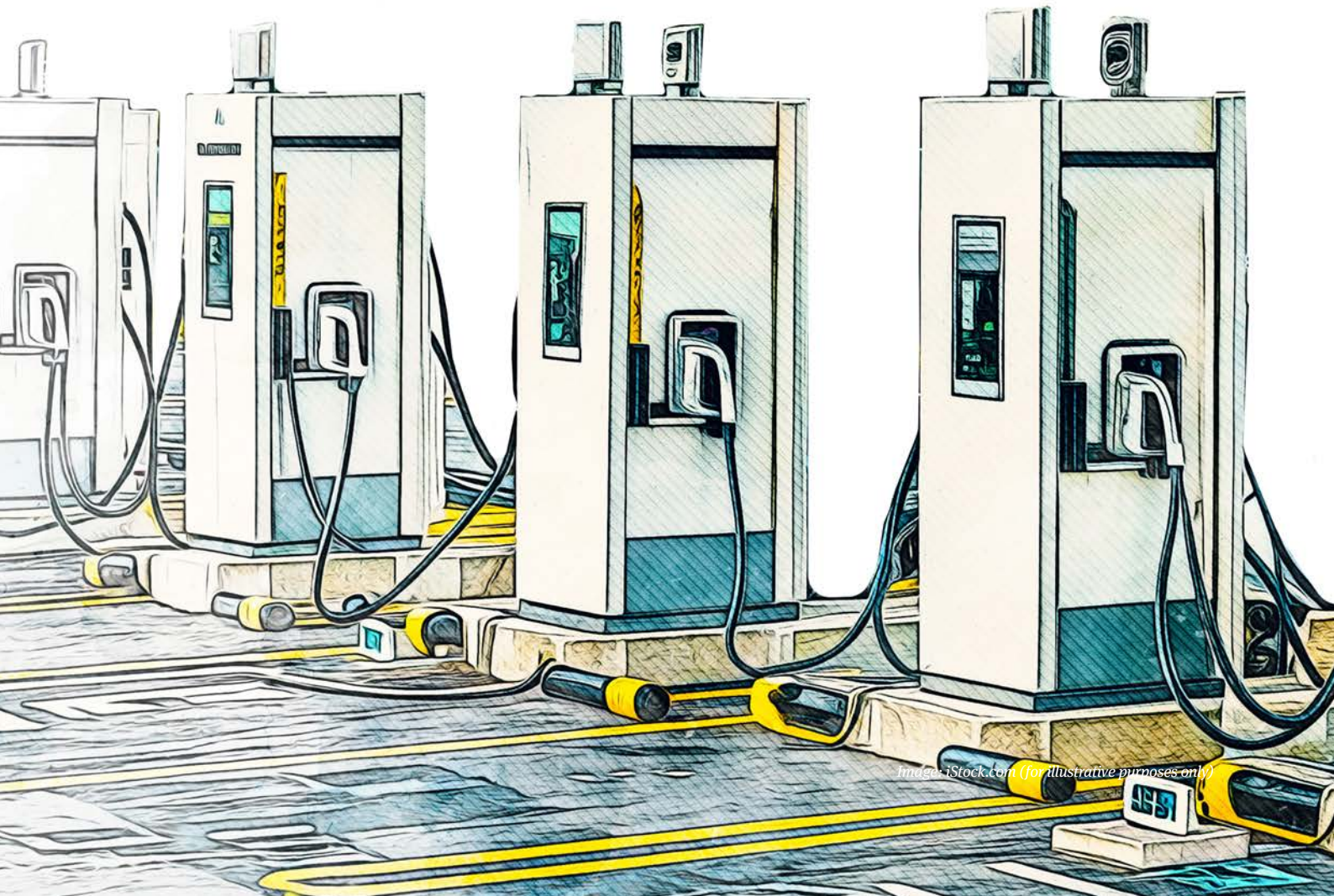


Image: iStock.com (for illustrative purposes only)

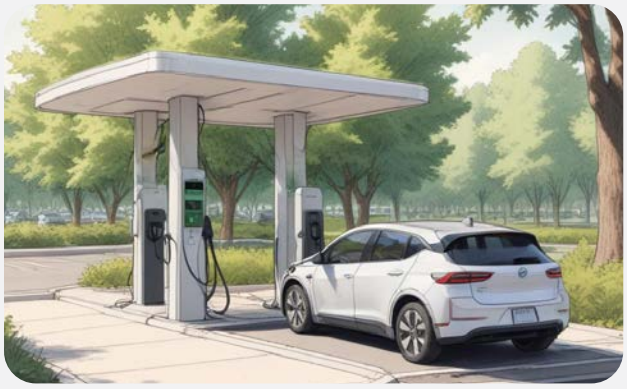
Why should Odisha invest in charging stations?

To enable EV penetration by scaling reliable, accessible, and affordable charging solutions.

To attain the co-benefits of the EV transition, such as lower import dependence and improved air quality in cities.

Inspiration from a success story

Tata Power operates one of India's largest public charging networks, with over 5,300 public charging points across 530 cities. To strategically identify optimum locations to set up charging stations, Tata Power plans to leverage data and insights from over 1.4 lakh EVs throughout India. Similarly, through its partnership with Shell, Tata Power will leverage Shell's existing network of fuel stations to expand its network of charging stations (Nigam 2024).



Departments that could support in scaling public charging infrastructure

- Department of Housing and Urban Development
- Department of Energy
- Commerce and Transport Department

Source: Authors' analysis

Overcoming challenges to scale charging stations

Technological/Technical challenge/s	Proposed interventions
Lack of interoperability resulting in physical and digital infrastructure challenges	The **Engineer in Chief (Electricity) (EIC)**, industry players, and CSOs should collaborate with the BEE to ensure interoperability for seamless EV charging by mandating standard charger types for various vehicle segments. The **EIC** can work closely with the **BEE** and the **DoE** to encourage all players providing charging services to join the app developed by BEE. The **DoE** should facilitate the seamless deployment of charging infrastructure to support grid connections.
Lack of a strong business case for establishing PCS due to low utilisation rates and uncertainty surrounding current and future demand	The **DoE** and the **Commerce and Transport (C&T) Department** should ensure government demand for charging through the procurement of EVs for government services – for example, e-buses. The **EIC**, in collaboration with private players, should address low utilisation rates by promoting EV roaming and interoperability.
Lack of identification of optimal locations for public charging to maximise utilisation	The **C&T Department** and the EIC should periodically evaluate EV volumes on the road to ensure that the need for charging stations on the road is met while infrastructure for future EVs is built. The EIC can encourage charge point operators (CPOs) to digitise charging-related payment processes and share this data with the EIC, facilitating the monitoring of utilisation rates and informing the planning of future PCSs.

Lack of viable options for establishing charging infrastructure in urban areas because of high land leasing costs (Singh et al., 2020)	The **C&T Department** should offer guidance on lease rate calculations for charging infrastructure, along with a cap for rent.[8] Additionally, they can regularly provide data-driven recommendations for optimising the location of charging stations. The **EIC** should also consider undertaking public–private partnerships (PPPs) for establishing public charging infrastructure. For example, the EIC may provide/aggregate land parcels, invite bids from private players, award the tender to those who charge the lowest service fees, and place the responsibility on the concessionaire to build, operate, and maintain the stations. Alternative models, such as service-provider and consumer-driven approaches, should also be considered.
Regulatory/Operational challenge/s	**Proposed interventions**
Lack of efficient processes in establishing PCSs due to time-consuming steps such as securing electricity supply and land-related procedures	The **C&T Department** and the **EIC** should set up single-window clearance for the deployment of charging infrastructure. The EIC may set up a central management system platform for the ease of CPOs as specified in the *Odisha Electric Vehicle Policy, 2021*.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of public charging

As EV penetration grows, there will be additional demand on the grid. To address this, Odisha can begin collecting data on peak charging demand patterns and locations to effectively plan the establishment of EV charging stations in high-demand areas. It can also implement time-of-day tariffs or other mechanisms to nudge charging during non-peak hours.

8 Rent caps may drive up prices, as the lessor may think of it as the best lease price. Having a methodology guides in setting up a lease rate, rather than just quoting the ceiling rate.

3.1.3 Electric vehicles and battery manufacturing

The main Electric Vehicle (EV) components include the battery pack, electric drive, power electronics, and vehicle interface module control (Singh et al., 2020). This analysis only encompasses the manufacturing of batteries, two-wheelers, three-wheelers, and four-wheelers.

Opportunities for 2030

~31,000* FTE jobs
against the manufacturing of 12 lakh units of EVs and 26-GW batteries

INR ~53,000 crore (USD 6,400 million)**
the estimated market opportunity.

INR ~25,000 crore (USD 3,100 million)***
the estimated investment opportunity

*Source: *Authors' analysis. ** Authors' analysis of BloomberNEF (2023). ***Authors' analysis of Singh et al. (2020)*

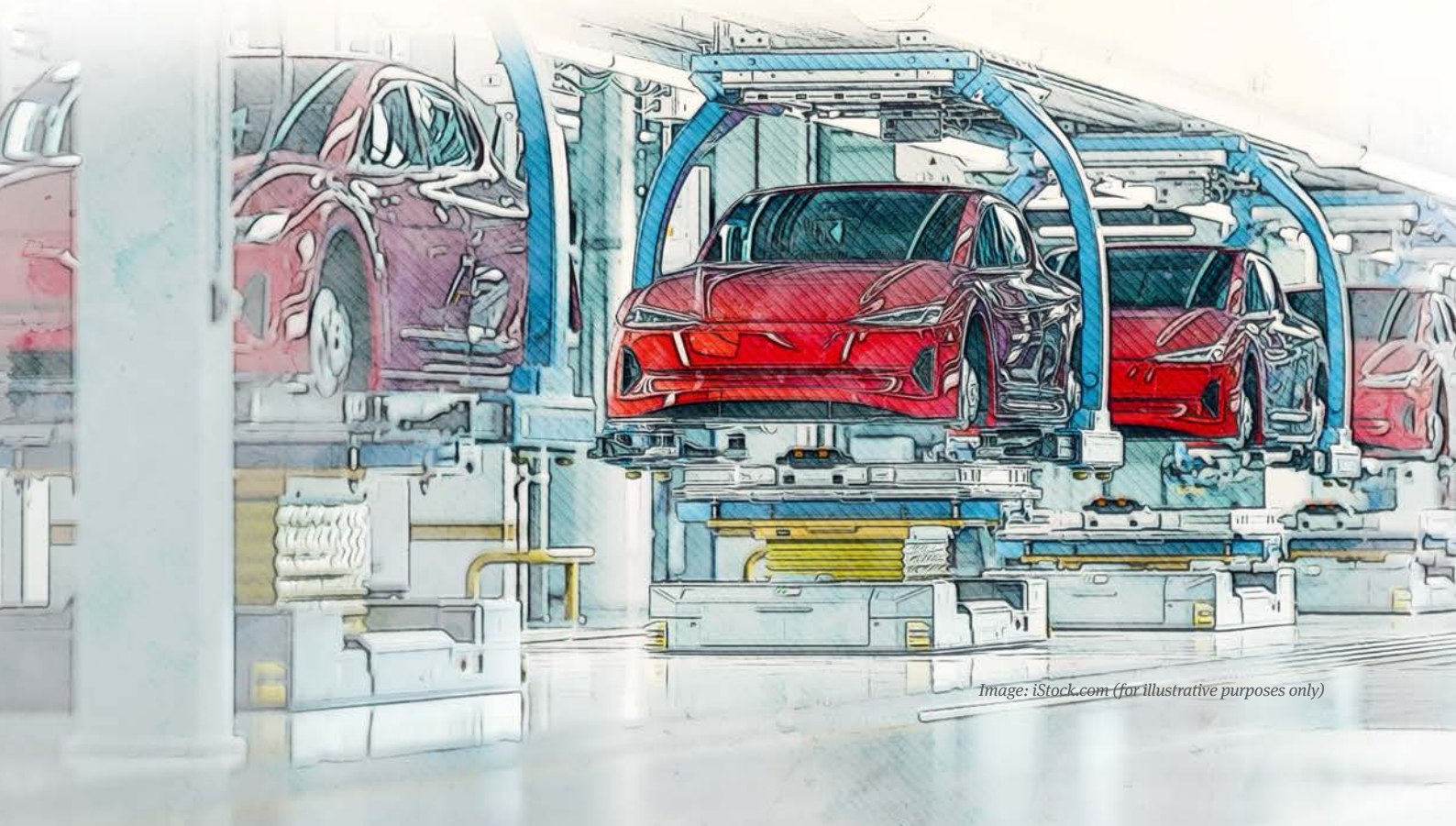


Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in EV and battery manufacturing?

To have economies of aggregation via the rise of towns/cities as manufacturing hubs, leading to economic growth in the surrounding areas, which in turn will lead to the development of economic and industrial clusters.

To encourage the MSME sector to develop a manufacturing ecosystem.

To scale EV demand, thereby leading to better air quality and a decrease in dependence on petrol (Harikumar et al. 2022).

Inspiration from a success story

Nexus Power, an Odisha-based start-up, specialises in manufacturing bio-organic and biodegradable batteries. It plans to transition from prototype testing to commercial-scale production in 2024. These rechargeable batteries use crop residue as their main input material. Nexus Power provides employment to individuals across various functions, including design, procurement, manufacturing, and testing. The company has also leveraged incentives for start-ups at both the central and state levels, such as financial support from the Technology Incubation and Development of Entrepreneurs Scheme (TIDE) (Tripathi 2021).

Departments that could support in scaling EV and battery manufacturing

- Industries Department
- Commerce and Transport Department
- MSME Department
- Skill Development & Technical Education Department
- Department of Housing and Urban Development

Source: Authors' analysis

Overcoming challenges to scale battery and EV manufacturing

Technological/Technical challenge/s	Proposed interventions
Lack of a robust EV manufacturing ecosystem in Odisha, as manufacturers rely heavily on vendors and local producers, operating in a just-in-time assembly/ production model	The **Industries Department** should focus on creating a manufacturing hub by streamlining the process of procuring or leasing land and conducting workshops with original equipment manufacturers (OEM) and other industry players to attract manufacturers to the state. The **MSME Department** should also evaluate the performance of the *Odisha Startup Policy–2016* and make appropriate revisions to the scheme such that there is a focus on making Odisha the start-up capital of India. Further, the **Industries Department**, along with other concerned departments, should offer incentives and create favourable conditions, such as developing plug-and-play services, creating special packages for players with large investment plants, developing Odisha as a hub for R&D in the sector, and establishing the state as a skilled-workforce hub in EV and battery manufacturing.

Lack of R&D infrastructure for advanced cell chemistries and insufficient support to scale prototypes from lab to commercial production	The **Science and Technology Department (S&TD)** should encourage research and provide grants for R&D in battery manufacturing while also promoting indigenisation. This includes developing centres of excellence on advanced battery technologies at universities and institutions. The department, in collaboration with CSOs, can partner with national and international organisations to lead knowledge-sharing by mentoring programmes and workshops. The **MSME Department** can develop a platform to facilitate industry connections and provide additional funds to take battery technology start-ups from lab and prototype development to commercial testing and scaling.
Lack of access to financing for Small and Medium Enterprise (SME) OEMs due to high barriers in the financial landscape	Apart from the benefits offered as part of the *Odisha MSME Development Policy–2022* and the *Odisha Startup Policy–2016*, the **MSME Department,** Odisha may offer a working capital loan guarantee to MSMEs and create or facilitate VC funding for EV SMEs (Singh et al.,2020).
Supply chain–related challenge/s	**Proposed interventions**
Lack of solutions to reduce dependencies and vulnerabilities of the critical mineral supply chain given that they are concentrated in a few geographical regions[9]	The **Science and Technology Department (S&TD)** can promote material innovations through R&D initiatives to reduce/replace the use of critical minerals. **Industry and private players** should tie up with local bodies to source battery waste and develop businesses focused on extracting useful materials from the waste.
Demand-side challenge/s	**Proposed interventions**
Lack of charging infrastructure, high upfront costs, and behavioural barriers present numerous demand-side challenges, preventing manufacturers from viewing Odisha as a significant demand centre	The **C&T Department** should allocate resources for information and communication campaigns to promote EVs. In addition to the existing incentives offered to consumers under the EV policy, the department could also link additional incentives to buying Odisha-manufactured EVs, such as waiving road tax. The department, along with the EIC (electricity), Odisha, may work towards strengthening charging infrastructure through better data collection and planning of charging stations and facilitation of deployment of charging stations through single window clearances, etc.
Skill-related challenge/s	**Proposed interventions**
Unavailability of a skilled workforce, leading to additional time and cost burdens for training new employees	The **OSDA** may facilitate courses in consultation with the industry on current skill needs, such as process engineering, quality control, cell simulation, etc. The **OSDA** can work closely with industry players to identify opportunities for placements and facilitate student and industry interactions.
Regulatory challenge/s	**Proposed interventions**
Unavailability of land and lengthy acquisition process	The **Industries Department** can create plug-and-play facilities for battery manufacturers and publicise manufacturing parks specific to EV manufacturing, such as the National Investment and Manufacturing Zone at Kalinganagar, Jajpur.

Source: Authors' analysis; stakeholder consultation

9 Currently, over 12–60 per cent of the battery value chain is dependent on imports (Warrior et al. 2023).

Risk-proofing the scale-up of battery and EV manufacturing

Transportation of batteries to demand centres poses significant safety hazards if these are not packed and labelled properly (CEEW 2023). Improper disposal of used batteries can lead to environmental risks. Additionally, scaling of EV demand can impact the fuel tax collected by the government. For example, a 30 per cent penetration of EVs in 2030 in Delhi would lead to a 10 per cent reduction in revenues from fuel tax (Harikumar et al. 2022). Increased demand in certain segments such as e-rickshaws could exacerbate urban congestion and battery waste. Short-term solutions could include implementing a congestion tax in certain areas, regulating the number of e-rickshaws, and regulating end-of-life management for conventional lead acid batteries, while long-term ones could include changes in road design. To address environmental concerns, the State Pollution Control Board should oversee compliance with the Battery Waste Management Rules, ensuring producers adhere to proper disposal methods. Additionally, new sources of revenue may need to be explored to offset the revenue loss from fuel tax.

3.1.4. **Biomass to power**

Bioenergy generated from organic waste can generate power through various methods, including the direct combustion of biomass, gasification of biomass into syngas, cogeneration of bagasse or non-bagasse feedstocks, and co-firing biomass pellets in coal power plants. This section emphasises the use of biomass for co-firing in power plants and for combustion to produce power.

Opportunities for 2030

~13,000 FTE jobs
against deployment of pellet manufacturing and ~150 MW biomass to power plants

INR ~2,300 crore (USD 280 million)**
the estimated market opportunity.

INR ~1,400 crore (USD 170 million)***
the estimated investment opportunity

*Source: *Authors' analysis of SCGJ (2020) and IASS, TERI, CEEW, and SCGJ, 2019. **Authors' analysis of IndiaMART n.d ***Authors' analysis of CEA and DEA(2022) and Aggarwal (2023)*

Image: CEEW (for illustrative purposes only)

Why should Odisha invest in biomass power plants and co-firing?

To leverage unused biomass for power, given that Odisha has a net sown area of 35 per cent (Ministry of Agriculture and Farmers Welfare 2023) and generates crop residue of over 3.88 million tonnes annually.[10]

To develop systems of biomass supply and pellet manufacturing to meet the Ministry of Power's mandate of having seven per cent co-firing of biomass pellets in thermal power plants by 2030.

To support grid stability since power from biomass plants can be dispatched on demand.

To provide value for and generate income from surplus crop residue and other waste for farmers.

Inspiration from a success story

The Siltara Industrial Area in Raipur district is becoming a significant hub for biomass power plants. For example, the 20-MW power plant developed by Godawari Power and Ispat Limited (GPIL) helps reduce greenhouse gas (GHG) emissions by more than 1,07,000 tonnes of carbon dioxide each year (Ecologi n.d.). GPIL's power plant uses rice husk as feedstock, which is procured from within a 50 km radius, leading to additional jobs in collection and transportation.

Departments that could support in scaling biomass

Department of Energy

Department of Agriculture and Farmers' Empowerment

Source: Authors' analysis

Overcoming challenges to scale biomass to power and pellet manufacturing

Technological/Technical challenges/s	Proposed interventions
Lack of reliable data on biomass feedstock availability at the district and block levels	The **Department of Agriculture and Farmers' Empowerment (DAFE)** should collate and publish detailed, granular data on biomass surplus, specifying the type of residue (such as rice or any other crop), predicted seasonality, and change in quantity over time. CSOs and ground-level organisations can collaborate with DAFE to assist in collecting and organising this data.
Lack of price stability and inconsistent supply of feedstock makes project planning challenging	**Biomass aggregators and power plants** could establish long-term contracts with predetermined quantity requirements aligned with seasonal availability. This approach would enable better planning and ensure a consistent biomass supply under agreed terms and conditions.

10 Authors' analysis adapted from MNRE and ASCI (2021).

Lack of adequate storage facilities and the high cost of specialised carriages needed for transportation	**Private companies involved in supply chain operations** can identify strategic sites for aggregation and storage facilities based on the availability of crop residue in nearby localities. The **DoE** could support these efforts by developing a holistic scheme for biomass, aimed at strengthening the supply chain through capacity building, including diverse stakeholders, leveraging their expertise, and providing financial assistance on pre-processing, storage, and transportation.
Lack of affordable financing options due to high costs of credit	The **DoE** may work with banks in the state to anchor interest rates for power projects to rates similar to those for other infrastructure or power-producing technologies.
Absence of trading platforms at a regional level increases the costs of coordination and transaction between biomass aggregators, processors, and power project developers	The **DAFE** should actively encourage the development of biomass feedstock markets to ensure a steady supply and facilitate connections between aggregators and buyers. This could be achieved by developing an online platform to link the stakeholders.
Lack of effective maintenance solutions for boilers due to the accumulation of fly ash, sulphur, chlorine, and other deposits on the boiler walls and tubes (CEA 2024)	The **DoE** could publish guidelines for preparing or augmenting equipment to make thermal plants capable of co-firing, to prevent boilers from getting damaged.
Regulatory challenge/s	**Proposed interventions**
Lack of willingness from discoms to sign Power Purchase Agreements (PPAs) with grid-connected bio-power projects due to concerns over high seasonality	The **DAFE** could create an ecosystem of information on biomass availability across seasons by developing a platform for coordination between stakeholders, which would lead to better reliability and prediction of power generation from plants.
Lack of targets in the RE policy for biomass	The **DoE** should publish targets for the use of biomass in the energy sector to signal and provide incentives to stakeholders, such as farmers, supply chain operators, and power producers.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of biomass to power and pellet manufacturing

Scaling biomass would lead to an increase in demand for crop residue, which could incentivise stakeholders to shift to crops that provide high-volume residue or even use forested land for cultivation. Also, while the use of biomass in coal power plants or through direct combustion is less polluting than coal, it still emits pollutants such as nitrous oxide, sulphur oxides, and heavy metals (when input is contaminated) (IEA Bioenergy 2024). To mitigate the risk of pollution, the State Pollution Control Board (SPCB) can provide financial assistance to purchase and install air pollution control devices.

3.1.5. **Green hydrogen and electrolyser manufacturing**[11]

GH2 is hydrogen produced through the electrolysis of water, which is powered by RE or biomass with carbon capture, thus yielding no carbon emissions (Jain, Ghosh, and Chhabra 2021). Electrolysers, using electricity generated from RE, split water into oxygen and hydrogen (IEA 2024). GH2 has diverse applications, including in refineries for desulphurisation, ammonia production, steel and cement manufacturing, transportation, and energy storage; it is also blended with natural gas in city gas pipelines. Odisha is 1 of 10 clusters identified by the Indian government as having a high GH2 potential (Goswami 2022). Similarly, one of the four upcoming GH2 valley projects identified for government funding is situated in Bhubaneswar (Koundal 2024).

Opportunities for 2030

65,000* FTE jobs
against ~1 MMTPA deployment and ~ 1 GW electrolyser manufacturing

INR ~40,000 crore (USD 4,900 million)**
the estimated market opportunity.

INR ~57,000 crore (USD 6,900 million)***
the estimated investment opportunity

*Source: *Authors' analysis. **Authors' analysis based on stakeholder consultations and Biswas et al. (2020).***Stakeholder consultations*

11 While green hydrogen deployment is a service/product and electrolyser manufacturing is core manufacturing, the two have been presented together as they are upstream and midstream of green hydrogen production.

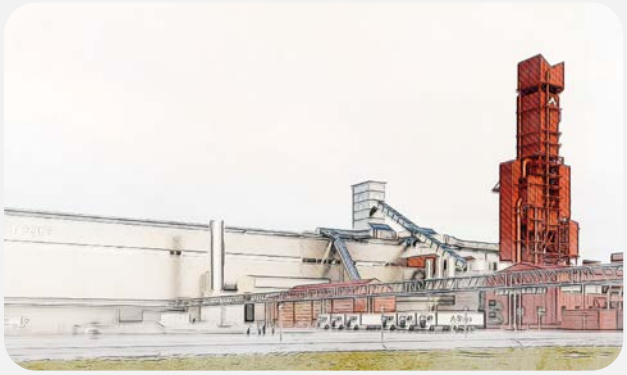
Why should Odisha invest in GH2 deployment and electrolyser manufacturing?

To prepare for the European Union's Carbon Border Adjustment Mechanism (CBAM), which will impact exports in key sectors like iron and steel, hydrogen, cement, aluminium, fertilisers, and electricity—critical to Odisha's economy—these industries must transition towards green hydrogen (GH2) or adopt other emission offset measures.

To leverage existing port infrastructure that has access to eastern markets such as Japan, South Korea, and Southeast Asia.

Inspiration from a success story

Stegra, a Swedish company, is targeting the production of 5 million tonnes per annum (MTPA) of green steel by 2026, with an investment of USD 1.6 billion. The plant is in northern Sweden, and this location was chosen for its access to RE and the availability of high-quality iron ore. By using GH2 instead of coal, the plant reduces carbon emissions by 95 per cent. Contracts for green steel are priced 20–30 per cent higher than those for fossil fuel-based steel (Reuters 2023), indicating that some companies are willing to pay a green premium[12] (Strega, 2023).



Departments that could support in scaling green hydrogen and electrolyser manufacturing

- Industries Department
- Department of Energy
- Ministry of Ports, Shipping and Waterways
- Department in sectors that may impact demand for GH2 - Department of Steel and Mines, Fertilisers

Source: Authors' analysis

Overcoming challenges to scale GH2 and electrolyser manufacturing

Technological/ Technical challenge/s	Proposed interventions
Limited offtake due to the high cost of green hydrogen (GH2), which ranges between USD 4.10/kg and USD 7/ kg, compared to natural gas-based hydrogen priced below USD 4/kg (Raj et al. 2022)	The **Industries Department** may reduce costs for GH2 developers by developing common infrastructure such as common storage tanks and service hubs providing spares, consumables, evacuation infrastructure, etc. in GH2 clusters. The **Industries Department** may provide plug-and-play services for electrolyser manufacturers, which may attract manufacturers to the state and aid in the cost reduction of electrolysers. The **DoE** may work towards attracting developers to deploy round-the-clock (RTC) RE in Odisha by pooling land and facilitating the deployment process. The **DoE** may work towards providing low-cost RE by creating a supportive power banking framework and providing low-cost open-access electricity (CFLI India & CEEW 2024). **Financiers and state government banks** may consider providing low-cost loans to GH2 pilots and projects.

12 This is because companies have sustainability targets or promises to customers – for example, one of the buyers of green steel, the Purmo Group, aims to be net zero by 2030.

Lack of established standards for hydrogen transport through pipelines, fuel cell modules, and refuelling stations, as well as gaps in standards for storage, transportation, application, and dispensation (Sripathy et al. 2023)	The **Industries Department**, in collaboration with GH2 producers, may work with the Bureau of Indian Standards (BIS) to develop standards or adopt international standards. The department may also work with the central government for certification of GH2, to develop confidence in buyers.
Supply chain–related challenge/s	**Proposed interventions**
Lack of domestic production for critical components such as membranes, electrolytes, and storage cylinders for manufacturing electrolysers leading to high import dependence	The **Science and Technology Department (S&TD)** should leverage its technical institutions and universities to develop centres of excellence and lead national and international partnerships in knowledge sharing to build technical know-how and spur innovation in components manufacturing. The **Industries Department**, by working with industry associations and the central government may plan for a self-sustained indigenised electrolyser manufacturing ecosystem after the completion of current schemes targeted towards indigenisation.
High import dependencies due to the concentration of essential minerals like nickel, platinum, and rare earth metals in countries such as China, DRC, Australia, Indonesia, South Africa, Chile, and Peru (CEEW 2023)	The **Industries Department**, by working with industry associations and the central government, may lead alliance-building to ensure the availability and unhindered procurement of these minerals. The department along with the **S&TD** may also start discussions and dialogues on the recycling of electrolysers and material recovery. The **Department of Steel and Mines** should take stock of the minerals found in Odisha that can be processed and used for the ET.
Regulatory challenge/s	**Proposed interventions**
Lack of long-term contracts and fixed-price offtake contracts makes the GH2 business highly risky for developers	The **Department of Steel and Mines** and the **DAFE** should mandate the use of GH2[13] and set up a roadmap to transition.
Lack of policy and signalling to other players apart from developers in the GH2 ecosystem	The **Industries Department** should draft a GH2 policy, covering all players in the ecosystem, such as electrolyser manufacturers, fuel cell manufacturers, GH2 refuelling, etc., and also outline the available incentives and exemptions and showcase policy stability to attract investment.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of GH2

According to the International Energy Agency (IEA), nine litres of water are required to produce one kilogram of GH2.[14] Taking this into consideration, water-scarce districts may be avoided for setting up GH2 manufacturing.

13 According to a CEEW study (Yadav et al. 2021), blending of up to nine per cent of green hydrogen is currently competitive when compared to upper-range blast furnace steel-making costs.

14 This is an estimate for de-ionised water. Industry consultations have also mentioned this number reached 25 litres per kg of GH2 produced if raw water/potable water is used.

3.1.6 **Rooftop solar**

RTS consists of photovoltaic panels installed on the roofs of buildings. India has 12.5 GW of RTS installed, which is ~six per cent of the total RE installed (MNRE 2024). The current installed capacity in Odisha is 48 MW.

Opportunities for 2030

~26,000* FTE jobs
against 1,200 MW of RTS deployment

INR ~400 crore (USD 50 million)**
the estimated market opportunity.

INR ~4,500 crore (USD 550 million)**
the estimated investment opportunity

*Source: *Authors' analysis of Kuldeep et al. (2017). **Authors' analysis*

Why should Odisha invest in rooftop solar?

To better manage daytime peak load, avoid transmission charges, decongest the grid, and contribute to renewable purchase obligation (RPO) targets.

To reduce fiscal burden, as the state government will no longer be required to provide electricity subsidies to consumers.

To leverage existing roof space, especially in cities and urban areas.

To reduce electricity bills for consumers.

To minimise the impact of outages by using RTS along with battery storage.

Inspiration from a success story

An evaluation of the performance of RTS systems by the Council on Energy, Environment and Water (CEEW), BSES Yamuna Power Limited (BYPL), and PV Diagnostic found that proper maintenance and cleaning were critical in ensuring performance, with improvements of at least 10 per cent observed, leading to prosumer savings (B. Tyagi et al. 2023). The study, which involved desk research and site visits, identified hotspots, visible trails, and cracks as key reasons for underperformance. Additional issues included shadows cast by nearby objects, deposition of dust, and bird droppings, which obstructed sunlight.

Departments that could support in scaling rooftop solar

Department of Energy

Source: Stakeholder consultation

Overcoming challenges to scale RTS

Technological/Technical challenge/s	Proposed interventions
Lack of a grievance redressal mechanism by discoms, unavailability of a system to track the status of applications and delayed installation of net metering	The **DoE** should frequently convene with discoms to ensure their role in promoting RTS in Odisha, focusing on raising awareness and setting targets. **Distribution companies (discoms)** could establish a dedicated RTS cell to assist with application tracking, grievance redressal, etc.
Lack of affordability in the residential segment due to high upfront capital investment costs, even with subsidies	The **DoE**, in collaboration with financial institutions, should develop affordable financial solutions for solar installations. This could include dedicated solar loans, reduced interest rates, lines of credit, and user-friendly non-bank financial apps.

Lack of proper maintenance for the RTS system, resulting in damage and underperformance	**Private players, including developers and channel partners/vendors,** should conduct annual check-ups of RTS systems and provide consumers with guidance on proper maintenance. The **DoE** should create a mechanism or use existing platforms to collect information and evaluate vendors. **Developers** should establish SOPs, especially for operations and maintenance (O&M), for vendors to follow to minimise damage and ensure the longevity of RTS systems.
Regulatory challenge/s	**Proposed interventions**
Lack of targets to scale RTS in Odisha	The **DoE** should collaboratively set targets – either annually or every five years – following the state RE policy. This will help measure targets and set ambitious goals, signalling a supportive environment for the industry and vendors.
Lack of awareness among residential consumers; only 68 per cent of consumers in urban areas and 48 per cent of consumers in rural areas know about solar home systems (Zachariah et al., 2023)	The **DoE**, in partnership with **CSOs**, should conduct awareness campaigns about the subsidies available and the benefits of RTS. **Discoms** can enhance the credibility of these campaigns through methods such as SMS outreach and lending their name and support to CSOs. The **DoE** could develop a one-stop platform with information for consumers – from low-energy users to commercial and industrial (C&I) consumers – with easy-to-access, reliable, and compelling information about various business models and available subsidies as well as other credible information. The **DoE** should target new consumer segments, particularly large C&I consumers and residential societies, to promote the uptake of RTS through demand aggregation campaigns.
Lack of incentives for consumers to transition to rooftop solar (RTS) due to subsidies on grid-based electricity	The **DoE** may introduce attractive feed-in tariffs for RTS, incentivising consumers to generate electricity and contribute to decarbonising the power sector.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of RTS

Solar waste, resulting from end-of-life panels or damage during maintenance, poses significant waste management risks if not properly addressed. As of now, the 66.7-GW installed solar capacity (utility and rooftop) has generated 100 kilo-tonnes of waste (MNRE and CEEW 2024). The collection and extraction of materials from this waste presents a business opportunity and should be incentivised through pilot projects, viability gap funding, or financial assistance. Similarly, academic institutions should research technologies to manage solar waste and develop innovative methods for material extraction from panels.

3.1.7 Floating solar photovoltaic (FSPV)

FSPVs, or floatovoltaics, are solar photovoltaic (PV) systems installed on water bodies like reservoirs and industrial ponds. Odisha has the third-highest FSPV potential in India, estimated at 21 GW (STAAI n.d.).

Opportunities for 2030

~17,000* FTE jobs
against 5,000 MW of FSPV deployment

INR 3,200 crore (USD 390 million)**
the estimated market opportunity.

INR 31,000 crore (USD 3,800 million)**
the estimated investment opportunity

*Source: *Authors' analysis of Tyagi et al. (2021a). **Authors' analysis.*

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in FSPV?

To leverage the existing infrastructure of 1.8 lakh water bodies (Irrigation census n.d.) and hydropower evacuation infrastructure.

To overcome issues of land acquisition and scarcity as FSPV is land-neutral.

To overcome the intermittency of RE by utilising existing infrastructure to store excess solar energy generated during the day. This can be done by co-locating FSPV systems with hydropower plants. The excess energy generated can be used during non-solar hours (Acharya and Devraj 2019).

To enable water conservation, as FSPV saves 90 per cent of water covered by the platform from being lost due to evaporation (Ravichandran and Ravichandran 2021).

Inspiration from a success story

Sembcorp's 60-MWp FSPV solar farm on the Tengeh Reservoir, spanning 45 hectares, powers five water treatment plants, making Singapore one of the few countries with a completely green waterworks system (World Bank n.d.(a)). During the development of the Sembcorp plant, special attention was paid to minimising its impact on the reservoir's ecology and quality of water. This included placing floats with adequate gaps between them to ensure that oxygen and sunlight reached aquatic life, deploying aerators to ensure proper airflow, and using durable, UV and corrosion-resistant materials to prevent rapid degradation of the floats (World Bank n.d.(b)).

Departments that could support in scaling floating solar

- Department of Energy
- Grid Corporation of Odisha
- Odisha Hydro Power Corporation
- Department of Water Resources
- Skill Development and Technical Education Department
- Odisha Electricity Regulatory Commission
- Fisheries and Animal Resources Development Department
- Industries Department

Source: Authors' analysis

Overcoming challenges to scale FSPV

Technological/Technical challenge/s	Proposed interventions
Lack of affordability in floating solar technology, which is 7–10 per cent more expensive than ground-mounted solar options (Jha 2023)	The **DoE** could offer financial incentives such as (i) a technology fund to encourage R&D among developers to reduce costs (STAAI 2024), (ii) generation-based incentives or equivalent to promote initial adoption, and (iii) higher clearing tariffs to enhance project viability. The **DoE** may also aggregate demand (combine identified sites in one tender) during tendering, enabling developers to benefit from economies of scale.
Lack of bathymetric/hydrographic surveys to understand the topography of waterbeds poses challenges in identifying FSPV installation sites and designing systems	The **Department of Water Resources**, in collaboration with the **DoE** and the **Fisheries and Animal Resources Development Department,** could conduct these surveys to identify relevant sites for FSPV installation.

Loss of livelihood and biodiversity associated with water bodies	The **DoE** should encourage developers to conduct environmental and social impact assessments during the project planning stage and prepare plans to mitigate any associated risks. **CSOs** may assist **developers** in designing these mitigation plans, ensuring that the strategies address risks faced by all sections of the community.
Lack of standards for PV modules used in floating solar photovoltaic (FSPV) plants that address the challenges posed by high humidity conditions	The **DoE** should coordinate with the **Ministry of New and Renewable Energy (MNRE)** to implement standards for PV modules used in FSPV plants, ensuring that they are corrosion-resistant.
Skill-related challenge/s	**Proposed interventions**
Lack of highly skilled individuals in areas such as hydraulics and marine architecture	The **OSDA** could implement training programmes in hydraulics, marine architecture, and the manufacturing of floats in consultation with industry players. **Developers** need to engage closely with the OSDA to share job potential, map skilling gaps, and design skilling programmes.
Lack of simplified operations and maintenance (O&M) processes for FSPV systems, which require frequent inspections	The **OSDA** could conduct courses on O&M-specific skills like diving and disseminate know-how related to FSPV equipment, etc. **CSOs** can coordinate with the OSDA to facilitate the training of local individuals for jobs in the sector.
Regulatory challenge/s	**Proposed interventions**
Absence of deployment targets and need for periodic ambition-setting	The **DoE** and **GRIDCO** could establish periodic targets for FSPV, supported by the **Odisha Hydro Power Corporation (OHPC).** This approach would signal a strong commitment to the industry, especially for developers and manufacturers, while ensuring a consistent deployment trajectory. **Manufacturers** need to invest in R&D and the production of FSPV components, such as supporting structures and PV modules, to build indigenous capacity, and lower costs. **CSOs** can enable the development of local industries and boost the manufacturing of supporting structures by facilitating access to finance and credit, etc.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of FSPV

Floating solar installations may negatively impact marine aquaculture, biodiversity, and water quality due to variations in oxygen levels. They can also interfere with local transportation and fishing activities. To mitigate these effects, continuous monitoring of microbiological parameters, algal composition, oxygen levels, and other chemical parameters is essential. Ensuring proper spacing between solar panels will allow sunlight and oxygen to reach aquatic life (Mathijssen et al. 2020). Additionally, conducting social impact assessments prior to site identification is critical to minimise disruptions to the livelihoods of local communities.

3.1.8 Solar mini/micro-grid

Mini/micro-grids are decentralised energy generation systems that can power homes, businesses, and so on. They could be off-grid systems with batteries, or they could be connected to the grid. Because generation is at the source of consumption, they provide reliable electricity to nearby connected areas.

Opportunities for 2030

~82,000* FTE jobs
against 720 MW of mini-grid deployment

INR 800 crore (USD 100 million)**
the estimated market opportunity.

INR 21,000 crore (USD 2,500 million)***
the estimated investment opportunity

*Source: *Authors' analysis of Joshi et al. (2021). **Authors' analysis. ***Authors' analysis of Das et al. (2019)*

Why should Odisha invest in mini/micro-grids?

To enhance access to reliable electricity especially in remote areas, provide high-quality electricity, and increase efficiency (Graber et al. 2019).

To generate direct and productive use jobs, reduce transmission losses to remote areas, and improve access to information and opportunities (MNRE and ISA 2024).

To stimulate rural economies by offering alternative livelihood options via productive use of appliances.

To complement national electrification efforts, offer decentralised solutions in urban areas, democratise the grid, and aid India's decarbonisation goals.

Inspiration from a success story

Mlinda, a DRE provider in Jharkhand, has successfully implemented a business model that expands beyond distribution and transmission by focusing on capacity-building initiatives. It aids its members in purchasing energy-efficient appliances and offers microfinance to purchase appliances such as rice hullers and millers, which help boost productive use loads and generate entrepreneurial opportunities (VoisPlanet 2022). The company has successfully implemented and managed mini-grids in 45 villages, impacting 7,000 households, providing electricity to 35,000 to 40,000 individuals, and generating around 986 jobs between 2016 and 2020, averaging 15 to 28 jobs for each mini-grid (Joshi et al. 2021).

Departments that could support in scaling solar mini/micro-grid

- Department of Energy
- Odisha Renewable Energy Development Agency
- Skill Development and Technical Education Department

Source: Authors' analysis

Overcoming challenges to scale mini-/micro-grid deployment

Cost-related challenge/s	Proposed interventions
Lack of self-sustaining models of mini-grid deployment due to high capex costs resulting in uncompetitive tariffs[15]	The **Odisha Renewable Energy Development Agency (OREDA)** could enable last-mile financing options by offering low-interest loans and subsidies. **International and national financiers** can provide flexible credit options to communities, helping them cover the upfront costs of associated productive use of electricity (PUE) appliances.

15 Energy charges vary across different states and different locations within the same state, and power from mini grids is approximately three to seven times more expensive than grid power (VoisPlanet 2022).

Lack of financing options due to unfavourable risk-return profiles, small investment volumes, and absence of appropriate financing structures	**Local non-governmental organisations (NGOs), non-banking financial companies (NBFCs), and microfinance institutions** may offer innovative solutions like dealer credit, pay-as-you-go models, etc. The **private sector and academic institutions** should undertake R&D for technology upgradation and lowering of costs, supported by incentives for R&D by the **OREDA.** **CSOs** may undertake demand aggregation and bundling of projects to increase market size and make it more financially viable. They may also mobilise finance and facilitate discussions between communities, financiers, and developers.
Regulatory challenge/s	**Proposed interventions**
Lack of regulation in the mini-grid ecosystem, leading to non-uniform tariff structures, determined by developers	The **OERC** may provide a regulatory framework with clear entry and exit policies, offer flexible and simplified procedures for a business set-up (Bhattacharyya and Palit 2016), and try to achieve parity of tariffs for electricity with the central grid. This will help the long-term business viability of mini-grids and aid in their adoption in rural and urban areas
Skill-related challenge/s	**Proposed interventions**
Lack of skilled personnel to effectively manage the system as well as undertake grid maintenance	**Developers aided by the OSDA** may undertake skilling at the local level to manage and maintain the system. Further, for successful implementation, the **implementing agency (developers, CSOs, etc.)** should undertake technical maintenance–related skilling, such as demand forecasting, load balancing, etc., and delegate other maintenance to locals. This can include collecting payments, electrical skill–related jobs, maintaining energy demand, etc. In the long term, the locals can also be trained in technical skills and independently manage the system.
Lack of technical capacity at different levels of implementation	The **OREDA** should undertake internal capacity-building to improve the governance structure for mini-grids. Additionally, **developers** should ensure capacity-building at the implementation level and train staff, technicians, and local community members in the effective management of mini-grids.
Local context-related challenge/s	**Proposed interventions**
Difficulty in aligning community interests makes it challenging to cater to community needs	**CSOs** should play a crucial role in connecting the system to address local development needs. Further, via last-mile financing offered by financiers, NBFCs, etc., CSOs can help unlock the full potential of the productive use of electricity. They can also play an important role in navigating social and economic hierarchies in cases of demand aggregation for higher financial viability. Additionally, the **implementing agency** should undertake efficient demand forecasting to ensure the reliability of supply.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of mini/microgrids

In grid-connected mini/micro-grids, several risks arise, including uncertainties related to strengthening grids in remote areas and maintaining grids in coastal areas prone to high rainfall, monsoons, or cyclone damage. Further, scaling mini/micro grids poses an environmental risk due to the accumulation of PV module waste; by 2050, India is projected to generate 19,000 kilotonnes of such waste (MNRE and CEEW 2024). To mitigate grid-related risks, investing in local skills and capacity building for grid maintenance is essential, along with targeted plans to strengthen grids in remote areas. To address environmental risks, proper management and recycling of PV modules is critical, with an emphasis on research and investment in recycling technologies (Tyagi et al. 2021b).

3.1.9 Pumped storage hydropower (PSH)

Pumped storage hydro is a type of hydroelectric energy storage that generates electricity using water previously pumped from a source at a lower level to a reservoir at a higher level. As the dominant form of energy storage technology, it accounts for ~95 per cent of global utility storage (MOP 2023). India has a potential of 103 GW, and Odisha, with its abundant water bodies and reservoirs, can harness this large-scale storage technology to meet long-duration storage requirements (Kumar 2022).

Opportunities for 2030

~3,300* FTE jobs
against 3,790 MW of mini-grid deployment

INR 6,200 crore (USD 750 million)**
the estimated market opportunity.

INR 19,000 crore (USD 2,300 million)**
the estimated investment opportunity

*Source: *Authors' analysis of IASS, TERI, CEEW, and SCGJ, 2019.**Authors' analysis*

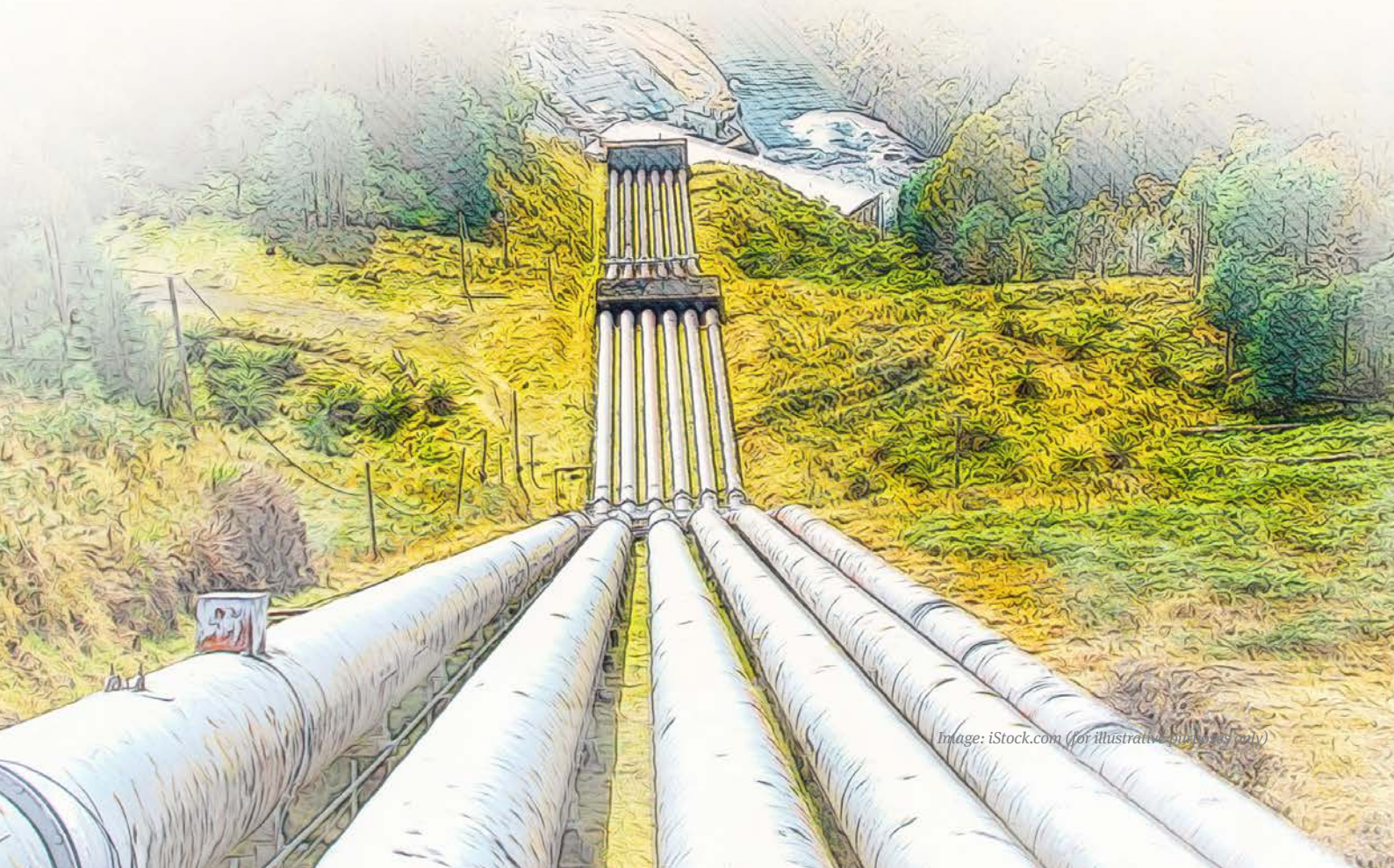


Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in pumped storage hydro?

To enable the rapid rise of variable wind and solar power by providing large-scale storage. PSH provides the largest and most mature form of energy storage compared to other energy storage devices (Koohi-Fayeh and Rosen 2020).

To support grid operations and enable grid balancing by providing services such as peak-load shaving, high ramping capability, round-the-clock support, as well as other ancillary services, such as voltage support and maintaining grid frequency (CSTEP 2021).

To enable local area development via the improvement of infrastructure, generation of job opportunities, arresting of migration, and so on.

Inspiration from a success story

Snowy 2.0 in Australia is the first 2-GW off-river system (Snowy Hydro 2024) which connects two existing dams and provides flexible, on-demand power while recycling water in a 'closed loop'. The project involves linking two existing dams, Tantangara and Talbingo, through 27 km of tunnels and building a new underground power station. It is expected to create ~4,000 direct jobs (Snowy Hydro n.d.) during its lifetime and has lower flood mitigation costs compared to river-based systems (Blakers et al. 2021). In India, all existing PSH systems are 'open loop' and significantly impact biodiversity and river ecology. Odisha, with over 200 large dams, (Government of Odisha n.d.b.) has the potential to pilot an off-river (closed-loop) PSH.

Departments that could support in scaling pumped storage hydro

- Department of Energy
- Odisha Hydro Power Corporation
- Department of Water Resources
- Skill Development and Technical Education Department
- Odisha Power Transmission Corporation Limited
- Odisha Electricity Regulatory Commission

Source: Authors' analysis

Overcoming challenges to scale pumped storage hydro

Land-related and social challenge/s	Proposed interventions
Lack of feasible land acquisition possibilities (Meghalaya Monitor, 2024) for deploying pumped storage hydropower (PSH), particularly in sensitive forest areas, which necessitates the resettlement and rehabilitation of local communities	The **OHPC** could minimise local opposition and reduce time and cost overruns by ensuring proper project siting, which includes conducting impact assessments on site characteristics, natural reserves, and community dependence. This should be accompanied by the creation of strategic mitigation plans through active engagement with local communities. **Local government bodies, such as gram panchayats and CSOs**, can facilitate knowledge dissemination regarding project specifics, completion dates, and benefits, as a lack of awareness is a major cause of local conflict. Further, developers should investigate rehabilitation and resettlement measures, which should be tailored to the land and ecological context, with the assistance of these local bodies and prepare mitigation strategies collaboratively.

Infrastructure-related challenge/s	Proposed interventions
Absence of roads and transmission lines is a critical technical barrier leading to delays in PSH development	The **OHPC** could work closely with the **Odisha Power Transmission Corporation Limited (OPTCL)** to develop transmission infrastructure in and around sites with technical potential. The **OHPC** could also assess all existing hydro projects, including run-of-the-river and storage dams, for PSH potential. This approach would minimise resettlement-related issues and ensure connectivity, etc. (Shankar et al. 2023). The **OHPC** could partner with the state **Rural Development Department**, in collaboration with **local gram panchayats**, to enhance road infrastructure to improve connectivity.
Technological/ technical challenge/s	**Proposed interventions**
Lack of technical research on various models of pumped storage hydropower (PSH) preventing India from utilising newer and more efficient technologies, such as closed-loop systems	The **private sector** needs to invest in R&D to reduce the environmental and social footprint of PSH. The **DoE** could also actively collaborate with **academic institutions, think tanks, and the private sector** to promote research and innovation as a part of the Renewable Energy Research Institute outlined in the *Odisha Renewable Energy Policy, 2022*.
Skill-related challenge/s	**Proposed interventions**
Lack of a readily available local skilled workforce	The **OHPC** could enlist help from the **OSDA** to formally skill local individuals in operations, maintenance, testing and quality assurance, etc. Current training centres established on-site can be utilised to upskill individuals to manage the complex equipment used in PSH.
Cost-related challenge/s	**Proposed interventions**
Lack of affordable technology due to high upfront investment costs and a long gestation period	The **OERC** could work closely with **academic institutions and the private sector** to develop viable financial models, deploy different pricing mechanisms during peak and off-peak periods to ensure profitability and assess potential integration with the national grid.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of PSH

Environmental risks include water loss, degradation of water quality, oxygen depletion, and threats to biodiversity due to disruptions in river ecosystems (Ali et al. 2021; Lu et al. 2018; Lu et al. 2020). Further, technological improvements and fluctuations in electricity prices pose financial risks (Wilson 2020). To mitigate environmental risks, it is essential to conduct comprehensive hydrological studies to identify reliable water resources and implement effective water management strategies, including inflow forecasting, reservoir management, and so on. Technological and financial risk mitigation can be done via PPAs, focusing especially on critical components such as turbines, generators, and control systems and utilising market hedging instruments.

3.1.10 Renewable energy equipment manufacturing

The RE equipments covered here includes solar modules and wind components, including nacelles, blades, towers, and monitor and hub systems. Odisha is the largest producer of aluminium, steel, and stainless steel in India, which are key raw materials for wind components and solar modules. By integrating these base metal industries with a strong downstream sector in RE equipment manufacturing, Odisha has the potential to unlock significant economic value.

Opportunities for 2030

~93,000* FTE jobs
against 35,650 MW of module manufacturing and 500 MW of wind manufacturing

INR 44,000 crore (USD 5,300 million)**
the estimated market opportunity.

INR 65,000 crore (USD 8,000 million)**
the estimated investment opportunity

*Source: *Authors' analysis of Kuldeep et al. (2017) and IRENA (2017). **Authors' analysis*

Image: Suzlon (for illustrative purposes only)

Why should Odisha invest in RE equipment manufacturing?

To enhance the value of existing mineral hubs and industries like aluminium, steel, and so on, given that it is a downstream industry.

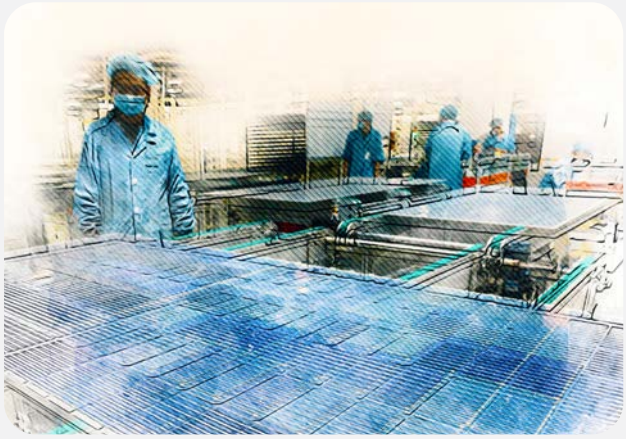
To establish Odisha as a leader in the eastern market for the supply of midstream and downstream RE components, aided by access to the 450-km coastline (Government of Odisha n.d.a.) and development of inland waterways and non-major ports (Department of Commerce and Transport 2022).

To capture the rising international interest in Indian-manufactured solar and wind components, with USD 1.9 billion worth of modules exported to the US in FY24 (Gupta 2024) and 680 GW of new wind capacity expected globally between 2023 and 2027 (Hitchinson and Feng 2023).

To generate direct and indirect jobs in the manufacturing of components like supporting structures, inverters, and so on.

Inspiration from a success story

Adani Solar plans to establish India's first integrated solar manufacturing facility with a capacity of 10 GW in Mundra, Gujarat, by 2027, with the potential to create over 13,000 jobs (PTI 2023a). This facility will encompass the entire solar manufacturing ecosystem, ranging from metallurgical grade silicon to PV modules, along with ancillary services and supporting utilities, all co-located geographically. By implementing backward integration across the value chain, this initiative aims to boost India's position as a hub for module manufacturing while reducing costs associated with the import of upstream components, such as wafers and ingots.



Departments that could support in scaling RE equipment manufacturing

Industries Department

Science and Technology Department

Skill Development and Technical Education Department

Source: Authors' analysis

Overcoming challenges to scale RE equipment manufacturing

Technological/Technical challenge/s	Proposed interventions
Lack of cost competitiveness in solar modules, with Indian modules being approximately 103 per cent more expensive than their Chinese counterparts[16]	The **Industries Department** could work with the **MNRE** to ensure lower module costs via R&D incentives like capital expenditure subsidies and encourage higher adoption of indigenous modules. Further, the **Science and Technology Department (S&TD)** could invest in R&D in the sector and lead industry-academia collaborations.

16 Based on the price of Mono Perc modules in India and China, the dominant form of module technology as of 2024; taken from PV Insights (n.d.) and InfoLink Consulting (n.d.).

Lack of domestic availability of components such as large castings and generators in India leads to reliance on imports, which account for 55 per cent of turbine costs and create a cost differential of INR 0.9–1 crore per MW between Indian and Chinese turbines (Jain et al. 2023)	The **Industries Department** could work with the **MNRE** to offer a production-linked incentive (PLI) scheme to wind energy component and sub-component manufacturers of casting, gearbox, and nacelle assemblies to enable vertical integration in domestic manufacturing.[17]
Lack of adequate investment in R&D compared to other countries such as China, South Korea, and the US[18]	The **Industries Department** should encourage R&D in RE equipment manufacturing with the **DoE** under the Renewable Energy Research Institute by collaborating with the private sector, academic institutes, etc. A capital subsidy on equipment/machinery for supporting new R&D centres can also be explored.[19] The **Industries Department** could also work with the **MNRE** to encourage R&D via industry-academia collaboration and capital expenditure subsidies for setting up R&D laboratories. The MNRE can also mandate minimum research expenditure for integrated solar manufacturers to spur technological innovations and establish cost competitiveness.
Supply-chain related challenge/s	**Proposed interventions**
Lack of operational wafer and polysilicon manufacturing capabilities in India, along with low cell manufacturing capacity and high dependence on imports. Additionally, there are significant gaps in backward linkages for essential wind components, such as large castings	The **Industries Department** could spearhead the creation of a manufacturing hub of RE equipment in Odisha to achieve supply chain integration via the measures elaborated below: The **Industries Department** could involve the private sector via investment facilitation measures like tax incentives, technology grants, and R&D incentives. The **Industrial Promotion and Investment Corporation of Odisha Ltd. (IPICOL)** could attract investment and increase the visibility of state policies via investor meets, international trade fairs, etc., whereas the **Industrial Development Corporation of Odisha (IDCO)** could provide the necessary infrastructural support[20] to establish the manufacturing hub. The **District Investment Promotion Agency (DIPA)** could actively engage in planning the creation of a supply chain ecosystem at the district level via measures like logistics management and advocacy for industrial infrastructure development.

17 India is currently heavily reliant on China, with 50 per cent dependence on hub castings and more than 90 per cent on gearbox castings.

18 India's 2022–23 Union Budget allocated only USD 5 million (INR 35 crore) for R&D spending across all renewable energy technologies, not limited to manufacturing, whereas the US, on the other hand, allocated USD 95 million to solar research and manufacturing innovations in 2023 alone. In China, 1–3 per cent of the gross revenue generated is utilised for R&D every year.

19 Limited to the first few units in the state.

20 Identifying suitable land parcels with low leasing rates and high connectivity, development of industrial complexes for supply chain integration of RE equipment manufacturing, etc.

Skill-related challenge/s	Proposed interventions
Lack of a skilled workforce may pose challenges in the future as the demand for semi to highly-skilled workers rises with the advancement of technology and maturity of the module manufacturing sector.[21] Additionally, the need for STEM professionals is greater in the onshore wind sector compared to the solar PV sector	The **OSDA** can support labour requirements through skill-training initiatives in material handling, software, and STEM-related courses. This will require close collaboration with the industry, academia, and ITIs. The OSDA may also aid in the creation of manufacturing hubs by ensuring the availability of skilled individuals from the local population to ensure the absorption of the local workforce and prevent rural–urban migration.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of RE equipment manufacturing

Changing technology poses a risk of obsolescence, leading to potential loss of investment. Further, India's heavy dependence on China for wind and solar components is a constant import risk, threatening energy security. Targeting the export market also introduces trade risks due to changing geopolitical conditions. To mitigate technology risks, Odisha can offer incentives such as grants for technology upgradation, tax incentives, and R&D grants, particularly for wind components. Manufacturers should stay up to date with emerging technologies, especially in the case of solar modules (Garg and Jain 2022). Import risks can be mitigated by incentivising the domestic manufacturing of critical solar components like wafers and ingots and key wind components such as large castings and generators, to secure the entire supply chain. This can be done via supportive industrial policies, initiatives to strengthen supply chains, and so on.

21 As per stakeholder consultations, in cases of high automation (~80 per cent) and large-scale production, 75 per cent of the individuals in the facility were highly skilled or semi-skilled.

3.1.11 Small hydropower (SHP)

Hydro plants with capacities between 1 and 25 MW are categorised as small hydro plants (SHPs) according to the MNRE. Given the multitude of water bodies in Odisha and an MNRE-assessed capacity of 286 MW, SHP offers significant benefits, including a high ramping rate and a high capacity utilisation factor. Scaling SHP in Odisha can help meet India's power demand while contributing to grid-balancing efforts.

Opportunities for 2030

~500* FTE jobs
against 286 MW of SHP deployment

INR 700 crore (USD 80 million)**
the estimated market opportunity.

INR 1,400 crore (USD 170 million)**
the estimated investment opportunity

*Source: *Authors' analysis of IASS, TERI, CEEW, and SCGJ, 2019. **Authors' analysis*

Image: Freepik (for illustrative purposes only)

Why should Odisha invest in small hydropower?

To aid grid balancing due to the high ramping rate. Additionally, it is an important source of power, and although there is significant expansion of variable sources of energy like solar and wind, there is reduced commitment towards large hydro.[22]

To lower the environmental and social footprint as compared to large hydro as it is also easier to deploy and maintain (Doso and Gao 2020; Khan 2015; Mishra et al. 2015).

To enable local area development via the improvement of infrastructure, generation of job opportunities, and arresting of migration, among others.

Inspiration from a success story

The San Michele dei Mucchietti Hydropower Plant is a 1.8-MW SHP plant located on the Secchia River in Italy. It is known for utilising an existing water distribution network and retrofitting it with smart technical solutions, resulting in a cost saving of EUR ~5,00,000 (UNIDO, ICSHP 2022). The plant enables carbon emission reductions of ~3,600 CO_2 tons/year. Its construction has had no negative impact on the river regime as the water is returned to the Secchia riverbed. The energy generated satisfies the annual energy requirements of 3,500–4,000 families (7–10 GWh/year) in the Sassuolo community (UNIDO, ICSHP 2022).

Departments that could support in scaling small hydropower

- Green Energy Development Corporation Odisha Limited
- Odisha Hydro Power Corporation
- Department of Water Resources
- Department of Skill Development and Technical Education
- Odisha Power Transmission Corporation Limited

Source: Authors' analysis

Overcoming challenges to scale small hydro deployment

Infrastructure-related challenge/s	Proposed interventions
Lack of availability of transmission infrastructure leading to delays in construction	The **OPTCL,** under the Odisha Distribution System Strengthening Project (ODSSP) (OERC 2015), could build transmission and distribution networks in prospective areas for SHP development.
Lack of road availability or poor conditions of roads leading to project delays	The **Green Energy Development Corporation Odisha Limited (GEDCOL), in collaboration with OHPC and the Rural Development Department Odisha,** could ensure adequate connectivity via roadways before project construction begins in order to minimise project delays.

22 The installed capacity of large hydro is 46.9 GW as of December 2023, whereas the CEA optimal generation mix forecast assumes 61.6 GW of large hydro by 2029–30 (including hydro imports of 5.8 GW). Thus, the energy generation mix in the coming years will not have much additional large hydro.

Skill-related challenge/s	Proposed interventions
Lack of local skilled manpower in regions near small hydro power (SHP) projects	The **GEDCOL** could enlist help from the **OSDA** to formally skill local individuals in areas relating to construction, contract management, testing, quality assurance, operation and maintenance, etc. Current training centres should be utilised to upskill local individuals in basic technical skills that can be used to create a permanent workforce for all RE sectors.
Technical challenge/s	**Proposed interventions**
Lack of adequate hydrological data to assess site viability leads to improper assessment of power potential (Khan 2014; Kishore et al. 2021)	The **GEDCOL, aided by the OHPC,** could actively look for potential sites for more SHP deployment, undertake feasibility studies, and work with the Department of Water Resources to identify suitable sites after assessing the geological, topological, and hydrological conditions.
Social challenge/s	**Proposed interventions**
Lack of clarity and assurance for landowners and land dependents, resulting in delays in land acquisition	The **GEDCOL** could minimise local opposition, land-related issues, and time and cost overruns by proper siting of projects through a thorough study of site characteristics, natural reserves, land and transmission infrastructure, etc. **CSOs and local government bodies like gram panchayats** can undertake knowledge dissemination on the SHP project since messaging and perception are essential for distinguishing between small and large hydro and for gathering local support. **Developers, facilitated by CSOs and local bodies,** should conduct stakeholder consultations to assess risk, formulate mitigation strategies to minimise adverse project impacts on local communities and create local development plans.
Statutory challenge/s	**Proposed interventions**
Lack of timely statutory permits, clearances, implementation agreements, and Power Purchase Agreements (PPAs), which pose risks to financiers and project completion	The **GEDCOL** could ensure interdepartmental coordination for issuing all statutory permits and clearances methodically from project inception. Likewise, all agreements, such as the implementation agreement, PPA, loan agreement, etc., are to be monitored periodically to ensure execution as per project timelines.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of small hydro

Flooding, damage to turbines from silt accumulation, and cyclones are some of the investment risks related to SHP (Sharma et al. 2017). The environmental risks include high waste and muck generation, water diversion, impact on aquatic systems, and so on. To mitigate investment and environmental risks, it is important to dispose of waste and muck sustainably (Kishore et al. 2021), implement rules to divert minimum water, and strike a balance between the local ecosystem and energy generation (Sharma et al. 2017; Khan 2015; Kumar, 2016). Assessing the impact on local ecosystems and formulating mitigation strategies will reduce risks and help attract investment.

3.1.12 Utility-scale solar deployment

This includes ground-mounted, large-scale solar technology for which Odisha has an assessed technical potential of 25 MW (MNRE 2024), assuming land utilisation of three per cent. With higher land utilisation,[23] this goes up to 149 GW (Singh et al. 2023). Thus, solar energy presents a huge opportunity for Odisha to meet the central RPO of 43.33 per cent by 2030 (Ministry of Power 2022).[24]

Opportunities for 2030

~6,900* FTE jobs
against 7,970 MW of utility-scale solar deployment

INR 2,700 crore (USD 300 million)**
the estimated market opportunity

INR 40,000 crore (USD 4,900 million)**
the estimated investment opportunity

*Source: *Authors' analysis of Kuldeep et al. (2017). **Authors' analysis*

23 Land utilisation of 50 per cent to 10 per cent in five wasteland categories of open scrub, mining wasteland, industrial wasteland, dense scrub, and rocky/stony land.

24 This is 33.57 per cent for 'other RPO', which majorly includes solar, by 2030. Currently, Odisha relies heavily on imports, with 58 per cent of electricity generated from solar imported and 436 MW of installed capacity within the state (DoE 2023).

Why should Odisha invest in utility-scale solar?

To enhance energy security since Odisha will no longer be reliant on imports and can safeguard itself from risks such as increasing cost of imports, risk to industrial growth due to lapsing ISTS waivers, and so on.

To attract investment, generate jobs, and arrest migration, with 50 per cent of jobs created in O&M,[25] all of which are permanent, resilient, and long-term.

To enable industrial growth with increasing opportunities for manufacturing and the development of local supply chains.

Inspiration from a success story

The Pavagada Solar Park in Karnataka, India's second-largest, with a capacity of 2,000 MW (NS Energy 2020), is a prime example of the successful use of the land lease model for land procurement and developer contribution to local communities. An SPV was specifically created to ensure the smooth management and implementation of the project, finalising on an initial annual rent of INR 21,000 per acre, with a five per cent escalation every two years, paid to ~2,300 farmers for 28 years (Tumukuru District n.d.). This arrangement benefited the drought-hit area, and ~INR 1 billion was contributed to the local area development fund (KSPDCL 2018), which was used to develop local infrastructure such as streetlights, local schools, and healthcare equipment, among other things.

Departments that could support in scaling utility-scale solar deployment

- Department of Energy
- Grid Corporation of Odisha
- Odisha Electricity Regulatory Commission
- Odisha Power Transmission Corporation Limited
- Skill Development and Technical Education Department

Source: Authors' analysis

Overcoming challenges to scale utility-scale solar deployment

Infrastructure-related challenge/s	Proposed interventions
Lack of robust transmission infrastructure, which can result in transmission line overloading, frequency and voltage issues	The **OPTCL,** under the **ODSSP** (OERC 2015), could build transmission and distribution networks in prospective areas. The OPTCL could also work with the **private sector** to adapt new innovative technologies like a compact tower design and increase utilisation of existing lines through Uprate and Upgrade designs, etc.
Lack of effective grid integration and stability measures due to the intermittent nature of wind energy and challenges in load balancing	In addition to strengthening transmission infrastructure, **GRIDCO Odisha** could investigate scaling large-scale storage systems such as BESS, plan for flexible thermal generation **along with the OERC and other generation companies,** and build capacities to undertake robust demand-and-generation forecasting to prepare the grid for intermittency.

25 Authors' analysis.

Land procurement-related challenge/s	Proposed interventions
Lack of land availability for solar projects due to competing land uses, land disputes, and sociocultural norms surrounding land ownership	**Developers** need to assess social and environmental risks and undertake proper siting of projects in low-conflict zones (Deshmukh et al. 2017). Additionally, there should be stakeholder consultations to understand the impact on local communities and establish a mitigation strategy for assessed risks and impacts. **GRIDCO Odisha** can pilot utilising mining wastelands for utility-scale solar deployment and contribute to understanding its feasibility and impact.
Supply chain–related challenge/s	**Proposed interventions**
Lack of domestic production for polysilicon and wafers, resulting in India's complete reliance on imports from China (Gulia et al. 2022), with 56 per cent and 66 per cent for import of cells and modules respectively in FY24 (CID, 2024)	The **Industries Department** with the **MNRE** should ensure the manufacturing uptake of solar components and lower costs via R&D incentives like capital expenditure subsidies. It should also incentivise higher adoption of indigenous products across the value chain. Further, the **Science and Technology Department (S&TD)** can organise workshops for enhanced industry–academia collaborations. The **Industries Department** could incentivise domestic manufacturing to strengthen supply chains by supporting MSME growth in the sector, strengthening domestic raw material supply chains and promoting industrial infrastructure development, etc.[26]

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of utility-scale solar

Social risks in solar energy projects arise due to land use, as over 85 per cent of solar projects in India are built on land with potential biodiversity and food security–related conflicts (Shivaprakash 2022). These concerns include the impact on agricultural production, local natural resources, loss of agricultural income, etc. (World Resources Institute 2021). Environmental risks include water-related conflicts, as ~24,000 litres of water are required per MW per wash of solar panels (Renewable Watch 2022). Additionally, the growing volume of PV module waste is another environmental risk, with estimates suggesting that India will accumulate 19,000 kilotonnes of PV module waste by 2050 (MNRE and CEEW 2024). To mitigate social risks, it is important to conduct thorough environmental and social assessments, including stakeholder discussions, which should inform mitigation strategies. Further, for environmental risks, newer technology like robotic dry cleaning (DQI Bureau 2022) of modules can be used to avoid high water usage. Addressing PV module waste is critical and can be managed through proper disposal and recycling strategies. Encouraging second-life use of substandard modules, offering incentives like green certifications, and encouraging research and investment in recycling technologies are key to mitigating these environmental challenges (Tyagi et al. 2021b).

26 More details on incentivising domestic manufacturing for RE equipment are given in the separate note on Renewable Energy Manufacturing.

3.1.13 Wind deployment

Wind energy can be of two types – onshore and offshore. Onshore wind energy is the power generated by wind turbines located on land. Odisha has an indicative wind potential of 12,000 MW at a hub height of 150 m (NIWE 2023) and must accelerate wind deployment[27] to meet the central wind RPO of 6.94 per cent by 2030 (Ministry of Power 2022). Here, we focus on onshore wind energy.

Opportunities for 2030

~600* FTE jobs
against 1,041 MW of wind deployment

INR 500 crore (USD 70 million)**
452 estimated market opportunity

INR 6,900 crore (USD 830 million)**
the estimated investment opportunity

*Source: *Authors' analysis of Kuldeep et al. (2017). **Authors' analysis*

27 Currently, Odisha imports all its contracted wind capacity, as per DoE (2023).

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in wind deployment?

To enhance energy security since Odisha will no longer be reliant on imports and can safeguard itself from risks, such as increasing cost of imports, the risk to industrial growth due to elapsing ISTS waivers, etc.

To attract investment, generate job opportunities, and arrest migration with ~80 per cent of jobs created in O&M,[28] all of which are permanent, resilient, and long-term.

To enable industrial growth with increasing opportunities for manufacturing and the development of local supply chains.

Inspiration from a success story

The Halkirk Wind Project, one of Alberta's largest wind power projects with a capacity of 150 MW, has been operational since 2012 (Jeyakumar and Todd 2017). It stands out for its effective public consultation and significant community support, achieving success by incorporating community-centric practices, such as inclusive compensation, proactive engagement, regular follow-ups with the community, and undertaking responsible practices beyond the statutory requirements.[29] Greengate Power, the developer, used a pooled lease system with a standardised payment structure that allocated compensation even to non-participating landowners adjacent to turbines. Its success is evident in Halkirk II being approved in 2023 (140 MW), which will help meet the annual electrical needs of ~63,000 Alberta homes (Power Technology 2023).

Departments that could support in scaling wind deployment

- Department of Energy
- Grid Corporation of Odisha
- Odisha Electricity Regulatory Commission
- Odisha Power Transmission Corporation Limited
- Skill Development and Technical Education Department

Source: Authors' analysis[29]

Overcoming challenges to scale wind deployment

Cost-related challenge/s	Proposed interventions
Lack of cost efficiency in wind energy generation, as achieving the same output as high-wind states requires installing turbines at higher hub heights[30]**, leading to increased investment and balance-of-station costs**	The **DoE** could offer generation-based incentives (GBI) and subsidies related to banking charges, and the **OERC** could offer site-specific auctions for tariff realisation. The **DoE and GRIDCO** could work with institutions like the **National Institute of Wind Energy (NIWE)** to assess the potential of different sites and obtain accurate mast data for site-specific auctions. The **DoE** could collaborate with **academic institutions, think tanks, and private-sector players** to undertake R&D on technological innovations in wind turbines to reduce costs at higher hub heights and increase generation capacity.

28 Authors' analysis.

29 AUC Rule 007 Requirements: Developers must notify stakeholders within 2 km of the project and have direct conversations with those within 800 m.

30 Odisha receives wind at 7.5 m per second at 150 m above ground level (agl), whereas the other 8 wind states – Tamil Nadu, Gujarat, Maharashtra, Karnataka, Rajasthan, Madhya Pradesh, Telangana, and Andhra Pradesh receive 6–7 m per second at 100 m agl (Ramesh 2023).

Infrastructure-related challenge/s	Proposed interventions
Lack of adequate transmission infrastructure, which may result in transmission line overloading and issues with frequency and voltage stability	The **OPTCL,** under the **ODSSP** (OERC 2015), could build transmission and distribution networks in prospective areas. It could also work with the **private sector** to adapt new innovative technologies, such as a compact tower design, and increase utilisation of existing lines through Uprate and Upgrade designs, etc.
Lack of effective grid integration and stability measures due to the intermittent nature of wind energy and challenges in load balancing	In addition to strengthening transmission infrastructure, **GRIDCO Odisha** could investigate scaling large-scale storage systems such as BESS, plan for flexible thermal generation along with the **OERC and other generation companies,** and build capacities to undertake robust demand and generation forecasting to prepare the grid for intermittency.
Land-related and social challenge/s	**Proposed interventions**
Lack of suitable site availability for wind energy development in Odisha's ecologically sensitive hilly areas which may also increase the risk of social conflicts	The **DoE and CSOs** may assist **developers** in undertaking proper siting of projects in low-conflict zones, assessing social and environmental impacts, and establishing appropriate mitigation strategies.
Supply chain–related challenge/s	**Proposed interventions**
Lack of availability of low-cost materials and upstream components, coupled with time-consuming procurement and supply processes, resulting in delays in project deployment	The **Industries Department** could incentivise domestic manufacturing of components to strengthen supply chains by supporting MSME growth in the sector and strengthening domestic raw material supply chains and industrial infrastructure development, etc.[31]

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of wind deployment

Environmental risks related to wind energy projects include risks to local and migratory bird species due to collisions with turbines as well as negative impacts on the breeding process. Wind turbines also generate a lot of noise, which can have notable impacts on the health of local inhabitants. Additionally, social conflicts may arise when turbines are installed in ecologically sensitive areas or forested zones with dense human settlements. Odisha is also prone to tropical cyclones, which are a considerable risk to wind turbine infrastructure (Dasgupta and Priyadarshini 2019; Chen, Li, and Tang 2016). To mitigate these environmental and social risks, several measures can be implemented. Bird collisions can be prevented by painting turbines. Detailed ecological and impact assessments prior to project deployment can help in formulating mitigation strategies to reduce environmental risks. Proper site selection of projects is also crucial to avoid ecologically sensitive zones and population centres. To prepare for cyclone risks, investment in climate modelling is essential, along with updated maps for better tracking of high-risk sites. Strengthening grid balancing and integration will also help manage the effects of weather anomalies (Shekhar et al. 2021).

31 More details on incentivising domestic manufacturing for RE equipment are given in the separate note on Renewable Energy Manufacturing.

3.1.14 Decentralised renewable energy (DRE) technologies for livelihoods

DRE technologies offer a sustainable solution to India's tripartite challenge of energy access, climate change mitigation, and growth priorities by ensuring last-mile access to renewable energy (RE) for boosting rural livelihoods.[32] Odisha currently has ~11,000 DRE technologies deployed, with 10,729 deployments of solar pumps alone.[33]

Opportunities for 2030[34]

~44,000* FTE jobs
through manufacturing and deployment of 7,00,366 DRE technologies

INR ~5,700 crore (USD 690 million)*
the estimated market opportunity

INR ~130 crore (USD 16 million)*
the estimated investment opportunity

*Source: *Authors' analysis*

32 This note captures the following DRE technologies: DRE-based refrigeration, cold storage, chillers, grain milling and processing, textile reeling and looming, sewing machines, fodder systems, aerators, pumps, charkhas, and dryers.

33 Stakeholder consultations.

34 These numbers are subject to the condition that the manufacturing of these technologies happens in Odisha itself. Jobs are calculated for activities that include design of the applications, procurement and assembly of components, installation, maintenance and corporate functions such as administration, marketing, installation and customer services, etc.

Image: CEEW (for illustrative purposes only)

Why should Odisha invest in DRE technologies?

To enhance its agricultural productivity and post-harvest management as DRE technologies can enhance the state's low agricultural productivity and reduce the annual post-harvest losses of over 6 lakh tonnes (Central Horticultural Experiment Station 2021).

To enhance income by improving the state's 22nd rank in per capita GDP through leveraging of DRE technologies, which have been shown to increase users' annual incomes by up to 35 per cent (Gaur et al. 2023).

To tackle unreliable power supply by mitigating the impact of brownouts and blackouts in the state, where 64 per cent of households face two or more 24-hour blackout days per month, and 31 per cent experience three or more days of low voltage supply (Tripathi and Jain 2017).

To localise economies by reversing Odisha's distress migration trends and positively impacting over 9,25,544 livelihoods,[35] while strengthening the local economy through the promotion of manufacturing and indigenisation of the supply chain.

Inspiration from a success story

With a market potential of 569 units valued at INR 18.208 million (Jain et al. 2023) and a network of 3,138 weaving households (CEEW 2021), Odisha presents a viable opportunity to scale the production and deployment of solar silk-reeling machines. Kuni Dehury, a skilled silk reeler from Keonjhar, Odisha, has leveraged her extensive experience to establish a small training centre in her village, where she teaches women the art of silk reeling. To date, she has successfully trained over 500 women at the Tussar Silk Park. According to Kuni, these machines have proven instrumental in helping women boost their monthly incomes from approximately INR 1,500 to INR 6,000 (Gaur et al. 2023). Moreover, these machines contribute to the centre's cost-cutting measures by reducing electricity expenses.

Departments that could support in scaling DRE livelihood technologies

- Odisha Renewable Energy Development Agency
- Department of Mission Shakti
- Department of Energy
- Odisha Skill Development Authority
- MSME and Industries Department
- Ministry of New and Renewable Energy
- Panchayati Raj and Drinking Water Department – Odisha Rural Development and Marketing Society

Source: Authors' analysis; stakeholder consultations

35 Authors' analysis.

Overcoming challenges to scale DRE technologies

Market creation and development related challenge/s	Proposed interventions
Low awareness and demand ignition due to the nascency of the sector (Jain et al. 2023)	The **Odisha Renewable Energy Development Agency (OREDA)** can implement concerted efforts to generate awareness through targeted campaigns and community engagement. The **Integrated Tribal Development Agency (ITDA)** can conduct needs assessments in Odisha's tribal regions and raise awareness to foster clean-tech integration. **Various line departments** can promote the adoption of DRE livelihood technologies. For example, the Fisheries & Animal Resources Development Department can mandate the use of solar-powered aerators in pisciculture and facilitate the availability of subsidies or interest-free loans for potential users. **Self-help groups (SHGs), farmer-producer organisations (FPOs), and CSOs,** such as PRADAN, SELCO Foundation, and Livelihood Alternatives, can contribute to building awareness and communicating the benefits of clean-tech applications to generate demand.
Lack of ecosystem support for market linkages (Jain et al. 2023)	The **Department of Mission Shakti** and the **Odisha Rural Development and Marketing Society (ORMAS)** should collaborate with **technology manufacturers, market enablers, and CSOs** to establish and strengthen forward and backward linkages.
Lack of trust among the stakeholders regarding the viability of DRE technologies	**Technology manufacturers** and **market enablers** can work on technology customisation, robust after-sales services, demand generation, and market linkages to ensure the reliability and continued functioning of DRE technologies in Odisha's remote areas. The **OREDA** should coordinate with the **MNRE** to implement standards for DRE technologies to ensure high quality.
Financial challenge/s	**Proposed interventions**
Lack of end-user financing (Jain et al. 2023)	The **ITDA** can leverage the *Special Central Assistance to Tribal Sub-scheme* to promote DRE technologies in high-potential tribal districts like Mayurbhanj, Keonjhar, Koraput, and Rayagada. The **National Bank for Agriculture and Rural Development (NABARD)** can play a pivotal role in unlocking finance for the sector. Its support in the form of interest subvention, first loss default guarantee, etc., can act as a catalyst by providing credit guarantees to financing institutions. Institutions like the **NABARD** and the **Small Industries Development Bank of India (SIDBI)** can establish a revolving fund for clean energy to be disbursed by regional rural banks (Jha et al. 2019) in the state **(Odisha Gramya Bank and Utkal Grameen Bank).** **Odisha Livelihoods Mission (OLM)** can channel institutional finance to scale up the uptake of DRE technologies in the state. The **State Level Bankers' Committee (SLBC) Odisha** can be leveraged for disseminating information and supporting physical demonstrations to build financiers' trust in DRE livelihood technologies.

Skill-related challenge/s	Proposed interventions
Lack of capacity building to ensure robust technical and after-sales services (Gaur et al. 2023)	**Pradhan Mantri Kaushal Vikas Yojana** and the **Odisha Tribal Empowerment and Livelihoods Programme** should target stakeholders involved in the deployment for capacity building and training. **CSOs** should coordinate with the **OSDA** to enable the training of local individuals for the uptake of jobs in the sector.
Policy-related and institutional challenge/s	**Proposed interventions**
Lack of dedicated policy support and targets	The **OREDA,** in collaboration with the **Department of Energy (DoE)**, can push to secure funding and policy support from the centre for DRE technology initiatives. Working in tandem with the **MSME and Industries Department**, it can develop policies to bolster the clean-tech ecosystem. The **OREDA** should set periodic targets for DRE technology deployments to provide signalling to the industry to scale up. The **MSME Department** could collaborate closely with the **OREDA** and the **Department of Mission Shakti** to effectively communicate information regarding incentives and support provided by the department to start-ups and companies in the DRE sector.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of DRE livelihood technologies

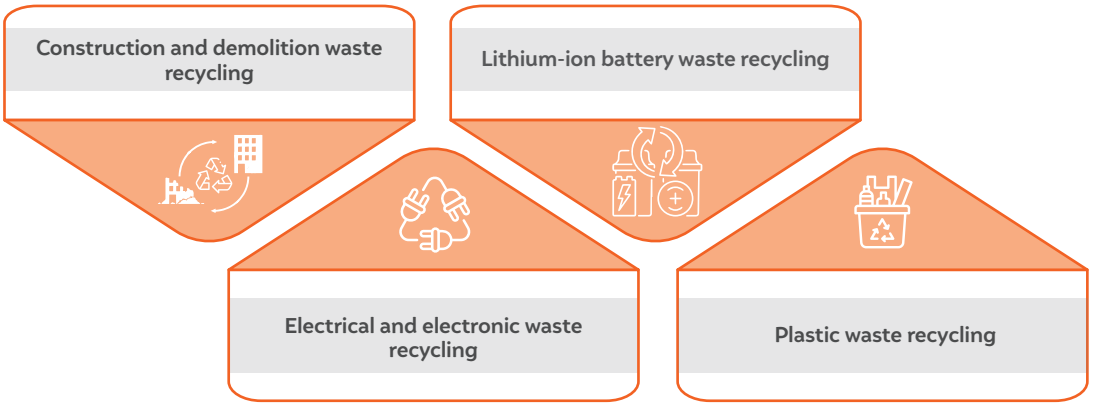
Improper disposal of DRE components can lead to significant ecological damage. Additionally, the heavy reliance on imports for critical components poses risks of production delays and increased costs during periods of geopolitical instability. Limited market linkages and the constrained expansion capabilities of enterprises can further hinder technology uptake. Mitigation strategies can include awareness programmes on safe disposal and take-back initiatives, targeted marketing, local sourcing of technology components, state government support in establishing distribution networks, capacity building of locals, robust after-sales services, and financial assistance to enterprises for expansion.

3.2 Circular economy

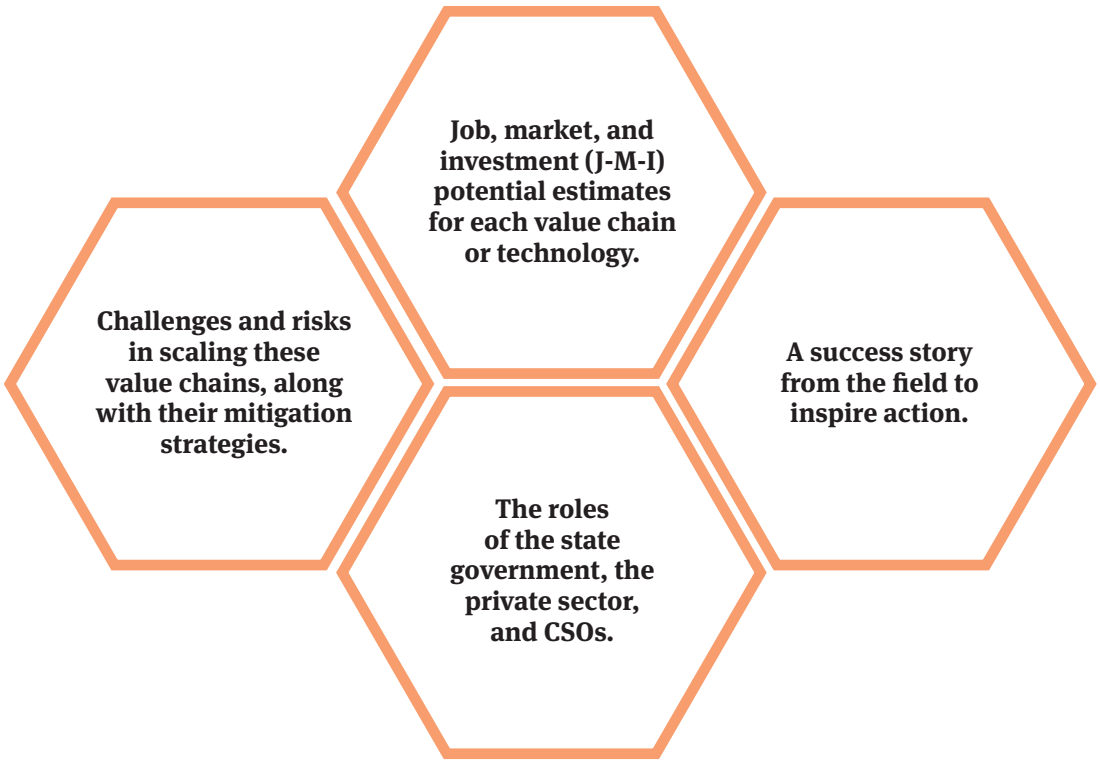
The CE sector is an emerging green sector that can help Odisha address the issues of waste management, while ensuring resource conservation, job-intensive growth, future job security, and economic resilience.

Importance of the CE sector for Odisha

The rapid development brings along issues of waste management. The CE sector helps addressing it while unlocking new employment opportunities that will also ensure sustainable use of resources. The value chains examined for Odisha in this sector include



For each value chain, we discuss



3.2.1 Construction and demolition waste recycling

Construction and demolition (C&D) waste recycling involves recovering materials from the waste generated during the construction, remodelling, repair, and demolition of civil structures. Odisha generated 455 tonnes per day (TPD) of C&D waste in 2022–23 (OSPCB 2023). However, the state has limited recycling facilities (Forest, Environment and Climate Change Department 2023), and most of this waste is disposed of in low-lying areas or solid waste dumpsites, resulting in minimal resource recovery.

Opportunities for 2030[36]

1,500 FTE jobs
against recycling of 3,000 kilotonnes of C&D waste

INR 80 crore (USD 10 million)**
the estimated market opportunity against recycling 1,000 kilotonnes of C&D waste

INR 80 crore (USD 10 million)**
the estimated investment opportunity for recycling 1,000 kilotonnes of C&D waste

*Source: *Authors' analysis of stakeholder consultations. **Authors' analysis*

36 Authors' analysis: (i) 1,500 jobs will be generated from recycling 3,000 kilotonnes of cumulative C&D waste generated in Odisha between 2024 and 2030; (ii) the jobs herein consider different stages of operations undertaken within the recycling facility; (iii) the market opportunity considers the maximum recovery of materials from C&D waste and their sale.

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in C&D waste recycling?

To reduce its reliance on virgin construction materials and minimise ecological impact due to their extraction and mining.

To reduce the carbon footprint of the building and construction sector by sourcing locally recycled construction materials.

To prevent the generation of dust particles from unmanaged or dumped C&D waste (CPCB 2017).

To divert land for other necessary purposes rather than using it to deposit voluminous C&D waste (Jain et al. 2019).

Inspiration from a success story

New Delhi's C&D waste recycling plant[37] at Burari, which was the largest in India, had a processing capacity of 2,000 TPD (Roychowdhury et al. 2020). It was a public-private partnership between the North Delhi Municipal Corporation (NDMC) and Indo Enviro Integrated Solutions Private Limited (IEISL). NDMC provided the land, while IEISL was responsible for building and operating the plant (Biswas et al. 2021). The integrated plant was equipped with machinery for both wet and dry processing. It produced ready-mix concrete, hollow bricks, pavement blocks, kerbstones, concrete bricks, and sand. Initially, due to the poor uptake of recycled C&D materials, the Delhi government mandated the use of recycled products in government and municipal contracts to boost confidence and encourage the use of such materials (Roychowdhury et al. 2023). The plant supplied over 1.8 million recycled C&D blocks for the construction of the Supreme Court Extension (Roychowdhury et al. 2020).

Departments that could support in scaling C&D waste recycling

- Department of Housing and Urban Development
- Works Department
- Odisha State Pollution Control Board

Source: Authors' analysis

Overcoming challenges[38] to scale C&D waste recycling

Supply-chain related challenge/s	Proposed interventions
Lack of awareness among the waste generators on the authorised manner of depositing C&D waste **Limited waste aggregation by authorised entities due to the presence of the informal sector**	**Local bodies** should conduct regular awareness campaigns targeting different stakeholders to educate them on authorised collection mechanisms, user fees, penalties for dumping, etc. Additionally, they should establish a robust collection and transportation mechanism with traceability measures to ensure channelisation by authorised entities and prevent leakages to the informal sector. Tenders should be issued to C&D waste recyclers for the establishment and operation of recycling plants, which should be aligned with the current and projected requirements. Odisha's collaboration with **Mission Shakti SHGs** on solid waste management can be extended to include awareness campaigns for C&D waste collection and compliance requirements.

37 The original plant was established in 2009 and has now been dismantled. A new C&D recycling plant with more efficient technology was inaugurated in its place in 2023 with the same capacity.

38 Based on stakeholder consultations

Regulatory challenge/s	Proposed interventions
Unauthorised collection and dumping of C&D waste; non-implementation of the Construction and Demolition Waste Management Rules, 2016 (C&D Rules)	The **Department of Housing and Urban Development (H&UDD)** could notify the state policy on C&D waste, as required by the C&D Rules, outlining the broad roles and responsibilities of stakeholders to facilitate the effective management of waste and promote the use of recycled products. **Local bodies** should notify the by-laws for C&D waste, specifying the entire process from collection to processing and detailing the duties of stakeholders, user charges, penalties, etc. Additionally, they should establish a robust grievance redressal mechanism to enable citizens to raise complaints.
Absence of monitoring and reporting framework	Mechanisms can be established under the **Odisha Development Authorities (Planning and Building Standards) Rules, 2020,** which promote transparency, such as (i) requiring proof of channelising C&D waste from demolition to an authorised facility before providing approval for a new building plan and (ii) verifying compliance with C&D waste management plans submitted by bulk generators before issuing an occupancy certificate. A **common monitoring system** between the local body's sanitation department and the development authority can ensure such compliance and record keeping. The **Odisha State Pollution Control Board (OSPCB)** should regularly inspect and monitor C&D waste management facilities to ensure compliance with the C&D Rules, dust pollution control, and terms of authorisation, among others.
Market creation challenge/s	**Proposed interventions**
Lack of awareness and confidence in recycled materials and products **Low uptake of recycled materials and products**	Obtaining a recycled product certification from an independent third party and listing the products in Green Rating for Integrated Habitat Assessment (GRIHA) or GreenPro Ecolabel will improve market acceptability and exposure (Niti Aayog 2018). **H&UDD** could incentivise builders to rate their buildings through certifications such as GRIHA, Indian Green Building Council (IGBC), etc., under the Odisha Development Authorities (Planning and Building Standards) Rules, 2020. Several state governments have provided incentives, such as an additional 10 per cent floor area ratio (FAR) for rated projects (Indian Green Building Council n.d.). **Industry associations** such as the Confederation of Real Estate Developers' Associations of India (CREDAI), in association with recyclers, could identify construction industry challenges in using recycled materials and disseminate successful examples. **State departments, the Works Department (WD), Odisha,** and **local bodies** could mandate the minimum use of recycled C&D waste products in building construction, road works, etc., as Delhi has done. Similarly, toilet construction under the *Swachh Bharat Miss*ion could be mandated with a minimum content of recycled C&D materials as per the specified design and quality control.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of C&D waste recycling

C&D waste collection, transportation agencies, and recycling facilities must consistently comply with their contractual obligations and regulations. One of the major challenges for C&D waste recycling risks is the unauthorised collection and dumping of waste, which can contribute to air and land pollution (Elshaboury et al. 2022; Du et al. 2020). Therefore, it is crucial for local bodies to impose strict penalties and enforcement measures to maintain a responsible C&D waste recycling industry.

3.2.2 Lithium-ion battery waste recycling

Lithium-ion battery (LIB) recycling involves recycling batteries that have reached the end of their life to recover intrinsic materials and, ideally, reintroduce them into the manufacturing supply chain. LIBs are a highly promising battery technology widely used in consumer electronics, EVs, and stationary storage applications.

Opportunities for 2030[39]

~200* FTE jobs
against recycling of 7 kilotonnes of LIB waste

INR 90 crore (USD 10 million)**
the estimated market opportunity against recycling 3 kilotonnes of LIB waste

INR 110 crore (USD 14 million)**
the estimated investment opportunity for recycling 3 kilotonnes of LIB waste

*Source: *Authors' analysis of stakeholder consultations. **Authors' analysis*

39 (i) Recycling 7 kilotonnes of cumulative LIB waste generated in Odisha from 2024 to 2030.
(ii) The jobs herein consider different stages of operations undertaken within the recycling facility.
(iii) The market opportunity considers the maximum recovery of materials and their sale.

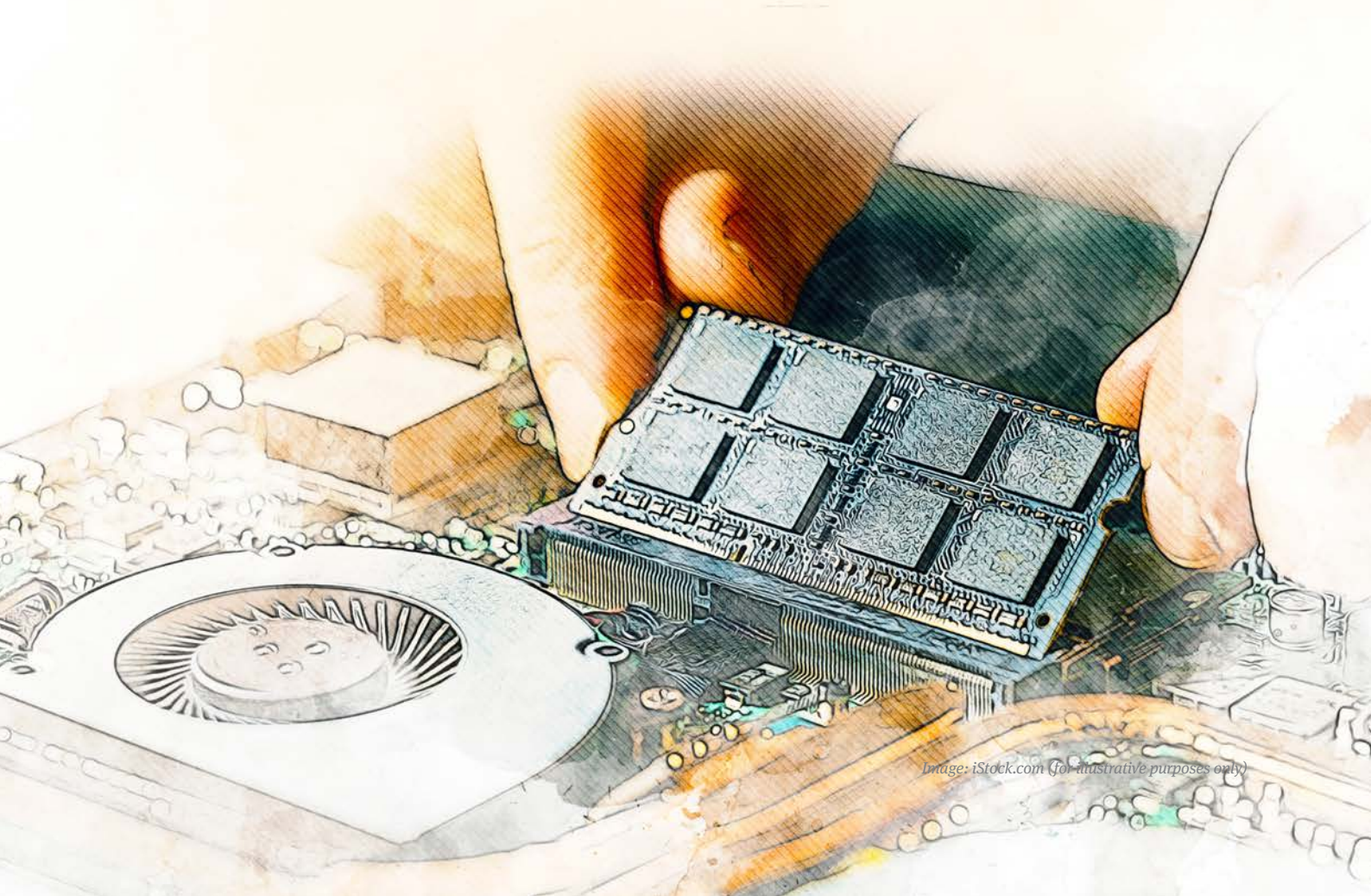


Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in LIB recycling?

To become a LIB recycling hub on the eastern coast of India so that the state is able to supply critical materials domestically and regionally and reduce import dependence (Warrior et al. 2023).

To create local jobs for the local workforce by scaling LIB recycling and thus reduce migration.

To reduce environmental contamination from untreated discarded batteries containing heavy metals like nickel and cobalt and prevent fires caused by the residual charge.

Inspiration from a success story

Lohum Cleantech Private Limited, India's first integrated LIB treatment facility, performs repurposing, recycling, and refining. The facility has been operational since 2018 and has a refurbishing capacity of 300 MWh and a recycling capacity of 10,000 TPA. Used batteries from EVs are repurposed and reused in stationary storage applications or recycled to recover raw materials. The facility is capable of recovering all major minerals, including lithium, cobalt, nickel, and manganese, which can be used in the manufacturing of new battery cells and can be recycled endlessly (Lohum n.d.).

Departments that could support in scaling LIB waste recycling

- Industries Department
- Forest, Environment and Climate Change Department
- Odisha State Pollution Control Board
- Skill Development and Technical Education Department

Source: Authors' analysis

Overcoming challenges[40] to scale LIB waste recycling

Supply-chain related challenge/s	Proposed interventions
Lack of awareness among relevant stakeholders to supply waste to authorised entities	The **Odisha State Pollution Control Board (OSPCB)**[41] can create awareness among registered vehicle-scrapping facilities and entities engaged in the O&M of stationary storage batteries about the facilitation of LIB waste to authorised recycling facilities.
Low levels of waste aggregation	**Local bodies** need to spread awareness to citizens, dealers, the informal sector, etc., on the disposal of LIB waste in an authorised manner. They can collaborate with authorised waste management entities to channel the battery waste collected through municipal channels. Further, a separate empanelment process can be created for private entities who intend to collect, sort, and channelise battery waste to authorised processing units. **Producers** may explore business models such as 'battery as a service' or a 'deposit refund scheme' for the handover of waste batteries. This can also be done by creating a strategic network of collection centres and EV battery replacement or scrapping centres in collaboration with the recyclers on a long-term basis.

40 Based on stakeholder consultations

41 Along with other state departments such as the Commerce and Transport (Transport) Department, Odisha.

Skill-related challenge/s	Proposed interventions
Limited knowledge of battery chemistries and recycling machinery	The **Skill Development and Technical Education Department (SD&TED)** can facilitate (i) the creation of short-term modules to upskill existing Industrial Training Institute (ITI) graduates and (ii) the inclusion of battery chemistries and waste management expertise in the ITI curriculum, including practical training and visits to battery recycling units. The **SD&TED** may leverage battery training programmes run by other institutions such as the Ministry of Electronics and Information Technology (MEiTY) to customise the curriculum for this sector (MEiTY n.d.). **Recyclers** should collaborate with government departments to design and update the respective courses.
Logistical and safety-related challenge/s	**Proposed interventions**
High chances of fire hazards during transportation due to the flammable nature of LIBs	The **Central Pollution Control Board (CPCB) and/or OSPCB** can specify compliance requirements or guidelines for the safe collection, packaging, labelling, transportation, and storage of battery waste, as has been issued for hazardous waste management (NPC 2019). The **OSPCB** should enforce these guidelines as and when issued. They should be further supplemented by awareness and skills development for all workers engaged in collection and transportation activities.
Policy-related challenge/s	**Proposed interventions**
Lack of a dedicated policy for LIB circularity	The **Industries Department**, in consultation with the **Forest, Environment and Climate Change Department** and **OSPCB**, should develop a comprehensive policy to encourage recyclers, as referred to in the *Odisha Electric Vehicles Policy, 2021*. The policy could focus on establishing recycling clusters to achieve economies of scale, providing various fiscal and non-fiscal incentives, promoting the uptake of refurbished products, and creating markets for the reuse of recovered materials.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of LIB waste recycling

One of the biggest risks of LIB waste recycling is the pollution from the spent chemicals used in recycling or the unprocessable waste. These materials contain toxins which must be disposed of in an authorised treatment, storage, and disposal facility (TSDF). Hence, periodic inspections are imperative for a responsible LIB recycling industry. Another risk is the obsolescence of battery technologies, which can make LIB unviable. LIB recycling is a capital-intensive industry, and a shift from precious metal–based chemistries, like nickel-rich, to chemistries of relatively abundant metals, like lithium ferro phosphate (IEA 2023), can impact the economies of recyclers. Recyclers should track these developments and stack multiple revenue streams to mitigate the risks.

3.2.3 Plastic waste recycling

The demand for plastic has been growing exponentially with the growth and development of all sectors. India reportedly generates approximately 4–9 million tonnes of plastic waste annually (CPCB 2021; MoHUA 2021), of which 13–60 per cent is recycled (CPCB 2021; MoHUA 2021), respectively. Therefore, it is critical to increase waste segregation levels and scale plastic recycling capacities to recycle plastic.

Opportunities for 2030[42]

~23,000* FTE jobs
against recycling 7,000 kilotonnes of plastic waste

INR 8,400 crore (USD 1,000 million)**
the estimated market opportunity against recycling 1,000 kilotonnes of plastic waste

INR 2,000 crore (USD 240 million)**
the estimated investment opportunity for recycling 1,000 kilotonnes of plastic waste

*Source: *Authors' analysis of stakeholder consultations. **Authors' analysis*

42 (i) Recycling 7,000 kilotonnes of cumulative plastic waste between 2024 and 2030 will generate 23,000 jobs. The jobs herein consider different stages of operations undertaken within the recycling facility. (ii) It is considered that Odisha will serve as a recycling hub for plastic waste, and in addition to recycling its own waste, it will channelise 50 per cent of the plastic waste generated in the states of Jharkhand, Chhattisgarh, and West Bengal. (iii) The market opportunity considers the maximum recovery of materials from plastic waste and their sale.

Why should Odisha invest in plastic waste recycling?

To avoid the disposal of plastic waste in dumpsites or water bodies or through open burning, thereby preventing environmental contamination, the release of microplastics, and the negative impact on ecosystems (OECD 2018).

To displace the requirement for virgin plastic, thereby reducing oil usage and emissions of GHGs associated with its production (Hopewell et al. 2009).

To become a plastic waste recycling hub for the nearby states and maximise the utilisation of its recycling infrastructure.

Inspiration from a success story

Banyan Nation is one of India's first vertically integrated plastic recycling companies, with a cumulative capacity of 12,000 tonnes (Banyan Nation n.d.; Khanna 2023). The company has developed a data-based platform to track the plastic waste recycling supply chain, which facilitates the integration of the informal sector into its collection operations. This platform has also been extended to municipalities. Banyan Nation processes high-density polyethylene and polypropylene plastic, such as detergent and toilet cleaner bottles. The collected plastic is cleaned using proprietary technology to eliminate contaminants from products and packaging, after which it is recycled and converted into high-quality granules. These are then sold to manufacturers to reduce the consumption of virgin plastic.

Departments that could support in scaling plastic waste recycling

Department of Housing and Urban Development

Industries Department

Odisha State Pollution Control Board

Source: Authors' analysis

Overcoming challenges[43] to scale plastic waste recycling

Waste segregation and supply chain-related challenge/s	Proposed interventions
Low levels of waste segregation due to loose enforcement and low awareness	**Local bodies** should maintain regular and robust door-to-door campaigns focused on source segregation of waste through various modes to foster behavioural change among waste generators. To further encourage active participation, incentives may be extended to nudge consumer behaviour, such as by offering points that can be redeemed at grocery stores, zero waste tags and similar initiatives.

43 Based on stakeholder consultations

Inconsistent supply of good quality and quantity of plastic waste	The **Department of Housing and Urban Development (H&UDD)** should integrate the informal sector for the collection and sorting of waste. This can be carried out through direct employment or indirect engagement, such as by providing a secure space for waste management activities.
Lack of integration between informal and formal waste management workforce	**Local bodies** could initiate training sessions for the informal sector and sanitation staff to familiarise them with the quality requirements set by recyclers. Local bodies should also facilitate data management at materials recovery facilities (MRFs), where data on plastic waste generation and quantities accepted for recycling can be systematically recorded. The Ministry of Housing and Urban Affairs (MoHUA) *Sansaadhan* portal can be leveraged to capture this data, making it available for recyclers. Performance-based incentives can be extended to the informal sector for continued integration.
Perception-related challenge/s	**Proposed interventions**
Low adoption of recycled plastic due to perceptions around the quality of recycled plastic	**Producers** should specify globally or nationally recognised certifications that recyclers can obtain to enhance the credibility and acceptability of their products.
Inconsistent supply of recycled plastic conforming to the specifications of different brands	**Recyclers** should conduct workshops for producers and their associations, such as the All-India Plastics Manufacturers Association (AIPMA), to look beyond pricing and adopt post-consumer recycled plastics to promote circularity, subject to it meeting their quality requirements. The **Central Pollution Control Board (CPCB)** should enforce provisions for minimum use of recycled content in plastic packaging and gradually increase the targets to ensure its consistent uptake.
Cost-related challenge/s	**Proposed interventions**
Unfavourable economics of plastic waste recycling due to high waste management costs and volatility of resale prices of recycled plastic	The **Industries Department** could establish plastic or resource recovery parks, offering subsidies for land, plants, and machinery, along with exemptions from electricity duty, to support recyclers in reducing costs and improving the economics of plastic recycling. Facilities such as Paradeep Park in Odisha can establish vital links between the upstream and downstream supply chains, encouraging manufacturers to use recycled plastics. Such a mechanism will also reduce the transportation of recycled plastic, which is often a significant expense. Parks with upstream and downstream industries can also facilitate common infrastructure, secure supply chains, and improve recyclers' margins.

Process and compliance-related challenge/s	Proposed interventions
Inefficient use of the plastic extended producer responsibility (EPR) portal due to frequent updates	The **CPCB** could extensively test various features of the EPR portal and consult with stakeholders before updating the portal. Several stakeholders have highlighted difficulties in using this portal. Some of the recommendations of the recyclers for ease of use include an increase in automation to avoid multiple manual entries and refraining from making frequent revisions to the portal.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of plastic waste recycling

Plastic often contains toxic chemicals, and a lack of effective processes to remove these contaminants can result in harmful chemicals being present in recycled plastic. This can expose consumers to chemical contamination from products made from recycled plastic. To mitigate these risks, central regulations should be established to set recycling and chemical safety standards for both virgin and recycled plastic products (Mahesh et al. 2024). Additionally, unscientific plastic waste recycling can exacerbate pollution rather than alleviate it. The OSPCB should conduct periodic audits of recyclers to ensure compliance (GHMC 2020). Another significant challenge is the improper handling of low-value plastic and multi-layered plastic waste due to their lesser value and non-recyclability when compared to other plastics (Singh 2021). Hence, this plastic either ends up in landfills or drainage systems or is burnt, leading to environmental degradation. Municipalities need to track the collection and ensure its safe disposal by the formal sector.

3.2.4 Electrical and electronic equipment waste recycling

E-waste recycling refers to the disassembly and processing of end-of-life electrical and electronic equipment to recover intrinsic materials. India generated 1.6 million tonnes of e-waste in 2021–22 and recycled only 33 per cent (PIB 2023b) of it. Because of the reduced lifespans of electrical and electronic equipment (Bhutta et al. 2011) and increased consumption, a large quantity of e-waste is generated, which must be responsibly managed and processed.

Opportunities for 2030[44]

~5,500* FTE jobs
against recycling of 1,000 kilotonnes of e-waste

INR 1,100 crore (USD 130 million)**
the estimated market opportunity against recycling 200 kilotonnes of e-waste

INR 400 crore (USD 43 million)**
the estimated investment opportunity for recycling 200 kilotonnes of e-waste

*Source: *Authors' analysis of stakeholder consultations. **Authors' analysis*

44 (i) For this study, we have taken an average of the workforce required for recycling IT and non-IT items to calculate potential jobs. Since the workforce required to recycle e-waste varies with the composition and size of the waste, the employment potential is subject to change with these variations; (ii) the market opportunity considers the maximum recovery of materials from e-waste and their sale. (iii) recycling cumulative e-waste of 1,000 kilotonnes in the period 2024–30 will generate approximately 5,500 jobs. It is considered that Odisha will serve as a recycling hub for e-waste and in addition to recycling its own waste, it will channelise 50 per cent of the e-waste generated in the states of Jharkhand, Chhattisgarh, and West Bengal.

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in e-waste recycling?

To overcome issues of unscientific handling and disposal of e-waste, related environmental contamination (Raghupathy et al. 2018), and adverse impact on marginalised communities (Singh and Ogunseitan 2022).

To recover materials from waste by leveraging the existing metallurgical industry, which will also aid the state's manufacturing industries.

To reduce the manufacturing industry's carbon footprint by reducing procurement of virgin raw materials with efficient recovery of material from e-waste.

Inspiration from a success story

Eco Recycling Limited (Ecoreco) is an R2-certified[45] e-waste recycler based in Maharashtra, with a recycling capacity of 25,000 TPA (Ecoreco 2018). Ecoreco operates a mobile application called Bookmyjunk, which allows waste generators to register for complimentary e-waste collection services (Wangchuk 2021). It undertakes end-to-end e-waste recycling and promotes the use of recovered materials by electronics manufacturers. On Global Recycling Day in 2024, Ecoreco successfully engaged 1,000 industrial and commercial units across Maharashtra to advocate for responsible disposal practices and collected over 10,000 kg of e-waste (ANI 2024). It has partnered with the National Skills Development Corporation (NSDC) to provide skills training for workers within the informal recycling industry (Ecoreco 2023).

Departments that could support in scaling e-waste recycling

- Department of Housing and Urban Development
- Industries Department
- Odisha State Pollution Control Board
- Skill Development and Technical Education Department

Source: Authors' analysis

45 R2 stands for 'responsible recycling' and is a voluntary standard specifically created for the electronics recycling industry by Sustainable Electronics Recycling International (SERI). Globally, it is the most widely adopted standard for responsible practices for used electronics.

Overcoming challenges[46] to scale e-waste recycling

Supply chain and informal sector-related challenge/s	Proposed interventions
Unavailability of the requisite quantity of e-waste to formal recyclers	The **Department of Housing and Urban Development (H&UDD)** can integrate the informal sector with the formal supply chain or formalise it: • The **H&UDD** could establish a framework where e-waste collected by the informal sector can be sold to the urban local bodies and then channelled to recyclers. The informal players will lead the collection exercise within such a framework. • It could set up infrastructure such as common dismantling and recycling facilities, where the informal sector can use the space to undertake safe and legally compliant operations. The private sector or local bodies can **invest** in these **facilities** based on a public-private partnership model. This integration is critical to capitalising on the informal sector's high e-waste collection rate and safeguarding economic and social benefits for these marginalised communities (Zhang et al. 2012).
Increased environmental pollution and health hazards due to unsafe practices of informal players	Through **local bodies,** the **H&UDD** could provide training to the informal sector on the collection of e-waste, scientific methods for sorting and dismantling it, and statutory requirements for channelling e-waste to authorised entities. The **H&UDD** could mandate that bulk consumers[47] submit annual returns on the proper disposal of their e-waste.
Lack of awareness among the waste generators and loose enforcement	**Local bodies** could conduct regular awareness sessions for households under the Standard Operating Procedure (SOP) For Decentralised Solid Waste Management in the state of Odisha on the segregation of e-waste and its handover. **Recyclers** should increase their awareness levels on the segregation and deposition of e-waste in an authorised manner. They can initiate tie-ups with local bodies with relatively higher segregation levels for the e-waste supply. **Recyclers** and **producers** could engage with **CSOs** to create awareness among e-waste generators. The **Industries Department** should establish resource recovery or industrial parks with dedicated zones for waste recycling, offering both fiscal and non-fiscal incentives, as well as a market linkage for the supply of recovered materials. This initiative may encourage more recyclers to enter the ecosystem and motivate some of the larger informal players to formalise their operations. Proximity to other recycling and manufacturing units would ease market uptake of materials recovered from e-waste. These initiatives can be a component of the *Odisha Electronics Policy–2021*, or a separate policy could be developed for e-waste recyclers.

46 Based on stakeholder consultations

47 As defined under the E-waste (Management) Rules, 2022

Skill-related challenge/s	Proposed interventions
Lack of skilled workforce for e-waste dismantling and recycling	The **Skill Development and Technical Education Department (SD&TED)** should introduce modules on e-waste recycling in the ITI curriculum. These modules should include lessons on the assembly of electrical and electronic equipment and an understanding of recycling machinery and related expertise in electronics and metallurgy. The **Odisha Skill Development Authority (OSDA)** should introduce or supplement existing courses with these topics. Existing courses on e-waste, supported by the Ministry of Electronics and Information Technology (MEiTY n.d.; NIEIT 2022), could be leveraged to update their courses.
Process and compliance-related challenge/s	**Proposed interventions**
Inefficient issuance of extended producer responsibility (EPR) certificates due to frequent changes and downtime	The **CPCB** could henceforth reduce the downtime of the portal to a minimum. Any future amendments to it should be tested extensively before being released to the stakeholders. Reduction of EPR targets should be avoided as it can undermine the feasibility of SMEs to continue with their operations. Similarly, consents and authorisations to the recyclers by the different **state departments** should be issued seamlessly, with a minimum turnaround time.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of e-waste recycling

Risks associated with e-waste recycling include pollution from spent chemicals and residue waste that cannot be further processed. These materials can be hazardous and should be disposed of at an authorised TSDF (CPCB 2022). Improper disposal or dumping can result in severe environmental degradation. Further, some recyclers may register but not conduct actual recycling operations, causing the recycling capacity of the state to be overestimated. Therefore, the OSPCB should conduct audits and inspections of recyclers periodically to verify their compliance. Additionally, if health and safety standards are not observed in recycling operations, it can lead to several health risks, especially for vulnerable populations (WHO 2023). To prevent this, the Labour and ESI Department may audit the facilities for compliance with the relevant approvals and requirements.

3.3 Bio-economy and nature-based solutions

The BE and NbS is an emerging green sector that can drive economic prosperity, job-intensive growth, and economic resilience while also advancing Odisha's climate goals by promoting the use of environmentally friendly and economically viable biological resources.

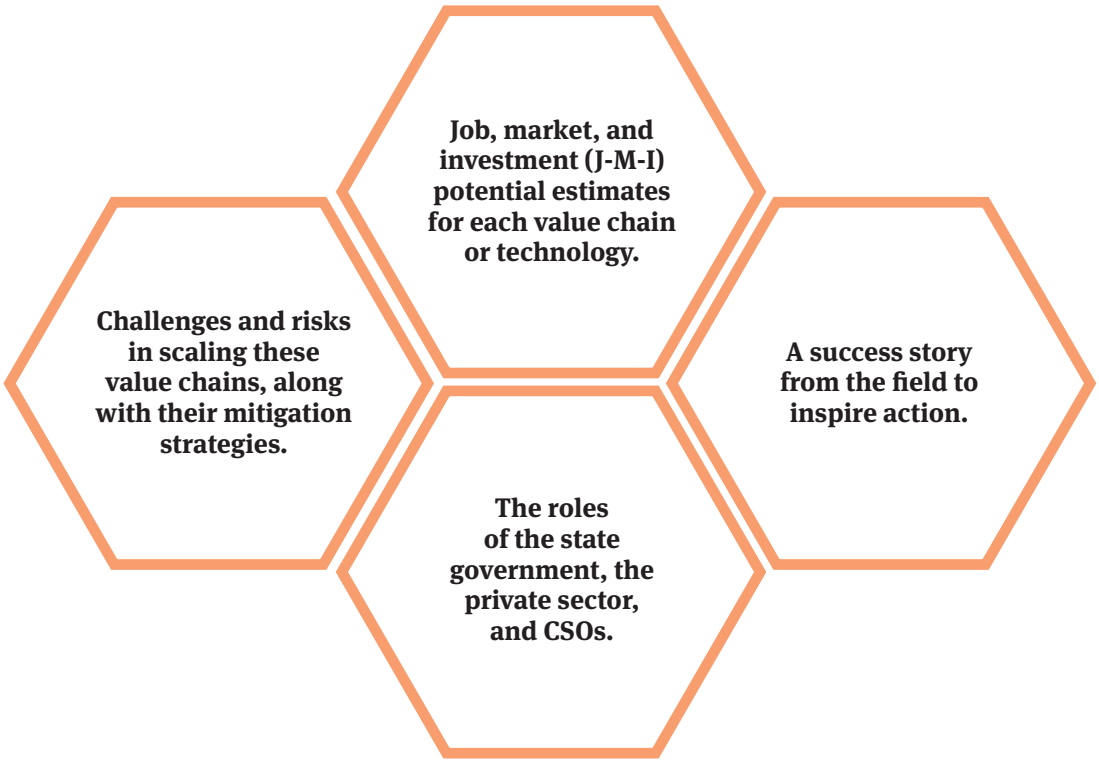
Importance of the BE and NbS sector for Odisha

Odisha is the 4th largest economy-wide GHG emitter in India and ranks 9th in emissions from the Agriculture, Forestry, and Other Land Use (AFOLU) sector, underscoring the urgent need for climate mitigation via the development of less GHG-intensive and resource-efficient value chains and enhancement of carbon sinks. Hence, a focus on BE and NbS enables economic diversification and creation of new markets for bio-based products and ecosystem services while creating localised employment by empowering local communities and small-scale producers.

The most promising value chains for Odisha in this sector include the following:

Bio-Economy (BE)	Nature-based Solutions (NbS)
biomass-based fibre manufacturing, bio-inputs, bio-based packaging material manufacturing, bamboo-based products, compressed biogas	agroforestry, ecological mangrove restoration, seaweed cultivation, sustainable forest management, sustainable tourism

For each value chain, we discuss



3.3.1 Biomass-based fibre manufacturing

Biomass-based fibres (BBFs) are derived from agricultural residues that can be processed into versatile, biodegradable fibres that match the strength and durability of natural and synthetic fibres (Jayaprakash et al. 2022). Cost-effective and customisable for various industries such as textile, technical textiles, or fibre-reinforced polymers (FRPs), BBFs are a sustainable alternative because of their lower environmental footprints and impacts (Dhir 2022). Odisha could capitalise on the residues generated from its existing coconut, banana, and pineapple fruit processing units to boost its BBF manufacturing to cater to global demand and also develop innovations for its local textile, handloom, and handicraft sectors.

Opportunities for 2030

~11,100 FTE jobs*,[48,49]
against the production of ~0.76 MMTPA[50] of BBFs from various feedstocks[51]

INR ~2,400 crore (USD 290 million)*
the estimated market opportunity[52]

INR ~2,500 crore (USD 310 million)*
the estimated investment opportunity[53]

*Source: *Authors' analysis*

48 Approximately 7,000 FTE jobs can be created by extracting ~0.75 MMTPA of coir (coconut fibre) from coconut husk, ~4,000 by extracting ~9,000 tonnes per annum (TPA) of banana fibre from banana pseudostem, and ~100 by extracting ~2,000 TPA of pineapple leaf fibre (PALF) from pineapple leaves.

49 FTE jobs calculated across the BBF value chains include activities of biomass aggregation, business development and design of extraction units, construction of fibre extraction units, and operations and maintenance of processing units and fibre extraction units.

50 The total annual production of BBF is estimated by calculating the combined annual residues from coconut, banana, and pineapple crop production, applying specific fibre yield coefficients to each type of residue and adjusting for fibre extraction value chain loss rates for each BBF.

51 Feedstock of BBFs includes coconut husk, banana pseudostem, and pineapple leaves, each yielding fibre amounting to 2 TPA or more.

52 The market opportunity is calculated based on the annual production of fibre and their corresponding current market prices (2024).

53 The investment is calculated based on the required capital costs involved in biomass aggregation, fibre extraction plants, and any intermediary processing units.

Image: iStock.com/For illustrative purposes only

Why should Odisha invest in BBF manufacturing?

To expand the raw material base of the state's textile industry beyond its current natural fibre base, which includes cotton, jute, and silk (Directorate of Textiles and Handlooms n.d.).

To boost the state's export capabilities by leveraging the progressive *Odisha Apparel and Technical Textile Policy–2022* and by establishing a dedicated textile park (Ministry of Textiles 2023).

To increase farm incomes and enhance livelihood opportunities for women.[54]

Inspiration from a success story

Mangalam Kalpatharu Enterprises in Burhanpur, Madhya Pradesh, operates a 0.1-TPD output capacity banana fibre extraction unit, producing 30–40 kg of fibre daily. This enterprise addresses the district's environmental challenge of crop-residue dumping and burning and supports Burhanpur's goal of a zero-waste model for banana cultivation, which covers 24 per cent of the district's cultivable area. It processes 300–400 pseudostems[55] daily, which are collected from places within a radius of 15 km, into 30–40 kgs of banana fibre and sap,[56] which are good bio-based inputs for agricultural intake. Operational for seven months a year, the fibre extraction unit employs six women and three men full-time. The enterprise also employs women from the SHGs and trains them to produce high-quality handicrafts from banana fibre in a decentralised model.[54]

Departments that could support in scaling BBF manufacturing

- Handlooms, Textiles & Handicrafts Department
- Science and Technology Department
- Industries Department
- Micro, Small & Medium Enterprise Department
- Department of Agriculture and Farmers' Empowerment
- Department of Co-operation
- Rural Development Department
- Odisha State Agricultural Marketing Board

Source: Authors' analysis

54 Stakeholder consultations

55 Banana pseudostems are stalks of harvested banana plants that contain 9–10 fibrous layers.

56 Banana pseudostem sap, a by-product of banana crop residue, is rich in nutrients such as potassium (K) and growth regulators, which when used in agricultural fields reduces the need for the application of chemical fertilisers.

Overcoming challenges to scale BBF manufacturing

Technological/technical challenge/s	Proposed interventions
Limited technical feasibility of BBFs to replace traditional fibres due to insufficient stand-alone mechanical properties (Fuentes et al. 2022; Muzyczek 2012, 312–28)	The **Handlooms, Textiles & Handicrafts Department (HTHD)** and the **Science and Technology Department** could encourage R&D efforts for blending BBFs with traditional fibres in **technological universities with textile engineering departments** and the **National Institute of Fashion Technology Bhubaneswar** that is working on 'farm to fashion.'[54] The **IPICOL** could leverage the Invest Odisha forum to attract strategic investments from alternative fibre-based textile or technical textile manufacturers and other **private sectors** by offering incentives to create an ecosystem for blending BBFs with traditional fibres.
Inadequate information on feedstock availability for manufacturing[54]	The **Department of Agriculture and Farmers' Empowerment** and the **Science and Technology Department** could map relevant resources to develop a repository of eligible crop residues and their availability for various BBF applications and manufacturing requirements. **Think tanks** and **CSOs** can work towards developing eligibility criteria or matrices for all crops and agri-residue for fibre conversion in consultation with subject matter experts.
Inefficient and weak downstream market linkages[54]	The **HTHD,** the **IPICOL,** and the **Industries Department** could implement regulations to ensure the widespread adoption of BBFs in traditional and handloom textiles while also encouraging their use in industrial production beyond just handicrafts. The **MSME Department** and the **OASME** could engage in the development of a sustainable label or eco-label for BBFs or products utilising BBFs to leverage the export market. The **Industries Department** could conduct conclaves with the **Directorate of Export Promotion & Marketing** in the state to display the raw material fibre base of Odisha. It can also highlight its BBF manufacturing capabilities and develop BBF raw material clusters in the state to indicate opportunities for industries to invest.

Supply-chain related challenge/s	Proposed interventions
Lack of storage and logistical infrastructure for feedstock inventory management and supply security[54]	The **Co-operation Department** and the **Rural Development Department** could promote farmers' collectivisation to manage, collect, and store crop residues for BBF manufacturing**.** The **Odisha State Cooperative Bank (OSCB)** could offer specialised financing options for establishing decentralised storage facilities for farmer cooperatives. CSOs could also encourage collectivisation among farmers and farmer families to boost crop residue management. The **Odisha State Agricultural Marketing Board** could establish market linkages between the BBF manufacturing companies and the crop-residue management cooperatives through OASME and MSME to ensure sustained supply to industries. For large storage facilities, the **Industries Department** and the **private sector** could engage in the PPP model of operating to manage storage facilities and transportation for the downstream industries.
Skill-related challenge/s	**Proposed interventions**
Lack of availability of skilled labour	The **OSDA** could implement training programmes for fibre extraction, maintenance and operation of fibre-extracting machines. The **private sector** must engage with the OSDA to develop training modules. Further, through their Corporate Social Responsibility (CSR) activities, the private sector should skill farm households to manage decentralised or at-source fibre extraction units.

Source: Authors' analysis; stakeholder consultation

Risk-proofing the scale-up of BBF manufacturing

The commercialisation of natural BBFs as high-value commodities risks soil health, as financial incentives may lead farmers to sell all crop residues, disrupting natural soil enrichment practices in crop production such as mulching.[54] For instance, applying banana pseudo stem to fields can naturally increase soil potassium levels (FAO n.d.a), and using coir pith as mulch can enhance soil structure and moisture retention (Mapa 1996). Consequently, diverting organic materials from agriculture to industry would interfere with natural soil enrichment. It would also increase the need for chemical fertilisers and contribute to the degradation of the soil.

Incentivising the use of only surplus crop residues can reduce waste and maintain soil health among agricultural fields while promoting the commercialisation of BBF products. This would help achieve a sustainable system that benefits both agriculture and industry.

3.3.2 **Bio-inputs**

Bio-inputs are natural or biological substances derived from plants, animals, or microorganisms that are used in agriculture to improve soil fertility, promote plant growth, and support crop health (FAO n.d.b). In this report, we have assessed bio-inputs such as biofertilisers,[57] biopesticides,[58] biostimulants,[59] and natural farming inputs,[60] which are vital for scaling up sustainable agricultural practices.

Opportunities for 2030

~2,100* FTE jobs[61]
against 5,49,000 MT bio-inputs produced in 2030*[62]

INR 100 crore (USD 12 million)*
the estimated market opportunity in 2030

INR 9 crore (USD 1 million)*
the estimated investment opportunity in 2030

*Source: *Authors' analysis*

57 Biofertilisers contain microorganisms, which, when added to the soil, increase its fertility and promote plant growth.

58 Biopesticides are derived from natural materials, such as plants, animals, bacteria, and minerals. They are used to control pests and manage agricultural diseases without harming the natural ecosystem.

59 Biostimulants are biological catalysts derived from natural sources that are used to improve plant processes such as nutrient uptake, photosynthesis, and stress tolerance.

60 Natural farming inputs include *jeevamrutham* and *beejamrit* prepared using local ingredients by farmers practising natural farming.

61 FTE jobs include operation and maintenance jobs spanning across sub–value chains such as biofertilisers, biopesticides, biostimulants, and natural farming inputs

62 The figure includes the projected production potential for centrally produced biofertilisers and biopesticides (~4,000 MT), decentrally produced natural farming inputs such as jeevamruthum, beejamruthum, and handi khata (14,000 MT), and centrally-produced biostimulants (~400 MT).

Image: Atul Loke, FOLU (for illustrative purposes only)

Why should Odisha invest in bio-inputs?

To significantly reduce the state's financial burden on fertiliser subsidies and healthcare costs (Gupta et al. 2020; Charyulu et al. 2011). Fertiliser subsidies have increased by nearly 158 times since 1980–81, reaching INR 79,530 crore in 2021–22, straining national finances (Ansari et al. 2022). Misuse of chemical inputs has contributed to an increase in conditions such as cancer and congenital anomalies, thereby increasing health costs (Medina, Rotondo, and Rodríguez 2023).

To enhance Odisha's agricultural resilience to climate change by adopting bio-inputs on a large scale, which boosts biodiversity (Protergium n.d.), improves soil fertility, and increases water retention (Jiménez et al. 2023). These bio-inputs also reduce the need for chemical fertilisers, cutting CO_2 emissions by 0.58 tonnes per tonne of chemical fertiliser produced, thereby supporting India's net-zero goals (Patidar et al. 2024).

To promote sustainable agricultural practices among farmers by increasing the accessibility of bio-inputs through bio-input resource centres (BRCs). These centres would be particularly valuable in remote areas with limited access to roads and chemical inputs, providing a one-stop solution for farmers practising sustainable agriculture (Gutiérrez 2022).

Inspiration from a success story[63]

The Watershed Support Services and Activities Network (WASSAN) has established six BRCs in the Sathya Sai and Annamayya districts of Andhra Pradesh to support natural farming by producing bio-inputs. Here, a major challenge in bio-input production is the collection of cow urine, which is a key ingredient and is often lost through seepage. BRCs are essential for increasing the adoption of sustainable agriculture. Each centre employs 20–30 entrepreneurs who provide bio-inputs to 100 farmers, each producing around 11 MT of bio-inputs annually. This initiative provides financial stability to farmers and reduces their reliance on chemical fertilisers. It also enhances soil health and promotes biodiversity.

Departments that could support in scaling bio-inputs

Department of Agriculture and Farmers' Empowerment

Fisheries & Animal Resources Development Department

Source: Authors' analysis

63 Based on stakeholder consultations

Overcoming challenges to scale bio-inputs

Technological/technical challenge/s	Proposed interventions
Low awareness of bio-inputs and prevalence of adulterated products (Gutiérrez 2022)[63]	The **Department of Agriculture and Farmers' Empowerment,** with support from **CSOs,** could implement targeted education and awareness campaigns to enhance farmers' understanding of bio-inputs and help them identify high-quality products. **State Agriculture Universities (SAUs) and CSOs** could advocate for bio-input usage and provide extension support to farmers, and guide them on effective application methods. The **Odisha Agro Industries Corporation Limited (OAIC)** could help with the strict implementation of quality assurances and regulatory frameworks to ensure that all available bio-based fertilisers are safe and effective, which can help in rebuilding lost trust among farmers due to the prevalence of low-quality bio-inputs. To enhance the availability of bio-inputs in the state, OAIC could mandate or incentivise retailers to allocate a portion of their inventory to bio-inputs.
Lack of consistency in the quality of bio-inputs due to varying grades of raw materials and production conditions. Additionally, there is a shortage of essential raw materials such as seaweed for biostimulants and cow urine for natural farming inputs[63]	The **Department of Agriculture and Farmers' Empowerment** can ensure consistent quality through certification and support systems for bio-input products. Moreover, the **Fisheries & Animal Resources Development Department** can support natural farming by promoting the use of animal waste, such as dung and urine, as raw materials for bio-input production. They can facilitate the collection and transportation of these materials from dairies and animal husbandry centres to BRCs through FPOs and SHGs. The department could also establish community-level cow urine collection centres to ensure a steady supply of urine for natural farming inputs. For an uninterrupted supply of seaweed for biostimulant production, **the private sector** should invest in infrastructure to promote seaweed cultivation.
Inadequate infrastructure for producing, storing, and distributing bio-inputs, along with suboptimal packaging methods, adversely affects product quality (Mishra et al. 2020)	The **IDCO** should provide the necessary infrastructure support, including land allocation and the development of industrial parks for bio-input production. The **Agricultural Promotion and Investment Corporation of Odisha Limited (APICOL)** should promote investment in agricultural enterprises producing biofertilisers, organic fertilisers, and biopesticides through the capital investment subsidy of the *Mukhyamantri Krishi Udyog Yojana* (MKUY). **Manufacturers** should adopt international standards for packaging, implement robust inventory management systems, and invest in advanced storage facilities to effectively manage the limited shelf life of bio-inputs. They should leverage the existing distribution networks of major **public sector undertakings (PSUs)** that currently handle chemical fertilisers to enhance the efficiency of bio-input distribution.

R&D–related challenge/s	Proposed interventions
Lack of systematic research on the efficacy of natural farming inputs, coupled with the absence of innovative products and solutions and insufficient investment in R&D for bio-inputs (Kumar et al. 2020)	The **Indian Council of Agricultural Research (ICAR) institutes and SAUs** should invest in research on refining production processes and conduct studies to build credibility on the efficacy of bio-inputs. The **private sector** can also invest in R&D for new formulations and improving production techniques. Similarly, industries such as agriculture, food processing, and biotechnology, can collaborate with bio-input manufacturers to develop innovative products and solutions tailored to their specific needs and serve as potential bio-input customers.
Regulatory challenge/s	**Proposed interventions**
Poor regulatory landscape and outdated production technology guidelines for biopesticides and biostimulants[63]	The **Department of Agriculture and Farmers' Empowerment** should streamline the registration process for manufacturers by establishing a single clearance window to expedite the process of establishing biopesticide units. The department should also develop process manuals that clearly outline regulatory requirements to assist manufacturers in reducing the complexity of and costs associated with licensing and update policy guidelines to include newer, cost-effective technologies.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of bio-inputs

Scaling up the use of bio-inputs in natural farming practices may temporarily impact food security due to fear of production losses during the initial adoption phase (Smith et al. 2020). Moreover, producing natural farming inputs requires significant effort, particularly in collecting raw materials like cow dung and urine. This often places a heavy burden on women and disproportionately impacts them, as they are the primary labour force in agriculture (Paliath 2022). Another significant risk is the potential harm to non-target organisms, including beneficial insects, wildlife, and humans, caused by improper handling of biopesticides. To mitigate these risks, SAUs should undertake more research to assess the impacts of natural farming input on crop yields and soil health (Smith et al. 2020). Farmers should also adopt a phased transition to natural farming by prioritising rain-fed areas in tribal regions where the use of chemical fertilisers is already low (Abraham et al. 2022). Integration of mechanised solutions, such as solar-based drava jeevamruthum unit developed by WASSAN, should be explored to reduce the drudgery faced by women as they significantly decrease bio-input production time.[63] Ensuring the safe and effective use of biopesticides requires further research in strain selection and stringent regulations in the form of rigorous lab testing and extensive field trials (Chakraborty et al. 2023; Yadav and Yadav 2024).

3.3.3 Bio-based packaging material manufacturing

Bio-based packaging materials leverage the lignocellulosic biomass and macromolecules in agricultural residues to create sustainable and biodegradable alternatives to conventional plastics and wood-based virgin packaging–grade papers. They offer similar durability but have lower carbon and environmental footprints (Stark and Matuana 2021). Odisha could harness its strong industrial base, start-up ecosystem, and stringent regulations on single-use plastics to take the lead in sustainable packaging material production in India.

Opportunities for 2030

~1,400–3,000* FTE jobs[64]
against polylactide-based bioplastic granule production of 0.14 MMTPA* and bio-based packaging paper production of 0.24 MMTPA*[65]

INR ~2,000–3,000 crore (USD 200 to 400 million)*
the estimated market opportunity in 2030

INR ~3,000–6,000 crore (USD 400 to 700 million)*
the estimated investment opportunity in 2030

*Source: *Authors' analysis*

64 The FTE jobs include activities spanning various production elements – biomass aggregation, business development and design, construction of biorefineries, and operation and maintenance of biorefineries.

65 The range indicates high-growth scenarios of production of bioplastic granules (0.14 MMTPA) and packaging paper (0.24 MMTPA) as they both utilise rice straw as the sole feedstock that allows for the establishment of either six bio-refineries for bioplastics or eight for packaging paper. The range captures FTE jobs, market, and investment opportunities in case of shared feedstock between the two manufacturing categories. Assuming a 50:50 split of available feedstock between the two, the economic potential for the value chain is estimated at ~ 2,900 FTE jobs, a $2,800 market opportunity, and a $4,800 investment opportunity, as referred to in the Executive Summary.

Image: Alamy.com (for illustrative purposes only)

Why should Odisha invest in bio-based packaging materials manufacturing?

To avoid GHG emissions from crop residue burning (Jain, Bhatia, and Pathak 2014) by repurposing the surplus crop residue – 1.76 million tonnes (MT)[66] of rice straw in the state – as a renewable feedstock for packaging material production.

To reduce reliance on crude oil and avoid deforestation (OECD 2014; Worku et al. 2023) by reducing the requirements for virgin plastic and virgin paper production in the packaging industry.

To prevent environmental pollution from microplastics and minimise negative impacts on natural ecosystems due to packaging waste disposal, which makes up 59 per cent of the total solid waste generated (CSE 2020). Bio-based packaging materials offer superior end-of-life waste management solutions due to their inherent biodegradability and compostability (Cruz-Romero and Kerry 2009).

To boost packaging material exports by leveraging port infrastructure and becoming India's manufacturing hub of sustainable packaging solutions and materials for the eastern zone.

Inspiration from a success story

Yash Pakka, with a mission to "let the world eat safe" from Ayodhya, Uttar Pradesh, transforms 75,000 tonnes of waste bagasse[67] into pulp and paper food-grade packaging materials annually. Reaching 43 countries through its compostable tableware brand, CHUK, and other agri–residue–based packaging paper and pulp for food service and delivery, Pakka utilises bagasse from three nearby sugar mills, roughly supporting 3,000 farm households. It runs year-round on 100 per cent biomass-based energy generated from the utilisation of black liquor,[68] ensuring nature- and climate-positive processes are used across all operations. Pakka has emerged as a pioneer in sustainable packaging solutions in India, boasting a state-of-the-art research lab for material development at the Indian Institute of Science (IISC), Bangalore.[69]

Departments that could support in scaling bio-based packaging materials manufacturing

- Science and Technology Department
- Industries Department
- Department of Agriculture and Farmers' Empowerment
- Micro, Small & Medium Enterprises Department
- Skill Development & Technical Education Department
- Department of Housing and Urban Development

Source: Authors' analysis

66 Authors' analysis of Sardar Swaran Singh National Institute of Bio-Energy (n.d)

67 Bagasse is a fibrous residue left over after crushing sugarcane or sorghum stalks to extract their juice. It is a by-product of the sugar industry.

68 Black liquor is a by-product of the kraft process when lignocellulosic biomass is digested into paper pulp, removing lignin.

69 Based on stakeholder consultations

Overcoming challenges to scale bio-based packaging materials manufacturing

R&D–related challenges	Proposed interventions
Limited market competitiveness of bioplastics against traditional plastics due to higher costs of production – by about three to five times (Awasthi et al.T2020)	The **IPICOL** and the **Science and Technology Department** could collectively facilitate the private sector's R&D activities for process transformation to reduce the costs of bio-based packaging materials by providing funding and grants. In addition, the private sector and **industry associations on compostable plastics** could establish strategic partnerships with players such as the **Indian Institute of Packaging (IIP)** to develop process technologies to achieve economies of scale[69] and optimise costs of production. The **Industries Department** and the **Government of Odisha** have a valuable opportunity to take the lead in leveraging the recently announced centralised PLIs for bio-manufacturing and bio-foundry. This strategic move will allow Odisha to capitalise on the upcoming indigenous manufacturing of biopolymers, thereby reducing import dependence.
Technical and operational challenge/s	**Proposed interventions**
Lack of consistent supply of feedstock leads to frequent shortages in manufacturing	The **Department of Agriculture and Farmers' Empowerment,** the **OREDA,** and the **Industries Department** should consider commissioning bioresource allocation modelling exercises to **CSOs** and **think tanks.** This will enable the development of policies for the optimised allocation of feedstock for bio-based packaging material production in the long term, the realignment of targets for competing sectors, and the identification of alternative feedstock sources for these sectors.
Poor logistical infrastructure to ensure supply security[69]	The **Industries Department,** the **MSME Department,** and the **C&T Department** could develop a roadmap to promote private sector engagement in providing logistical support to sectors utilising bio-resources as feedstock. This roadmap could be formulated with the help of **supply chain management experts in the private sector.** To support this, the **Department of Agriculture and Farmers' Empowerment** could develop cluster-based resource maps to identify feedstock variety and availability in the region.
Lack of clarity in the certification of end products that limits adoption and hinders market acceptance of the materials (Tewari, Batra, and Balakrishnan 2009)	The **Odisha Pollution Control Board (OPCB),** in collaboration with the **BIS,** could develop a state-wide certification mechanism for bio-based packaging materials to justify the cost of the material according to sustainability standards. This would also facilitate a higher uptake of the products in the market.
Lack of industrial composting units to ensure the safe disposal of end products (CSE 2020)	The **OPCB** can strengthen the regulatory framework on the use and manufacturing of single-use plastic to facilitate the uptake of alternative packaging materials by the industries in the state. To ensure the safe disposal of alternative materials, the OPCB, in partnership with the **H&UDD** and the **Directorate of Municipal Administration,** should lead the efforts in establishing industrial composting units in PPP models across the state. This can be accomplished by developing guidelines and issuing tenders.

Skill-related challenge/s	Proposed interventions
Limited awareness of the application of bio-based packaging products among industries[69]	The **Industries Department** could commission and host workshops with the **OASME** as part of the ProPack Odisha International Expo in collaboration with the IIP and the **Packaging Industry Association of India**. The ProPack summit can also be supplemented by multiple industry-specific interactions to explore the possibility of moving to sustainable packaging materials along with bio-based packaging materials. Start-up Odisha could develop specialised incubation support for bio-based packaging industries, including early biopolymer manufacturers, biopolymer to bioplastic manufacturers, and bioplastic to packaging product manufacturers, and similarly for paper-based packaging products. In addition, the **OASME** and Start-up Odisha can facilitate investments across the value chain of bio-based packaging material and product manufacturing.
Absence of ancillary and supporting industries such as printing, labelling, adhesives and others, (Tewari, Batra, and Balakrishnan 2009)	The **Industries Department,** the **IPICOL,** and the **MSME Department** could promote the development of ancillary industries for packaging (coatings, labels, adhesives, etc.) in collaboration with the **private sector.** They could co-create standards for the industry to engage in sustainable sourcing practices to create demand for bio-based packaging products. IPICOL can also integrate **Odisha's Plastic Park** to facilitate bioplastic production.
Lack of availability of skilled labour for the operation and maintenance of biorefineries hinders indigenous manufacturing[69]	The **OSDA,** along with the **Skill Development & Technical Education Department,** can develop courses and diplomas that specialise in the management of biorefineries. The modules and diplomas could be designed by the **Indian Institute of Packaging (IIP)** and updated continuously to cater to the regional need for technicians and managers of biorefineries in collaboration with the Indian Oil Corporation Ltd (IOCL) and Bharat Petroleum Corporation Ltd (BPCL), which already manage the biorefineries in the state.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of bio-based packaging materials manufacturing

India's push for bioplastic manufacturing could potentially jeopardise food security and lead to increased import dependence. Seventy per cent of the requirements of the current market are fulfilled by imports of fossil-fuel-based biopolymers such as polybutylene adipate terephthalate (PBAT),[69] with the rest obtained from food/1-G biomass. In addition, the environmental risks of pollution from agro-waste-based paper mills and other biorefineries can be significantly higher than that for virgin refineries unless chemical wastes such as black liquor are responsibly managed, as mandated by the Central Pollution Control Board (CPCB) for all red industries (Tewari, Batra, and Balakrishnan 2009). However, this would increase the capital costs for pollutant treatment or chemical/energy recovery by 1.5 times (Tewari, Batra, and Balakrishnan 2009),[69] further straining the economic viability of commercial manufacturing facilities (Symons 2022).

A careful whole-of-state push towards achieving the techno-economic feasibility of bioplastic manufacturing from biomass can be driven by strong and dedicated R&D support for material and process development. Capital incentives that are linked to environmental **regulations could be redesigned with periodic environmental impact assessments (EIAs).**

3.3.4. **Bamboo-based products**

Bamboo is a fast-growing, woody grass known for its strength and rapid renewability (Bansal 2020), making it a valuable resource across various sectors, including the furniture, construction, and power generation sectors. In this report, we have focused on its applications in the construction, furniture, ethanol production, *agarbatti* (incense sticks), charcoal, and packaging sectors.

Opportunities for 2030

~29,000 FTE jobs[70]
against 15,000 hectares of bamboo cultivation in 2030*

INR ~6,400 crore (USD 770 million)*
the estimated market opportunity in 2030

INR ~9,500 crore (USD 1,100 million)*
the estimated investment opportunity in 2030

*Source: *Authors' analysis*

70 These jobs include cultivating *Bambusa balcoa* across ~15,000 ha in Odisha and integrating it into Odisha's bamboo-based industries such as *agarbatti*, furniture, housing, packaging, ethanol, and activated charcoal in 2030.

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in bamboo-based products

To utilise degraded lands by growing suitable bamboo species on ~15,000 hectares of cultivable wastelands, enhancing soil biomass and increasing carbon sequestration capacity.[71]

To unlock new market avenues for bamboo products (Patel et al. 2019), such as public housing and bamboo-based packaging, while also expanding the export potential of conventional bamboo-based products like agarbatti sticks.

To establish Odisha as a design and innovation hub (Patel et al. 2022) for bamboo-based products in the eastern zone by leveraging its large base of highly skilled artisans with extensive indigenous knowledge of bamboo processing.

To empower women-led small-scale enterprises (Datta et al. 2016), such as those producing bamboo mats and sticks, providing women with a stable source of income and improving their social status.

Inspiration from a success story

Bamboostan, a Guwahati-based start-up, is building a robust bamboo supply chain in the Northeast by procuring raw bamboo from farmers and processing it into beams, sticks, slats, and other products for the construction and paper industries. Bamboostan procures nearly 24,000 MT of raw bamboo annually from local farmers to ensure a steady supply of standardised bamboo products to private players. This creates value for local communities by providing a steady income as well as livelihood opportunities.[72]

Departments that could support in scaling bamboo-based products

- Odisha Bamboo Development Agency
- Odisha Rural Development and Marketing Society
- Micro, Small, and Medium Enterprises Department
- Department of Housing and Urban Development
- Science and Technology Department
- Skill Development and Education Department

Source: Authors' analysis

71 The *National Bamboo Mission* promotes wasteland development through bamboo plantations. Although this analysis covers only a small percentage (3.1 per cent) of the total cultivable wasteland, it is essential to undertake baseline studies on the socio-ecological impacts and the selection of native bamboo species suitable for Odisha to ensure that the wasteland ecology is not disturbed.

72 Based on stakeholder consultations

Overcoming challenges to scale bamboo-based products

Demand and supply–related challenge/s	Proposed interventions
Limited demand for bamboo products and an inconsistent supply of standardised products (Patel et al. 2022; APN-GCR 2020)	The **Government of Odisha** can support manufacturers by spurring initial demand for bamboo-based products in public sector initiatives, such as installing bamboo road dividers and furniture in public spaces. The **H&UDD** can promote bamboo as a construction material among builders and developers by mandating that a certain percentage of government housing projects use bamboo as the primary raw material through targeted policies. Additionally, the **MSME Department** could play a pivotal role in supporting the **Odisha Bamboo Development Agency (OBDA)** by collaborating with incubators like Sambalpur University and KIIT-TBI, as well as initiatives such as *Start-up Odisha* to support bamboo-based start-ups during the R&D phase.
R&D–related challenge/s	**Proposed interventions**
Lack of R&D on diverse bamboo applications, product designs, and manufacturing processes prevents cultivators, entrepreneurs, and bamboo-dependent communities from fully utilising bamboo	The **Science and Technology Department,** the **OBDA,** and the **Indian Council of Forestry Research and Education (ICFRE)** need to explore novel and diverse industrial applications of bamboo, such as composites and fibres. They should identify the most suitable bamboo species for each application and determine the preferred areas for cultivation. The **Science and Technology Department** could improve technology promotion and dissemination by specifically focusing on bamboo in incubators supported by the department and in other government programmes. The **private sector** can be crucial in addressing functional gaps in scaling up the bamboo value chain by innovating product designs and improving quality to meet customer needs.
Awareness-related challenge/s	**Proposed interventions**
Limited awareness of bamboo products among architects, entrepreneurs, practitioners, and other value chain actors, particularly regarding its use in the construction and furniture industries[72]	The **OSDA** could collaborate with the **Building Materials and Technology Promotion Council (BMTPC)** and the **Construction Skill Development Council of India** to align consumer needs with manufacturing capabilities. This could be done by facilitating interactions between designers, architects, builders, and the bamboo industry and integrating bamboo into architecture and design curricula through specialised training programmes and workshops to address the current lack of awareness about its diverse uses. **Private players** and CSOs could also engage with the **OSDA** and the **ORMAS** to ensure that skilling initiatives and FPOs align with industry needs.

Process-related challenge/s	Proposed interventions
Higher transportation costs owing to bamboo's physiology and higher GST compared to conventional products skew the cost-benefit ratio and reduce the competitiveness of bamboo products (Patel et al. 2022)[72]	**Industry groups** and **CSOs** should advocate for lowering the GST on bamboo products to bring down costs and enhance competitiveness. The **Ministry of Finance** could implement these tax changes to support the growth of the bamboo industry. **Private players** could establish manufacturing units closer to cultivation areas and secure long-term contracts with FPOs cultivating bamboo through local CSOs, ensuring the year-round availability of cheap raw materials. **CSOs** can also help **private players** by promoting simple hand-held mechanical equipment among bamboo farmers, enabling them to process raw bamboo into splinters on-site. This increases the loading capacity of bamboo per ton for transport to manufacturing units.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of bamboo-based products

The adoption of large-scale bamboo monocultures on wastelands raises significant environmental concerns, particularly related to biodiversity loss (Bowyer 2014). These risks are compounded by the unclear classification and ecological importance of wastelands (Kar et al. 2024; Varma 2017). Using chemicals such as CCB[73] during processing can harm human health and biodiversity, while poorly designed bamboo charcoal production units could increase GHG emissions. Cultivating bamboo solely for bioenergy purposes can lead to inefficient land use and resource inefficiency. To mitigate these risks, it is important to conduct detailed EIAs before repurposing wastelands for bamboo cultivation, as they often serve as habitats for endemic species such as striped hyenas. Moreover, only diverse native bamboo species should be grown on these wastelands through mixed cropping or agro-forestry. It would also be important to transition to eco-friendly alternatives such as neem oil (Kaur et al. 2016) during processing and strictly monitor charcoal production units. Prioritising use of bamboo for product-based applications over energy usage can ensure efficient resource optimisation and minimise environmental impact (Stegmann, Londo, and Junginger 2020).

73 Copper chrome boron (CCB) is a common chemical used as a preservative during bamboo processing.

3.3.5 Compressed biogas

Compressed biogas (CBG) is a RE source produced by compressing purified biogas, typically derived from the anaerobic digestion of organic matter, making it suitable for use as a fuel in vehicles and for various energy applications (Dey and Thomson 2023).

Opportunities for 2030

~21,000* FTE jobs[74]
against 648 TPD of CBG deployment in 2030

INR ~1,000 crore (USD 120 million)*
the estimated market opportunity in 2030[75]

INR ~200 crore (USD 24 million)*
the estimated investment opportunity in 2030[76]

*Source: *Authors' analysis*

74 These FTE jobs include activities spanning across the following phases: feedstock collection and aggregation, construction and commissioning of CBG plants, and operations and maintenance of CBG plants.

75 The market opportunity is calculated by multiplying the total volume in cubic metres of biomethane to be produced in 2030 by the CBG procurement price set by the government.

76 The investment opportunity is calculated by multiplying the CAPEX required to set up one plant by the total number of plants needed to be set up.

Why should Odisha invest in CBG?

To reduce reliance on natural gas and enhance energy security by meeting approximately 13 per cent of Odisha's total natural gas requirements by 2030 through CBG.[77]

To drive the growth of localised circular bio-economies in agriculture through CBG production. For instance, a single 1 TPD CBG plant can save Odisha approximately INR 1.5 crore in fertiliser subsidies by converting bio-slurry, a by-product of CBG production, into fermented organic manure (FOM),[78] an organic fertiliser (GT 2024).

To reduce GHG emissions and improve air and water quality through effective waste management (Sakthivel et al. 2024).

Inspiration from a success story

Banas Dairy's 40-TPD industrial-scale CBG plant in Banaskantha, Gujarat, has a digester with a volume of 3,000 cubic metres that produces ~300 MT CBG annually. Slurry from the plant is processed further to obtain an organic fertiliser and is sold to farmers as a replacement for diammonium phosphate (DAP)[79] at one-third of the subsidised DAP price. The project has increased income and job opportunities for farmers who sell dung. It has also provided other co-benefits, such as improved hygiene and sanitation in the village and lower GHG emissions (TNRDPRD 2021).

Departments that could support in scaling compressed biogas

- Department of Agriculture and Farmers' Empowerment
- Fisheries & Animal Resources Development Department
- Department of Skill Development and Technical Education
- Department of Energy

Source: Authors' analysis

77 Author's analysis as a percentage of Odisha's total natural gas consumption that can be replaced by CBG by 2030 based on Odisha's capacity to produce 648 MT of CBG per day.

78 FOM, or fermented organic manure, refers to the digestate left over from the biogas production process in a CBG plant, which farmers can use as an organic fertiliser to replenish low soil organic carbon levels.

79 DAP is used as a chemical fertiliser to promote plant growth.

Overcoming challenges to scale CBG

Feedstock handling and slurry management–related challenge/s	Proposed interventions
Difficulty in ensuring an affordable and steady supply of feedstock (EAC 2023)	The **OREDA**, along with the **Department of Agriculture and Farmers' Empowerment,** could conduct community-level mapping of potential feedstocks to identify areas with abundant raw materials, such as dairy pockets. The **Department of Agriculture and Farmers' Empowerment** could help establish a robust pricing mechanism for feedstock accessibility and affordability. **CSOs** can assist in forming FPOs and facilitating feedstock supply to CBG plant operators using a hub-and-spoke model. The **Department of Agriculture and Farmers' Empowerment** could also facilitate long-term supply contracts between farmers and CBG plant operators. The **private sector** can collaborate with local FPOs and waste management entities through CSOs to ensure a steady supply of feedstock. They could also help in promoting the use of hand-held mechanical harvesters to ensure easy collection of good quality agri-based feedstock.
Challenges in managing and disposing of slurry (FOM) (PIB 2023c)	The **Fisheries & Animal Resources Development Department** could promote the use of animal waste as feedstock and facilitate its collection and transportation. To further promote slurry utilisation, the department could collaborate with **SAUs** and local **CSOs** to mainstream bio-manure usage among farmers. **Fertiliser PSUs** could support large biogas plants by branding and marketing FOM/PROM[80] and establishing long-term procurement contracts for organic fertilisers.
Skill-related challenge/s	**Proposed interventions**
Lack of a skilled workforce for biomethane production and distribution (Jagtap and Dalvi 2021)	The **OSDA** could implement training programmes for technicians and workers by integrating biogas-related modules into existing skill courses across technical domains. It could also actively utilise MNRE's **biogas development and training centres** (BDTCs) to conduct training programmes on the modules developed, making them hubs for equipping workers with the necessary skills and facilitating job placements. **CBG plant operators** need to engage closely with the OSDA and share employment potential, map skilling gaps, and design skilling programmes.[81] **CSOs** can coordinate with skilling programme coordinators to ensure that local communities acquire the necessary skills for getting jobs in the biomethane sector (feedstock aggregator and CBG machine operator jobs).
Finance-related challenge/s	**Proposed interventions**
Limited financing options and high interest rates charged by private banks (Nandigama 2023)	**Private-sector banks** should include more banks that are under priority sector lending and offer loans at lower interest rates. The **OREDA** could communicate information about lower lending rates and the banks offering them to a wider range of CBG producers, facilitating the entry of more entrepreneurs to the sector.

80 PROM, or phosphate-rich organic manure, is a valuable co-product generated in CBG plants that can be used as an organic fertiliser.

81 Based on stakeholder consultations.

Challenges related to high machinery import reliance	Proposed interventions
High dependency on the import of plant and machinery, highlights the need for indigenisation of manufacturing (Nandigama 2023)	**The private sector** could play a crucial role in supporting **CBG plant operators** by investing in the manufacturing of CBG components, such as biogas digesters, purification systems, and other essential machinery, to support the domestic production of CBG equipment.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of CBG

As more CBG plants are established, the demand for feedstock will rise, resulting in increased prices. This could act as an impetus for potential land diversion to cultivate bioenergy crops, leading to inefficient land use and higher GHG emissions (Searchinger and Heimlich 2015). Prioritising organic waste streams, such as dung, over the cultivation of bioenergy crops as potential feedstocks (Nandigama 2023) can counteract this and support climate mitigation goals as well. Further, potential methane leaks from these plants could counteract climate benefits due to methane's high global warming potential. Therefore, strict monitoring and maintenance (Dahlgren 2022) of CBG plants by implementing continuous monitoring systems and adopting advancing sealing technologies is crucial to prevent such leaks. Additionally, the possibility of export of good-quality biomass can lead to domestic shortages, which could impact the economic viability of these plants. To mitigate these risks, export restrictions should be imposed on biomass, which will ensure its availability for domestic use (Nandigama 2023).

3.3.6 Agroforestry

Agroforestry (AF) is a land-use system and technology in which woody perennials (trees, shrubs, palms, bamboo, etc.) are deliberately planted on the same land as agricultural crops and/or on land used by animals, in some form of spatial arrangement or temporal sequence (FAO 2008). Odisha could adopt AF as a viable long-term strategy to reach a targeted forest cover of 43 per cent (Kumar, Hooda, and Bahadur 2016).

Opportunities for 2030

~1,36,000 direct FTE jobs
against AF adoption across 41,700 sq.km by 2030*,**,[82]

INR ~4,900 crore (USD 590 million)*
the estimated market opportunity in 2030 (ICAR-CAFRI 2015)*,[83]

INR ~29,000 crore (USD 3,500 million)*
the estimated investment opportunity by 2030 *,[84,85]

*Source: *Authors' analysis. **Authors' analysis of (FAO 1985)*

82 30,500 FTEs for 5000 sq. km of fallow land; 1,05,500 FTEs for 36700 sq. km of crop land

83 Based on the benefit to cost ratio range calculated for 24 different agroforestry models – 1.01–4.17. Here, 1.01 was used as a conservative factor to calculate market opportunity in 2030

84 The investment opportunity is calculated based on the total investment required to produce planting material, plant, and maintain the agroforestry system for four years until it becomes self-sustainable (validated by stakeholder consultations).

85 Based on stakeholder consultations

Image: Dr. J.R. Jat, ICRD (for illustrative purposes only)

Why should Odisha invest in agroforestry?

To arrest agricultural land degradation.

To achieve land neutrality by rehabilitating 28.79 per cent of its degraded agricultural land (GoO 2020); increase the state's crop productivity by 20–60 per cent while reducing input cost (CAFRI 2020); and increase its carbon sink (Forest, Environment and Climate Change Department n.d.).

To unlock nature finance for increasing farm incomes by claiming credits for increased soil carbon by 21 per cent per hectare and reduced freshwater pollution by preventing nitrogen and phosphorus groundwater leaching by up to 97.7 per cent and 90 per cent, respectively (Muchane et al. 2022).

To enable a diversified, secure, and sustainable raw material base for timber-based industries, such as paper and pulp, the furniture industry, and bamboo-based industries and contribute to reducing India's import dependence on timber.

Inspiration from a success story

The Wadi AF system, promoted by the BAIF Development Research Foundation in Maharashtra, integrates multipurpose trees and fruit and nut trees within agricultural fields. This model improves soil and water conservation through the use of trenches and bunds. The programme was implemented from 2001 to 2005 and saw a 64 per cent adoption rate among eligible farmers. Each Wadi typically included 0.4 ha of land with an average of 43 surviving fruit trees per farm, primarily cashew, mango, and amla. This system increased tree cover, reducing the community's reliance on local forests for fuel wood. As regards its socio-economic benefits, 48 per cent of adopters reported income from fruit yields, and the programme helped mitigate distress migration. The key to its success was the five-year technical support, provision of free planting materials, and community-based planning, which aligned local needs with conservation goals (Doshi, Brockington, and Brook 2015).

Departments that could support in scaling agroforestry

- Department of Agriculture and Farmers' Empowerment
- Odisha State Agricultural Marketing Board
- Forest, Environment & Climate Change Department
- Department of Co-operation

Source: Authors' analysis

Overcoming challenges to scale agroforestry

Socio-economic challenge/s	Proposed interventions
Lack of information and availability of financial mechanisms for smallholders (Beetles et al. 2021)	The **Department of Agriculture and Farmers' Empowerment** with the **ICAR–CAFRI** (a nodal agency of AF in the state) could develop standardised risk assessments and implement technological solutions for data collection to improve lender confidence in the adoption of the AF system by smallholders. The **NABARD** and **cooperative banks** could develop specialised credit mechanisms for AF projects, including loans without collateral and zero-interest credit, to avail certifications that enable market linkages and fair trade. Additionally, **CSOs** could provide financial literacy training to farmers to improve their access to formal financial channels for better credit access for AF systems.
The absence of formal land tenure systems combined with the reduced size of operational holdings (UNDP 2008)	The **Department of Agriculture and Farmers' Empowerment** could collaborate with the **Department of Land Resources** to streamline and digitise land records through initiatives such as the *Bhulekh* portal for transparent resolution of land tenure conflicts. Additionally, **CSOs** could mobilise farmers' support for AF through collectivization and promote community-based AF models on common lands, especially for the long-term sustainability of AF projects.
Implementation/design-related challenge/s	**Proposed interventions**
Lack of availability and access to quality planting material (QPM) (NAP 2014)	The **Department of Agriculture and Farmers' Empowerment,** the **Directorate of Horticulture,** and the **ICAR–CAFRI** could develop standards for the development of AF quality planting material (QPM) by providing prescriptions of species-wise-appropriate planting seasons and seedling ages for planting. The **ICAR–CAFRI** could develop certification processes for nurseries and establish quality control methods for the production of planting materials. In addition, the **Odisha State Agricultural Marketing Board** could expand to develop input-based market linkages to enable equitable access to QPM.
Poor integration of socio-economic needs and capacities for implementation of AF project plans (Mathur et al . 2020)	The **Department of Agriculture and Farmers' Empowerment,** in collaboration with the **Odisha University of Agriculture & Technology (OUAT**), could conduct region-specific baseline studies of existing capacities and develop land suitability analysis on AF at the farm level. District and block-wise yearly dissemination of information on capacities and land suitability analysis must be done by developing applications for remote access with the help of the **Science and Technology Department** and **CSOs.** The **Forest, Environment & Climate Change Department,** the **Department of Agriculture and Farmers' Empowerment,** and the **ICAR-CAFRI** could develop a repository of AF models with AF species suitable at the landscape level, considering biophysical limits. Additionally, **CSOs** could facilitate participatory design processes involving local stakeholders to ensure that AF models align with local needs and biophysical conditions**.**

Market challenge/s	Proposed interventions
Underdeveloped market linkages (Kristina, Adser and Loibl 2020)	The **Department of Co-operation** could develop incubation centres through the **Odisha State Agricultural Marketing Board** to ensure branding, certifications, and marketing strategies for cooperatives and FPOs for AF based products. The **ORMAS** could assist in developing market linkages and value chains for AF products. The **private sector** could engage in contract farming and sustainable sourcing practices to create demand for AF products by ensuring financial support for certifications and assured buy-back policies.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of agroforestry

Natural hazards such as cyclones and floods can severely impact early-stage AF, causing significant economic losses for farmers.[85] Small and marginal farmers might be particularly vulnerable to these risks as well as pest infestation risks in monoculture plantations. In addition, AF systems could introduce new niches for pests and diseases, which could challenge traditional pest control methods. This would require innovative, ecologically sensitive solutions (Schroth et al. 2000).

Solutions could include developing financing mechanisms to provide insurance cover for early-stage AF against losses caused by natural hazards. To control pests and diseases, integrated research that makes use of farmers' knowledge, takes into account pest–predator dynamics, and considers natural biocontrol mechanisms could be helpful. Other mitigation measures could involve adopting comprehensive management strategies, including host and vector management, tending operations, and avoiding monoculture in block plantations.

3.3.7 Ecological mangrove restoration

Ecological mangrove restoration (EMR)[86] is the process of repairing damage caused by humans to indigenous mangrove ecosystems (Jackson, Lopoukhine, and Hillyard 1995; World Rainforest Movement 2010), enhancing storm and cyclone protection, carbon sequestration, and biodiversity (Teutli-Hernández et al. 2020). Given Odisha's high and medium coastal vulnerability indices (CVIs)[87] and its susceptibility to cyclones, floods, and sea-level rise, mangrove restoration becomes pertinent. With a 450 km coastline and an area of 1,55,707 sq. km. (Government of Odisha n.d.a), Odisha could leverage its coastline's potential to support mangrove ecosystems and boost its coastal hazard resilience.

Opportunities for 2030

~2,200 FTE jobs*[88]
can be generated by restoring 84 sq. km. of open mangrove cover area[89] by 2030

INR ~8 crore (USD 1 million)
the estimated market opportunity in 2030*[90]

INR ~130 crore (USD 16 million)
the estimated investment opportunity by 2030*[91]

*Source: *Authors' analysis*

86 The restoration process followed uses globally acknowledged principles of restoring ecology.

87 The Indian National Centre for Ocean Information Services classifies nearly 400 km of Odisha's coast as vulnerable to coastal hazards; of this, 297 km is classified as 'medium', and 107 km along northern Puri and other areas is deemed 'high' risk (MoEFCC 2018).

88 The FTE job activities include QPM production, nursery management, site preparation, plantation, and maintenance and conservation for a five-year implementation period.

89 The mangrove cover area includes the total open mangrove cover of 84 sq. km. across the state as per the *India State of Forest Report 2021*, which is considered eligible for restoration (Forest Survey of India. 2021b).

90 The market opportunity is calculated using the carbon sequestration potential of 84 sq. km. area under restoration in 2030.

91 The total investment opportunity includes labour costs, establishment costs of nurseries, costs of planting, and costs of other materials required for activities for a five-year implementation period.

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in EMR?

To implement an efficient means of protection against coastal and climate hazards, rather than investing in built-up protective infrastructure. This can be achieved by leveraging mangrove restoration, which is estimated to have a four times higher return on investment (UNEP 2021).

To become only the second state in India to declare a mangrove biodiversity heritage site by harnessing the potential of hosting the highest diversity of mangrove species in mainland India and enabling their conservation through restoration (Kathiresan 2010).[92]

To sequester up to five times more carbon than forests on land (UNEP 2021) by increasing the state's contribution to Nationally Determined Contributions through total carbon sink enhancement using EMR, as mangroves act as potent carbon sinks.

Inspiration from a success story

The Action for Protection of Wild Animals (APOWA) facilitated a successful community-led mangrove restoration project in Kendrapara and Basantpur. This project transformed 12 hectares of degraded mangroves, enhancing the self-sufficiency of these villages and ensuring food security and livelihoods for the coastal communities. The ten village mangrove councils, which were established with women at the helm, produced and planted 48,000 saplings, leading to a tenfold increase in fodder production within two years and creating 560 man-days of work, boosting the local economy. The restoration model was centred on building coastal resilience through capacity development and stewardship enhancement to restore and protect the mangrove cover of the region (APOWA 2013).[93]

Departments that could support in scaling EMR

- Forest, Environment & Climate Change Department
- Revenue and Disaster Management Department
- Rural Development Department
- Fisheries & Animal Resources Development Department
- Department of Agriculture and Farmers' Empowerment

Source: Authors' analysis

92 EMR can help protect 11 of the 70 mangrove species worldwide that are at an increased risk of extinction, including two species found in Odisha – *Sonneratia griffithii* (critically endangered) and *Heritiera fomes* (endangered).

93 Based on stakeholder consultations

Overcoming challenges to scale EMR

Technological/technical challenge/s	Proposed interventions
Lack of scientifically designed restoration guidebooks and absence of bio-resource repositories[93]	The **Forest, Environment & Climate Change Department,** along with the **National Centre for Sustainable Coastal Management (NCSCM)** and the **Central Marine Fisheries Research Institute (CMFRI),** could conduct biophysical resource mapping to align restoration efforts with ecological realities. The **Odisha Coastal Zone Management Authority** could map degraded mangrove forests and potential restoration sites. In addition, the Forest Department could collaborate with **scientists and technical experts** to develop guidelines and SOPs for the communities and village-level institutions regarding appropriate site selection and restoration techniques. The department could also commission the development of key performance indicators to continue monitoring and verifying the restoration activities.
Socio-economic challenge/s	**Proposed interventions**
Inadequate integration of community aspirations and mobilisation (Minchinton et al. 2019)	The **Forest, Environment & Climate Change Department** could establish long-term affiliations and community institutions for ownership of restoration projects. In addition, **CSOs** could facilitate community mobilisation and participation in restoration efforts by utilising the community-based incentives offered by the government's Mission Shakti**,** the **Rural Development Department,** the **Fisheries and Animal Resources Development Department,** and the **Department of Agriculture and Farmers' Empowerment.** These agencies could assist the **Forest, Environment & Climate Change Department** in developing community-led restoration models based on livelihood generation, such as beekeeping or aquaculture development.
Poor redressal of current land use and land tenure issues (Kathiresan 2010)	The **Revenue Department** and the **Forest, Environment & Climate Change Department** could collaborate to address land tenure issues and illegal aquaculture farms. The **Forest, Environment & Climate Change Department** could develop innovative solutions to ensure the long-term availability of land for mangroves through financial incentives provided annually to landowners. **CSOs** can play a vital role in engaging with communities to aid site selection and long-term management for sustainable governance.
Anthropogenic challenge/s	**Proposed interventions**
De-prioritisation of restoration due to the increasing expansion of port–industry complexes and aquaculture (Agarwal et al. 2017).	The **Fisheries and Animal Resources Development Department** could develop sustainable aquaculture management guidelines in mangrove ecosystems and develop traceability mechanisms. The **Forest, Environment and Climate Change Department** and the **Revenue Department** could control illegal mangrove conversion through stringent regulation, penalties, and periodic checks.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of EMR

EMR is a complex, time-sensitive process prone to failures due to various ecological risks involved in converting vital ecosystems such as salt marshes (Mishra et al. 2024) into mangroves. Likewise, socio-economic risks arise from excluding the needs and aspirations of the community during restoration, which may lead to destruction-associated failures (APOWA 2013). Climatic risks, including natural hazards, can cause failures early in the restoration process and require robust financial provisions such as insurance cover or buffer funds in the finances allocated for the project.[93]

Mitigating ecological, socio-economic, and climatic risks involves robust bio-resource and ecosystem suitability mapping. Furthermore, community-led models can ensure the long-term success of the projects. In addition, early warning systems may also help mitigate and manage the impact of natural hazards.

3.3.8 Seaweed cultivation

Seaweeds are macroscopic algae classified into red, blue, and green based on their pigmentation. They are found in marine, shallow coastal, and brackish water habitats (Mantri et al. 2019). *Gracilaria* and *Kappaphycus alvarezii* are traditional sources of food, feed, and fibre for coastal communities, yet they remain commercially underutilised owing to a lack of awareness (Marine Stewardship Council n.d.).

Opportunities for 2030

~1,08,000 FTE jobs[94]
against ~26,000 hectares of seaweed cultivation in 2030*

INR ~800 crore (USD 100 million)*
the estimated market opportunity in 2030[95]

INR ~1,100 crore (USD 130 million)*
the estimated investment opportunity in 2030[96]

*Source: *Authors' analysis*

94 The FTE jobs include cultivating *Kappaphycus alvarezii* and *Gracilaria* seaweed species in ~1,400 hectares along Odisha's coast and 25,000 hectares in Chilika, Odisha.

95 The market opportunity is calculated by multiplying the average price of one kg of dried seaweed by the estimated total amount of dried seaweed that might be cultivated in 2030.

96 Total investment opportunity includes the capital expenditure required to establish seaweed cultivation plots, which includes ropes, anchors, floats, and fishing nets.

Why should Odisha invest in seaweed cultivation?

To position Odisha as a leader in seaweed cultivation on the eastern coast by meeting the growing demand for carrageenan and agar, which are crucial for the food, feed, pharmaceutical, cosmetic, and biotech sectors (Lomartire and Gonçalves 2022).

To improve livelihood opportunities for fishing communities, particularly women and tribal communities; seaweed cultivation is a good alternative livelihood option because it has a short cultivation period with low entry barriers (Krishnan and Narayanakumar 2013).

To leverage seaweed's CO_2 absorption capacity for supporting carbon sequestration and emission reduction while enhancing marine habitats and mitigating coastal erosion and flooding. Seaweed also acts as a natural nutrient scrubber (ICAR 2018).

Inspiration from a success story

In Chilika Lake, Odisha, approximately 100 trained individuals, particularly women, cultivate Gracilaria, which is indigenous to the area near Balugaon. The seaweed matures for harvesting within just 45 days of planting, enabling cultivators to earn up to INR 10,000 per month from a 10-acre underwater area. Besides providing a reliable source of income, this initiative has empowered the local community, restored the water's capacity for carbon absorption, and improved overall water quality.[97]

Departments that could support in scaling seaweed cultivation

- Fisheries & Animal Resources Development Department
- Odisha State Pollution Control Board
- Science and Technology Department
- Skill Development and Technical Education Department

Source: Authors' analysis

Overcoming challenges to scale seaweed cultivation

Seaweed farm management–related challenge/s	Proposed interventions
Limited commercial cultivation practices owing to inadequate infrastructure and a lack of policy support (NAAS 2003)	The **Fisheries and Animal Resources Development Department** could support seaweed cultivation by offering investment incentives, transferring technology to entrepreneurs, and establishing a seaweed park. The **Science and Technology Department**, in collaboration with **CSIR-CSMCRI**, could invest in research on high-yielding varieties, improve cultivation methods, and explore novel applications. Additionally, **CSIR-CSMCRI** could support the **Fisheries and Animal Resources Development Department** by training seaweed farmers and setting up cultivation plots.
Deteriorating farming environment and recurrent shortages of seedlings limit scaling up (Anilkumar 2022)	The **Fisheries and Animal Resources Development Department** could collaborate with **CSIR-CSMCRI,** the **Science and Technology Department,** and **private actors** to develop seed banks in PPP mode, devise efficient cultivation methodologies, and propagate high-yield varieties among seaweed farmers.

97 Based on stakeholder consultations

Unregulated shrimp operations pollute waters and impact seaweed cultivation (Bull et al. 2021)	In partnership with the **OSPCB,** the **Fisheries and Animal Resources Development Department** could implement coastal management plans and enforce zoning regulations. **CSOs** could create awareness among fishing communities on sustainable cultivation practices and the importance of protecting the marine environment.
Skill-related challenge/s	**Proposed interventions**
Lack of trained manpower and entrepreneurs[97]	The **OSDA** could collaborate with **CSIR-CSMCRI** and **CSOs** to conduct training and awareness campaigns on seaweed cultivation for coastal communities. Together with effective marine spatial plans and leasing policies, these efforts would help attract younger farmers by showcasing the profitability and sustainability of seaweed farming. Such efforts can raise the overall awareness of seaweed-driven industries among local communities and help them gain insight into potential of industrial utilisation of seaweed.
Regulatory challenge/s	**Proposed interventions**
Lack of regulation leads to unsustainable harvesting of wild seaweed, depleting natural populations and reducing biodiversity (Mantri et al. 2022)	The **Fisheries and Animal Resources Development Department** could incentivise entrepreneurs to export only cultivated seaweed by implementing strict export regulations that require proof of cultivation sources or imposing higher prices for cultivated varieties can discourage wild harvesting and promote traceability. The department, in collaboration with **CSOs**, could encourage coastal communities to participate in seaweed cultivation by providing training, technology dissemination, and financial assistance.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of seaweed cultivation

Odisha is vulnerable to extreme weather events, such as cyclones, which damage seaweed farms. These events are becoming more common due to climate change, impacting seaweed yields by shortening growing seasons and increasing water temperatures. Environmental risks include threats to marine life, as smaller animals like turtles can get entangled in nets. Poor seaweed farm management can spread diseases, leading to production failures. To mitigate these risks, researchers should focus on developing climate-resilient seaweed species and cultivation techniques; meanwhile, farmers should adopt adaptive farming techniques, thereby improving farm management (UNEP 2023). Encouraging the use of wildlife-friendly seaweed farming structures and enforcing strict monitoring can prevent damage to marine life. Implementing biosecurity measures, such as regular health checks and quarantine protocols for new stocks (Watsoncapps and Mann 2005), designing resilient structures, and developing early warning systems can mitigate the risk from cyclones and other climate change-induced weather events (Safdar et al. 2021).

3.3.9 **Sustainable forest management**

Sustainable forest management (SFM) aims to enhance the economic, social, and environmental value of all types of degraded and deforested forests to benefit present and future generations (FAO n.d.c; IUCN n.d.a). Three relevant and high-impact SFM practices that Odisha could adopt (MoEFCC 2014; MoEF 2006) are as follows:

- **Assisted natural regeneration (ANR)** is a flexible reforestation approach that enhances forest recovery by aiding natural succession processes while effectively boosting the productivity of deforested or degraded lands and their ecosystem functions (ANR Alliance 2023).
- **Forest fire prevention and management (FFPM)** aims to reduce the occurrence of large-scale forest fires and their impact on the environment while maintaining the ecological benefits of controlled burns by leveraging natural resource management techniques (NDMA 2022).
- **Terrestrial invasive alien species management (IASM)** is a process of controlling[98] or eradicating non-native species that threaten ecosystems, habitats, or other species (IUCN n.d.b).

Opportunities for 2030

~2,44,000 FTE jobs*,[99]
can be generated across ANR, FFPM, and IASM inside the recorded forest area (RFA) of 61,204 sq. km. by 2030 (Forest Survey of India 2021a).

INR ~3,300 crore (USD 390 million)
the estimated market opportunity in 2030*,[100]

INR ~14,000 crore (USD 1,700 million)
the estimated investment opportunity by 2030*,[101]

*Source: *Authors' analysis*

98 The three acceptable methods of IASM are as follows: chemical control, biological control and mechanical control. For our analysis, we are considering mechanical control methods only.

99 ANR and IASM implemented over 5 years can generate ~2,23,000 FTE jobs and ~ 3000 FTE jobs respectively. FFPM could generate ~18,000 additional jobs.

100 On completion of ANR implementation, non-timber forest produce (NTFPs) worth of USD 940 per hectare can be harvested leading to an annual income of USD 300 million in 2030. In 2030, FFPM implementation can generate carbon credits worth of USD 90 million owing to avoided emissions. IASM implementation will lead to USD 5 million worth of annual income in 2030 for the communities through harvested biomass utilisation.

101 ~USD 1,682 million to restore ~81 per cent of the degraded forests. USD 1700 million is required for implementing all SFM activities by 2030. The investment pool includes labor costs, input costs and logistical costs required across ANR, FFPM and IASM.

Image: CEEW (for illustrative purposes only)

Why should Odisha invest in SFM?

To increase the state's forest cover from 37 per cent to 43 per cent by 2030 (Forest, Environment and Climate Change Department n.d.) while arresting degradation, creating carbon sinks, and preserving the biodiversity of the state's forest area by leveraging ANR (costing one-fifth of the traditional afforestation cost),[102] FFPM, and IASM.

To avoid ecological losses while significantly reducing GHG emissions and managing air pollution as SFM practices make forests 40 per cent less susceptible to large forest fires.[103]

To conserve local biodiversity and enhance economic benefits to local communities (Abeysinghe et al. 2023) by becoming the only state with an action plan to control and manage invasive species.

To secure and enhance the livelihoods of 12 million people dependent (RCDC 2018) on the forest by enhancing forest productivity and ecological functioning using SFM, which will unlock opportunities for a Sustainable Forest Economy (The IOFE 2022).

Inspiration from a success story

An initiative by the Foundation for Ecological Security in Mandla, Madhya Pradesh, eradicated *Lantana camara* from 7,000 hectares, boosting agriculture and biodiversity in the region. Half the farmers now cultivate lands previously infested with this shrub, 94 per cent use these restored areas for grazing or fodder collection, and village common lands have seen an eightfold increase in fodder production. Forty-six per cent of farmers reported more forest produce and fewer human–wildlife conflicts, showcasing the IASM's wide-ranging benefits.

Departments that could support in scaling SFM

- Forest, Environment & Climate Change Department
- Department of Mission Shakti
- Finance Department
- Planning & Convergence Department

Source: Authors' analysis

102 Authors' analysis per the financial outlay declared in the Annual Plan of Operation (APO) 2023–24 by the Forest, Environment & Climate Change Department (CAMPA 2024)

103 Based on stakeholder consultations

Overcoming challenges to scale SFM

Technological/technical challenge/s	Proposed interventions
Limited integration of scientific principles of restoration across ANR, FFPM, and IASM (Chazdon and Guariguata 2016)[103]	The **Forest, Environment & Climate Change Department** could partner with research institutions to develop technical guidelines based on Chazdon's 10 principles of restoration. The department, in coordination with the **Science and Technology Department, CSOs,** and **ecologists**, could commission a bio-resource mapping exercise to ensure that projects are ecologically aligned. **CSOs** and **implementing agencies** could add to this by developing a state-wide repository of successful restoration case studies.
Absence of technical and scientific capabilities and skills for restoration[103]	The **ODSA**, in consultation with **CSOs** and **experts**, could collaborate with the **Forest, Environment & Climate Change Department** to develop training programmes, modules, and diplomas in restoration and ecosystem management for local communities in vernacular languages. Further, Mission Shakti, the **ST & SC Development, Minorities & Backward Classes Welfare Department**, and the **Rural Development Department** could ensure integration of OSDA's training as part of their livelihood programmes so that each community institution (VSS or eco-development committees (EDC)) has at least one certified **community-based ecosystem manager.**
Implementation challenge/s	**Proposed interventions**
Lack of QPM for restoration[103]	The **Forest, Environment & Climate Change Department** could develop SOPs for forest-based seed collection and local species nursery management. The department should also mandate that restoration activities use only locally sourced planting material. **CSOs** must engage with biodiversity management committees (BMCs), VSSs, and EDCs to augment community-level knowledge of biodiversity. The **OSDA** and Mission Shakti could train **local communities** in quality seedling production and nursery management while supporting them in maintaining local biodiversity banks and specimens.
Insufficient departmental resources and expertise in FFPM (World Bank 2018)	The **Forest, Environment & Climate Change Department** could partner with the **Forest Survey of India** and **ecologists** to develop annual fire damage assessment frameworks and predictive modelling. This will help in making informed decisions about annual budgetary allocations and also help plan for the cyclical nature of forest fire damages based on biomass assessments. The **Finance Department** and the **Planning & Convergence Department** could make provisions for early disbursement of annual budgets for the FFPM months ahead of the annual forest fire season. These departments could develop seasonal co-management models with **forest fringe community institutions** through the disbursal of forest rights and financial and in-kind incentives.

Absence of data or resource information on the spread of invasive species	The **Forest, Environment & Climate Change Department** could collaborate with **CSOs** for ground-truthing and species identification through community engagement and developing indigenous knowledge repositories. The **Odisha Biodiversity Board** could become a nodal department to integrate resources from Access and Benefit Sharing (ABS) for aiding IASM at the community level, apart from undertaking quarterly ecosystem assessments and empowering BMCs to lead IASM work.
Economic challenge/s	**Proposed interventions**
Inadequate monetization and economic benefits derived from SFM practices (Michon et al. 2007)	In partnership with Start-up Odisha**,** Mission Shakti**,** and the **Odisha Forest Development Corporation (OFDC),** the **Forest, Environment & Climate Change Department** could be encouraged to develop business models using non-timber forest products (NTFP) to attract investments from th**e private sector** for restoration work.
Inconsistent community stewardship and engagement	The **Forest, Environment & Climate Change Department** could enhance the agency of communities for restoration through the legalisation of community institutions and ensure the disbursal of forest rights through Ama Jungle Yojana**. CSOs** could assist in mobilising long-term community support for restoration. The **private sector** could also partner with CSOs and communities to ensure the long-term sustainability of the restored area through nature financing tools, such as payment for ecosystem services, and disseminating about various economic models for restoration within communities.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of SFM

SFM practices are technically challenging and time-sensitive, requiring implementation in the appropriate season and as per the area's biophysical attributes (Chazdon and Guariguata 2016; Chazdon et.al 2023). Any deviations can alter ecosystems and harm biodiversity, causing degradation. Additionally, misaligned conservation goals and community needs pose significant socio-economic and ecological risks, further exacerbating degradation.

Mitigation requires a community-centric approach in SFM project planning and execution by engaging forest-dwelling and local communities in all phases of the project to align their needs with conservation goals (Vasundhara Odisha, n.d.). Building localised technical restoration capacities by leveraging indigenous ecosystem knowledge becomes critical to ensure successful restoration. However, resolving land tenure issues, granting community forest rights, and empowering community-based institutions such as *Van Suraksha Samities* (VSS) and eco-development committees (EDC) through legal recognition becomes inevitable for long-term sustenance of the restored area and conservation (Foundation for Ecological Security 2016).

3.3.10 Sustainable tourism

Embracing sustainable tourism involves conscientiously considering the present and future economic, social, and environmental impacts of tourism while catering to the needs of visitors, the industry, the environment, and host communities (UN Tourism, n.d.a). There are two critical types of sustainable tourism among the many types:

- **Ecological tourism, or ecotourism,** involves responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and provides education (The International Ecotourism Society 2015).
- **Rural tourism, or agri-tourism,** involves visitors experiencing a wide range of activities and products related to nature, agriculture, and a rural lifestyle and culture, including angling and sightseeing (UN Tourism n.d.b).

Odisha could leverage its agricultural and ecological landscape, which has garnered global and national recognition, to attract tourism inflow to the state, supporting both forest and agriculture-based livelihoods.[104]

Opportunities for 2030

~7,500 direct FTE jobs
against the development of ~1,500 sustainable tourism centres by 2030*,**,[105]

INR ~4,800 crore (USD 580 million)
the estimated market opportunity in 2030*,**,[106]

INR ~1,800 crore (USD 210 million)
the estimated investment opportunity by 2030*,**, [107,108]

*Source: *Authors' analysis **Stakeholder consultations*

104 The FAO has classified one of its agricultural systems as a 'Globally Important Agricultural Heritage System' (GIAHS) (FAO 2012). Additionally, the Odisha Government declared four 'Biodiversity Heritage Systems' in 2023 (PIB 2023d).

105 ~6000 FTE jobs can be generated through establishment of ~1400 ecotourism centres (Forest, Environment and Climate Change Department 2020). Similarly, ~1000 FTE jobs can be generated through establishment of ~130 agri-tourism centres.

106 USD 600 million of annual revenue can be generated through ~1400 eco-tourism centres with an average annual occupancy rate of 25 per cent. Similarly, USD 20 million of annual revenue can be generated through ~130 agri-tourism centres with average annual occupancy rate of 50 per cent.

107 Estimates are based on the investment required for construction and infrastructure set-up for the hospitality and activities at each tourism centre. It does not include operational costs.

108 USD 200 million worth of investments will be required to set up ~1400 ecotourism centres with 10 dual-occupancy rooms and ~130 agri-tourism centres with six dual-occupancy rooms.

Image: iStock.com (for illustrative purposes only)

Why should Odisha invest in sustainable tourism?

To create resilient alternative income sources for forest-dwelling communities and farmers by leveraging 39 per cent of the total geographic area (TGA) under forest area, 37 per cent forest cover, and 40 per cent cultivable land (Finance Department 2023), of which 14 per cent is under agroforestry (Gupta et al. 2021).

To become the first state to develop a sustainable tourism policy by diverting at least 25 per cent[109] of the tourists towards low-carbon-footprint tourism practices.

To preserve indigenous cultures and community-based environmental stewardship.

Inspiration from a success story

Spanning 30 districts with 328 agri-tourism centres, the Baramati Agritourism Centre in Maharashtra and its sister company, Agritourism Development Company (ATDC), received 1.63 million tourists in just three years, accounting for five per cent of the state's total tourism footfall in 2023.[110] It generated a substantial revenue of INR 3.5 crore for farmers' families and created valuable job opportunities in rural communities.

Departments that could support in scaling sustainable tourism

- Department of Tourism
- Department of Co-operation
- Department of Agriculture and Farmers' Empowerment
- Science and Technology Department
- Forest, Environment and Climate Change Department

Source: Authors' analysis

Overcoming challenges to scale sustainable tourism

Economic challenge/s	Proposed interventions
Income instability due to seasonal variability of sustainable tourism[111]	The **Department of Tourism,** in collaboration with Start-up Odisha, can enhance tourism offerings by leveraging the expertise of the **Indian Institute of Tourism and Travel Management.** Through tailored marketing and year-round tourism engagement campaigns, the collaboration can provide incubation support to local businesses, addressing income instability and fostering sustainable growth. In addition, the **Department of Tourism** could collaborate with **banking, financial services insurance enterprises, and cooperative banks** to develop insurance packages that address income disruptions caused by natural hazards or other external factors that may lead to a decrease in overall tourist footfall.

109 Authors' analysis

110 According to the ATDC survey conducted in 2014, 2015, and 2016, the agri-tourism centres collectively received 0.40 million, 0.53 million, and 0.70 million tourists, respectively.

111 Based on stakeholder consultations

Skill-related challenge/s	Proposed interventions
Lack of trained professionals in hospitality or enterprise management[111]	The **OSDA** could collaborate with the **Indian Institute of Tourism and Travel Management** to develop courses and diplomas on hotel management. The **OSDA,** in partnership with the **Forest, Environment & Climate Change Department,** could provide training and certification programmes for nature guides, camping guides, and birding field guides. In addition, the **Department of Tourism**, along with **hotels, restaurants, and café industry associations**, could organise workshops and seminars on best practices in hospitality, customer service, and sustainable tourism management.
Conformity challenge/s	**Proposed interventions**
Lack of verification mechanisms for sustainability claims undermining the authenticity of sustainable tourism (Netto et al. 2020).	To ensure compliance with sustainability principles, the **Department of Tourism** could enforce stringent certification policies and provide licences and codes of conduct, which should be coupled with regular monitoring. **CSOs** could enhance consumer awareness and education regarding genuinely sustainable practices and their positive impact on local communities and the environment. The **private sector** could foster partnerships between local communities, government agencies, and tourism stakeholders to develop responsible tourism initiatives through coalitions.
Inconsistent metrics for measuring tourism sustainability[111]	The **Department of Tourism,** in collaboration with the **Forest, Environment & Climate Change Department,** could develop standardised tools and methodologies for calculating and monitoring carbon emissions and evaluating nature-positive practices associated with sustainable tourism centres. **Government agencies** could implement capacity-building initiatives to train managers and stakeholders in the use of these tools, with support from the **Science and Technology Department** to support digital evaluations. **Academia, CSOs,** and **hospitality industry associations** could assist in integrating essential methodologies such as 'tourism carrying capacity', 'limits of acceptable change', and 'visitor impact management' into the sustainable tourism policy framework.

Source: Authors' analysis; stakeholder consultations

Risk-proofing the scale-up of sustainable tourism

Sustainable tourism can pose some environmental risks, primarily related to potential overcrowding and ecological disturbances. These risks may manifest in wildlife movement disruption, habitat degradation, and pollution from various sources, including litter, vehicle emissions, and wastewater.[111] In addition, safety and health risks are also a concern, particularly in natural settings where tourists might be vulnerable to accidents or injuries, such as from animal encounters or environmental hazards. According to Mohanty and Wadhawan (2021), a high risk of natural hazards could reduce tourism footfall. To mitigate these risks, the state could undertake capacity assessments, implement visitor limits, develop localised activity guidelines, and base tourism licences on eligibility and regulations. The state could also provide insurance cover for income loss resulting from unprecedented climatic events, train local communities in first aid, and enforce strict regulations with fines for violations of tourist behaviour and facility management guidelines.

A multi-departmental institutional mechanism guided by a common results framework is critical to realise the Green Odisha Initiative (The Lok Seva Bhavan is in the picutre).

Image: CEEW

4. Green Odisha Initiative: An action plan for mainstreaming the green economy in Odisha

The green economy offers immense potential for Odisha to achieve a low-carbon growth trajectory. To realise this potential, we propose an implementable action plan in the form of the GrOI. The action plan is unique as it calls for

- a **whole-of-government approach**. We propose an institutional framework for the GrOI, in which the host department is identified in addition to lead and allied departments. The framework also includes a common results tool/framework to plan and monitor progress.
- a **whole-of-economy approach**. We propose engaging with diverse stakeholders in the economy, including the government, the private sector, and civil society. We have outlined their specific roles and responsibilities to scale up the green economy in Odisha.
- a **whole-of-state approach**. We propose identifying and including value chains corresponding to the state's geographical spread as well as its physical and social diversity. While value chains such as bio-fibre and bio-inputs require the active engagement of SHGs, others, such as DRE technologies and seaweed cultivation, can significantly benefit tribal populations.

We propose an implementable action plan in the form of the Green Odisha Initiative to realise Odisha's green economy potential

4.1. Institutional mechanism for the Green Odisha Initiative: A whole-of-government approach

The green economy in Odisha will comprise three green economic sectors and 28 value chains. We, therefore, strongly recommend a multi-department engagement approach. Typically, climate action measures are associated with the mandates of specific government departments. However, given the scope and scale of the green economy, it is necessary to involve all major government departments in its planning and implementation. We have identified five lead departments and corresponding allied departments that would be critical to implementing the green economy through the GrOI. Annexure C includes a complete list of these departments.

As a multi-department engagement, the GrOI must be housed in a particular department to ensure efficient planning and coordination. Accordingly, we propose that the Planning and Convergence (P&CD) be the lead department and house the GrOI. The P&CD could serve as the ideal nodal department due to its official long-term economic development planning mandate and interdepartmental convening and coordination authority. As the nodal department, the P&CD can convene the relevant government departments to support the planning and implementation of the departments' respective value chains. We also recommend setting up a high-level special committee within the P&CD for overarching interdepartmental coordination with the mandate to mainstream the green economy in the state.

With the P&CD as the nodal department, the institutional framework for implementing the GrOI will include the following:

- A **high-level special committee** that will be* chaired by the chief secretary and comprise the principal secretaries of all lead departments and the state development commissioner. The special committee will also include the principal secretaries of other departments, such as the Finance Department and the Skill Development and Technical Education Department (SD&TED), which are crucial for the overall implementation of the initiative. The special committee will be convened each quarter and be responsible for the following:
  - Allocating budgets for different departments and centrally sponsored schemes to scale up green value chains and perform other aligned activities.
  - Developing and monitoring the common results framework (CRF) and ascertaining annual targets for all value chains.
  - Monitoring and evaluating the activities undertaken under the GrOI.
  - High-level policymaking to provide additional incentives to the private sector to scale up green value chains in the state.
  - All other tasks that may be required for the successful implementation of the initiative.
- A **lead department** will be assigned to each value chain, which will be responsible for its overall implementation and scaling up. This department must be chosen based on its mandate, resources, and capacity. When deciding on lead departments, it is paramount that they are assigned to value chains with converging or overlapping targets. The lead department will coordinate among its allied departments to promote and advance the value chain that it is leading.
- In addition to a lead department, one or more **allied departments** will be assigned to each value chain. These departments will be responsible for implementing specific sub-outputs mapped in the CRF and leveraging schemes and programmes falling within their mandate to benefit the GrOI.
- A **standing subcommittee** comprising directors of all lead, allied, and other relevant departments will also be set up. This standing subcommittee will support the special committee and be responsible for the day-to-day interdepartmental coordination required to implement the initiative. While the special committee will meet each quarter, the subcommittee will meet more frequently to ensure consistency and progress in implementing the GrOI. The chairperson of this subcommittee may be decided on a rolling basis.

A high level special committee chaired by the Chief Secretary and comprising principal secretaries of lead departments combined with a standing subcommittee will form the backbone of the institutional mechanism needed to deliver on the green economy

4.2. A common results framework for the Green Odisha Initiative

A CRF is necessary for the nodal, lead, and allied departments to achieve their common goal with clarity and accountability. We drafted a CRF at the value-chain level to guide the implementation of each value chain and set annual targets for realising the full potential of the green economy in Odisha. We identified the following key result areas for the CRF:

- Increase the demand and improve the delivery of GrOI-related schemes and entitlements to identified citizen groups and communities.
- Increase the capacity and commitment of the state to GrOI through capacity-building initiatives and partnerships with CSOs and private actors working for the green economy.
- Improve multi-sectoral planning and coordination as all relevant departments come together for harmonised delivery.
- Improve political commitment and leadership for GrOI, including dedicated governance infrastructure.

A common results framework is necessary for the nodal, lead, and allied departments to achieve their common goal with clarity and accountability

This CRF builds on several existing frameworks of the Government of Odisha, such as the Odisha Sustainable Development Goals (SDGs) Indicator Framework (OSIF) 2.0 (Planning and Convergence Department 2023), the SDG Budget (Finance Department 2021), and the Climate Budget 2023–24 (Finance Department 2023). The specific verticals of the CRF will include the following components for each value chain:

- **Lead departments and allied departments** will be responsible for identifying annual budgets, geographical hubs, and the overall scaling-up of the value chain while mitigating risks and challenges; these departments have been identified and listed in Annexure C.
- **Outcomes, outputs, and sub-outputs** are to be developed for the GrOI. Outcomes are high-level targets that the GrOI intends to achieve by promoting a specific value chain, and outputs and sub-outputs are particular activities and tasks that must be done to achieve the identified outcomes. These will be aligned with each other. To accelerate implementation, existing government **programmes and schemes will be mapped at the sub-output level**; existing programmes and schemes will help provide initial funding and implementation support to the GrOI. If there are no matching pre-existing schemes or programmes for specific sub-outputs, new ones may need to be designed. The special committee may allocate funds for the GrOI from a common pool of funds generated by combining allocations for existing schemes or allotting additional funding under existing budget heads. According to our estimates, approximately INR 1,750 crore[112] will be needed to skill the workforce for the GrOI, which is more than the total budget of INR 1,583 crore meant for the SD&TED (Finance Department 2024). Addressing this deficit will require additional financial allocation from either within the overall budget (adjusting it from other budget heads) or by increasing the overall budget itself.
- **SDGs and OSIF indicators** have been mapped to each value chain so that the outcomes, outputs, and sub-outputs can be aligned with these indicators to achieve Odisha's existing SDG targets. Consequently, initial funding for implementing green value chains can be derived from the state's existing SDG budget.
- **Annual targets** will track the percentage increase in green jobs, market size, and investments in green value chains within the state. Annual targets can contribute to each value chain reaching its total potential by 2030; depending on whether they are being met or not, the targets should be adjusted accordingly. The special committee on the green economy will be responsible for ascertaining these targets. Figure 4.1 provides an indicative CRF for the mangrove management value chain.

112 We considered the standard cost of training per hour for workers in a particular industry, and multiplied it to the standard number of hours prescribed by a public or private training institute. The total cost of training per person was then multiplied to the total number of potential jobs to be created to arrive at the final number of direct costs. For indirect and administrative costs related to trainings, we considered a proxy of 36 per cent of direct costs (based on the Odisha Climate Budget), and then added it to the total direct cost to arrive at the total cost of (approximately) INR 1,750 crore. In cases of industries for which the standard rate or hours of training was not available, we considered the closest available proxy.

Figure 4.1 CRF for GrOI: ecological mangrove restoration

Allied departments	Existing government programmes and schemes	Sub-outputs	Outputs	Outcomes	Aligned with SDG (and OSIF indicators)
Panchayati Raj & Drinking Water Department; Rural Development Department	*Odisha Livelihoods Mission* (OLM); *National Afforestation Programme* (NAP); and *Integrated Watershed Management Programme* (IWMP)	Skilling programmes in mangrove nurseries	**Increase in rural mangrove nurseries**	**1. Ecosystem restoration: mangroves** **2. Fisheries and animal resource development** **3. Income diversification**	**SDG 1: No poverty; SDG 13: Climate action, SDG 14: Life below water;** and relevant corresponding OSIF indicators
MSME Department and *Mission Shakti*	-	Subsidised credit for SHGs to start nurseries			
-	-	Establishing standards for sustainable eco-tourism	**Increase in mangrove eco-tourism**		
Department of Tourism	*National Parks and Wildlife Sanctuaries Development and Eco-Tourism* (NPWDET)	Certification of hotels/homestays			
-	*Enhancing Climate Resilience of India's Coastal Communities* (ECRICC) - Conservation and *management of mangroves*	A cadre of grassroot workers trained in mangrove community awareness and support programmes	**Increase in number of mangrove-related community awareness-building programmes**		
-	-	Organisation of mangrove cultural festivals			
-	*Mangrove Mitra*	Identification, outreach, and induction in land banks	**Increase in mangrove reforestation land bank**		
-	-	Plantation drives			
-	-	Bio-fencing and other earthworks			

Source: Authors' analysis

4.3 Roles and responsibilities of different stakeholders in the economy: A whole-of-economy approach

The huge potential of the green economy in Odisha can be fully realised only if the private sector, civil society, and the government collaborate towards the same objective

The huge potential of the green economy in Odisha can be fully realised only if the private sector, civil society, and the government collaborate towards the same objective. While the private sector could potentially drive innovation and investment in green sectors, civil society and the government must ensure widespread community involvement and effective on-the-ground implementation of the initiative. A macro-level overview of the roles of each stakeholder is outlined below.[113]

- **Private sector**: In order for Odisha to achieve significant green economic progress, the private sector must take advantage of the opportunity to invest in green value chains within the state. The following three types of private-sector companies will find it attractive to invest in Odisha's green economy:
  - **Large industries**: Odisha is already home to several large industries. These industries have a well-established presence in the state and possess the capital and technology to invest in Odisha. The *Industrial Policy Resolution 2022 Odisha* and the *Odisha Renewable Energy Policy, 2022* currently incentivise green private investments in the state through an attractive rebate on capex for investments in green sectors. Over the past two years alone, the state has attracted over INR 3,700 crore in investments in RE value chains (The Hindu Bureau 2024). To accelerate the pace of private-sector innovation and investment, large industrial actors must partner with universities and other educational institutions to set up centres of excellence. They should also collaborate with the government to design skill development courses and modules. Meanwhile, the state should provide viability gap funding for certain technologies to help in demand aggregation and promote R&D by providing initial funding. Large value capital expenditure will benefit value chains that are relatively mature and require high capital expenditure, especially ET value chains.
  - **Existing MSMEs**: MSMEs, especially medium and small enterprises with a presence in green sectors, have a competitive edge in establishing or expanding operations in green value chains in phases. They are well-positioned to benefit from their knowledge of the state's ecosystem. Green economic growth, led by MSMEs, will not only be sustainable and equitable but also ensure higher job generation. Evidence suggests that MSMEs provide more job opportunities with relatively lower investment. For instance, up to 62 per cent of the total jobs in India exist in the MSME sector (Kumar 2024).
  - **New companies and start-ups**: As discussed in several of our value chain–specific sections, new and emerging private-sector players will play an increasingly important role in scaling up the green economy in Odisha. Start-ups are more inclined to take bold risks and introduce innovations, yet they also require backup measures to guarantee their resilience. Measures such as low-interest debt financing, supported incubation programmes, and increasing linkages to the market can significantly contribute to creating a robust green start-up ecosystem in the state. Nexus Power and Bamboostand exemplify how successful start-ups can drive the transition towards green economic growth.

113 Detailed roles and responsibilities of the private sector and civil society for each value chain are included in the dossiers published alongside this report.

- **Civil society organisations and research institutions**: Community engagement, civil society participation, and grassroots implementation will be extremely crucial to maximise the potential of the green economy in Odisha. The state has a vibrant civil society network that has been working for decades across diverse regions and communities. Several of these organisations have extensive expertise in fostering grassroots entrepreneurship in the state and implementing related government schemes. We interacted with eight large CSOs in the state, and there is a clear opportunity and need to engage civil society in establishing value chains that require community participation, such as sustainable forest management, mangrove management, and sustainable tourism, among others. CSOs can play the unique role of connecting individuals to new and upcoming job opportunities by building capacity, transferring knowledge, and generating awareness. Similarly, research institutions can play a crucial role in filling existing gaps in the research required to adequately scale up all value chains and adopt new mitigation strategies for any unanticipated risks and challenges.

In mainstreaming a green economy, Odisha can serve as an example for the rest of the country

The GrOI is a first step towards realising the potential of the green economy in Odisha. Collaboration and cooperation among multiple stakeholders utilising an objective, target-led model will allow Odisha to mainstream green economic development in the state, which can then serve as an example for the rest of the country. The measures in the initiative are non-exhaustive and will benefit greatly from continuous and direct feedback from the government and other stakeholders. It can play a crucial role in helping India achieve its dual targets of climate action and job creation.

Annexure A: Sector-specific approach for value chain identification

Our approach to selecting value chains across sectors was two-fold: first, by applying the common selection criteria applicable to all sectors, and second, by tailoring the selection process to the specific characteristics and requirements of each individual sector.

Accordingly, as a first step, we developed a comprehensive list of green value chains across three identified green economic sectors, guided by principles derived from existing literature. These principles focus on the suitability of value chains for Odisha's geographical and resource contexts, the prioritisation of established value chains, the inclusion of emerging high-potential value chains, and the avoidance of long-term ecological damage.

Following the curation of this list, we evaluated the value chains based on five key parameters: **policy support, natural endowment, supply-side feasibility, the presence of an ecosystem of related goods, and global momentum**. In addition to the overarching parameters delineated above, we applied sector-specific criteria to refine our shortlist and conducted stakeholder consultations, including a closed-door roundtable with experts from eight civil society organisations and over 22 discussions with state officials. Such a sector-specific approach was necessary to account for the diversity in the level of development (nascent or advanced), regulatory frameworks and growth potential of different value chains within each sector.

We provide a detailed overview of the approach undertaken by each sector to identify its respective value chains below:

- **Energy transitions sector:** Technology is at the core of the possibilities for India's energy transitions. These technologies were selected based on the following principles. After developing the list of technologies, relevant departments in the Government of Odisha were consulted to validate the technologies selected.
  - **The technologies form a part of India's energy ambitions**: All clean technologies that are a part of India's portfolio and integral to India's energy transition ambitions have been included. These include renewable energy (RE) technologies such as solar, wind, biomass, etc. Green hydrogen has been included given the global momentum and the policy push through the National Green Hydrogen Mission. Similarly, Electric Vehicles and module manufacturing have been included because of schemes such as the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME I and II) scheme and the Production Linked Incentive scheme for PV modules.
  - **Focus on livelihoods**: The application of renewables has expanded to provide livelihood opportunities such as biomass cold storage/ chillers, solar dryers, solar charkhas, etc. This sector has immense potential to impact 37 million livelihoods and an approximate 50 billion dollar revenue opportunity (Jain et al., 2023). The 'Framework for the promotion of decentralised renewable energy livelihood applications ' published by the Ministry of New and Renewable Energy was used as a starting point to select the applications. Based on existing deployments and the maturity of the market for the product, 14 applications were shortlisted.
  - **The technologies form a part of the State's energy transition ambitions**: The selected technologies align with Odisha's clean energy ambitions. The '*Odisha Renewable Policy, 2022*' was used as a guiding document to ensure that all technologies of priority to the state were included.

- **Emerging sectors**: Emerging sectors that offer significant promise and are required to meet the state's RE targets with potential in the state have been considered. For example, energy storage is critical to addressing RE's intermittency and variability and ensuring grid stability. Thus, Battery Energy Storage systems (BESS) and Pumped Storage Hydropower (PSH) have been included.

Haryana and Karnataka are the top ranking states on the index

- **Circular economy sector:** Our initial focus was on the downstream circular economy, specifically waste management. This excluded aspects such as design, reuse, and repair, as we aimed to concentrate on immediate post-consumer waste management. Although pre-consumer stages, such as extraction and processing of raw materials and manufacturing of goods, also generate waste, they are well managed by the concerned entities as per the consent issued by the relevant State Pollution Control Boards. When the waste reaches consumers, there is an increased likeliness of resource misuse. Hence, we focused on estimating the jobs, market and investment opportunities for post-consumer waste management activities.

  We compiled a comprehensive list of waste streams to choose the waste value chains to work with. These were evaluated based on various factors, such as existing national regulations, state policies, and initiatives and the volume of waste being generated and processed. This thorough evaluation allowed us to identify the nuances and gaps in each waste stream.

  We further supplemented this approach with inputs from state departments involved in these value chains. These consultations helped us better understand the on-ground implementation, challenges, and interests of the relevant departments. Based on these consultations, we narrowed down to emerging or existing value chains that are complex to manage in Odisha.

- **Bioeconomy and Nature-based solutions sector:** We identified Bioeconomy (BE) and Nature-based Solutions (NbS) value chains using a combination of secondary literature reviews and industry reports.

For BE, we identified relevant value chains based on:

- The definition of Bio-economy as used by the Ministry of External Affairs (MEA)[114] and Biotechnology Industry Research Assistance Council[115] (BIRAC)'s classification of Indian bioeconomy into key segments such as biopharma, bio-agri, bio-industrial, and bio-IT.
- Additionally, the reports on relevant value chains from industry associations (e.g., Indian Biogas Association) and multilateral organisations (e.g., International Energy Agency, INBAR) were used to arrive at an exhaustive list of value chains.

Similarly for NbS, relevant value chains were identified based on:

- Definition of NbS considered by United Nations Environment Programme (UNEP)[116]
- Secondary literature survey that recognises any intervention as NbS based on the International Union for Conservation of Nature (IUCN)'s Global Standard for NbS.
- The applicability of value chains to India's bio-geographic regions, degraded regions and ecosystems as listed out by the National Remote Sensing Authority (NRSA) and the Envistats Report -2023 released by the Ministry of Statistics and Programme Implementation (MoSPI).
- An exhaustive list of BE & NbS value chains was prepared to further prioritise for deeper analysis.

114 MEA defines Bioeconomy as a sector that includes the production, utilisation, and conservation of biological resources, including expertise, science, technology, and innovation, to provide information, products, processes, and services across all economic sectors that are aiming for sustainable growth.

115 BIRAC is a public sector undertaking set up by Department of Biotechnology, Government of India

116 UNEP defined Nature-based solutions (NbS) as actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature.

Value chain selection framework:

We applied a set of filtering criteria and a multi-criteria scoring system as a selection framework for prioritising the value chains for deeper analysis from the exhaustive list.

I. Shortlisting value chains:

- We considered only value chains that either replace or provide alternatives to brown economy products or services with high GHG emissions, offering lower-emission/ greener alternatives or enabling enhancement of natural capital[117]. However, we excluded those value chains where the science behind them was still evolving, and the potential risks associated with scaling them were significant.
- We selected product-based value chains with Technology Readiness Levels (TRL) of 7 or higher, and practice-based value chains (NbS) that demonstrate practical applicability and proven success within Odisha or other regions in India.
- We selected value chains relevant to Odisha. We established the relevance of each value from the exhaustive list through extensive stakeholder consultations involving state government departments, active CSOs, and private sector participants based in Odisha.

The value chains were filtered sequentially through these criteria to produce a shortlist of value chains for further prioritisation and deeper analysis.

II. Selection of value chains:

We applied a multi-criteria scoring framework to evaluate the shortlisted BE & NbS value chains for sizing their potential in Odisha using the following criteria:

- **Future potential:**
  - **Market demand**: For BE, we assessed market demand and scalability using either the brown economy product as a proxy or the direct product. For NbS, we considered investment potential due to limited direct marketability. We prioritised value chains aligned with global and continental nature finance trends, based on insights from reports like the State of Nature Finance Report[118]. Value chains with a growing market share or higher investment trends received higher scores.
  - **Resource availability**: We evaluated the availability of critical resources, scoring higher for abundant resources, especially in NbS (e.g. degraded forests for assisted natural regeneration).
- **Policy environment/government and regulatory support**: We reviewed the extent of government subsidies, incentives, and policy mechanisms that promote each value chain. Value chains with strong government backing and financial incentives were scored higher.
- **Data availability:** We assessed the availability of comprehensive data on critical resources (e.g., natural resources, financial flows, technology), established policy targets and market-related factors (e.g., trends, pricing, competition). Value chains with well-documented and accessible data were scored higher.

117 For example- The use of this criteria allowed us to not consider a major chunk of the food-based value chains. We did not consider the final agricultural produce but included the bio-inputs used to produce them as they are replacing a brown or non-green product available that are chemical agri-inputs. However, we considered the sustainable practices followed for agriculture as they are an alternative to conventional farming practices that emit lesser GHGs. However, such sustainable agricultural practices were considered as part of nature-based solutions.

118 The 2023 edition of the State of Finance for Nature report estimates the scale of nature-negative finance flows from both public and private sector sources globally.

Annexure B: List of departments consulted

An indicative list of state departments we consulted.

Sectors	State departments and agencies
Overarching	• Planning and Convergence Department • Odisha Skill Development Authority, World Skills Centre • Odisha Livelihoods Mission and Mission Shakti • Panchayati Raj & Drinking Water Department • The Odisha Industrial Infrastructure Development Corporation (IDCO)
Energy transition	• GRIDCO,[1] Department of Energy • OREDA,[2] Department of Energy • Industries Department • Invest Odisha
Circular economy	• Department of Housing & Urban Development • State Pollution Control Board • Bhubaneswar Municipal Corporation
Bio-economy and nature-based solutions	• Forest, Environment and Climate Change Department • Directorate of Soil Conservation and Watershed Development • Odisha Forest Development Corporation • Department of Agriculture & Farmers' Empowerment • Climate Resilience Cell • Bhubaneswar Development Authority • Handlooms, Textiles, and Handicrafts Department • Science and Technology Department • Odisha Bamboo Development Agency • Directorate of Horticulture • Directorate of Handicrafts

Authors' compilation

1. Grid Corporation of Odisha

2. Odisha Renewable Energy Development Agency

Annexure C: GrOI value chains with their corresponding departments

Value chains and corresponding departments identified under the GrOI

S. No.	Value chain	Department
Energy transition		
1	Green hydrogen	**Industries Department**
		Department of Energy
		Department of Steel and Mines
		Science and Technology Department
		Department of Agriculture and Farmers' Empowerment
		Ministry of Ports, Shipping and Waterways
2	Mini and micro-grids	**Department of Energy**
		Odisha Renewable Energy Development Authority (OREDA)
		Odisha Skill Development Authority (OSDA)
3	Small hydro	Department of Water Resources
		Skill Development and Technical Education Department
		Green Energy Development Corporation of Odisha Limited (GEDCOL)
		Odisha Skill Development Authority (OSDA)
		Odisha Power Transmission Corporation Limited (OPTCL)
		Odisha Hydro Power Corporation (OHPC)

S. No.	Value chain	Department
4	Wind deployment	**Department of Energy**
		Odisha Electricity Regulatory Commission (OERC)
		Grid Corporation of Odisha (GRIDCO)
		National Institute of Wind Energy (NIWE)
		Odisha Power Transmission Corporation Limited (OPTCL)
		Industries Department
5	EV and battery manufacturing	**Industries Department**
		Commerce and Transport Department
		Odisha Skill Development Authority (OSDA)
		Micro, Small & Medium Enterprise (MSME) Department
		Science and Technology Department
		Department of Housing and Urban Development (H&UDD)
		Skill Development and Technical Education Department
6	Battery energy storage system (BESS)	**Department of Energy**
		Science and Technology Department
7	Pumped storage hydropower	Skill Development and Technical Education Department
		Odisha Hydro Power Corporation (OHPC)
		Odisha Electricity Regulatory Commission (OERC)
		Odisha Power Transmission Corporation Limited (OPTCL)
		Department of Energy
		Department of Water Resources
8	RE manufacturing	**Industries Department**
		Ministry of New and Renewable Energy (MNRE)
		Science and Technology Department
		Industrial Promotion and Investment Corporation of Odisha Ltd. (IPICOL)
		Odisha Industrial Infrastructure Development Corporation (IDCO)
		District Investment Promotion Agencies (DIPA)
		Skill Development and Technical Education Department
9	Utility-scale solar	**Department of Energy**
		Odisha Power Transmission Corporation Limited (OPTCL)
		Grid Corporation of Odisha (GRIDCO)
		Science and Technology Department
		Odisha Electricity Regulatory Commission (OERC)
		Skill Development and Technical Education Department
10	Biomass to power	Department of Agriculture and Farmers' Empowerment
		Department of Co-operation
		Department of Energy
		Department of Steel and Mines
11	EV charging infrastructure	Department of Housing and Urban Development (H&UDD)
		Department of Energy
		Commerce and Transport Department

S. No.	Value chain	Department
12	DRE technologies for livelihoods	**Department of Energy**
		Department of Mission Shakti
		Micro, Small & Medium Enterprise (MSME) Department
13	Floating solar	Department of Water Resources
		Department of Energy
		Industries Department
		Grid Corporation of Odisha (GRIDCO)
		Odisha Hydro Power Corporation (OHPC)
		Industries Department
		Odisha Electricity Regulatory Commission (OERC)
		Fisheries and Animal Resources Development Department
14	Rooftop solar	Department of Energy
Circular economy		
15	Battery waste	Forest, Environment and Climate Change Department
		Industries Department
		Department of Housing and Urban Development (H&UDD)
		Skill Development and Technical Education Department
16	Construction and demolition waste	**Department of Housing and Urban Development (H&UDD)**
		Works Department (WD)
17	E-waste	**Forest, Environment and Climate Change Department**
		Department of Housing and Urban Development (H&UDD)
		Labour and Employee's State Insurance Department
		Industries Department
		Skill Development and Technical Education Department
18	Li-ion battery waste	Forest, Environment and Climate Change Department
		Industries Department
		Department of Housing and Urban Development (H&UDD)
Bio-economy and nature-based solutions		
19	Agroforestry	**Department of Agriculture and Farmers' Empowerment**
		Forest, Environment and Climate Change Department
		Science and Technology Department
		Skill Development and Technical Education Department
20	Bamboo	Skill Development and Technical Education Department
		Department of School and Mass Education
		Micro, Small & Medium Enterprise (MSME) Department
		Department of Agriculture and Farmers' Empowerment
		Department of Housing and Urban Development (H&UDD)
		Science and Technology Department
		Panchayati Raj and Drinking Water Department
		Forest, Environment and Climate Change Department

S. No.	Value chain	Department
21	Biogas	**Department of Energy**
		Forest, Environment and Climate Change Department
		Department of Agriculture and Farmers' Empowerment
		Fisheries and Animal Resources Development Department
		Industries Department
		Skill Development and Technical Education Department
22	Bio-inputs	ST & SC Development, Minorities & Backward Classes Welfare Department
		Department of Agriculture and Farmers' Empowerment
		Fisheries and Animal Resources Development Department
		Industries Department
		Skill Development and Technical Education Department
23	Bio-fibre	Industries Department
		Micro, Small & Medium Enterprise (MSME) Department
		Department of Agriculture and Farmers' Empowerment
24	Sustainable forest management	**Forest, Environment and Climate Change Department**
		Department of Water Resources
		Revenue and Disaster Management Department
		Panchayati Raj and Drinking Water Department
		ST & SC Development, Minorities & Backward Classes Welfare Department
		Skill Development and Technical Education Department
		Micro, Small & Medium Enterprise (MSME) Department
		Science and Technology Department
		Department of School and Mass Education
25	Bio-based packaging	**Industries Department**
		Skill Development and Technical Education Department
		Department of Agriculture and Farmers' Empowerment
26	Mangrove management	**Forest, Environment and Climate Change Department**
		Fisheries and Animal Resources Development Department
		Department of Agriculture and Farmers' Empowerment
		Revenue and Disaster Management Department
27	Seaweed cultivation	**Fisheries and Animal Resources Development Department**
		Science and Technology Department
		Department of Agriculture and Farmers' Empowerment
		Forest, Environment and Climate Change Department
		Skill Development and Technical Education Department
28	Sustainable tourism	Department of Agriculture and Farmers' Empowerment
		Department of Tourism
		Odia Language Literature & Culture Department
		Handlooms, Textiles, and Handicrafts Department
		Rural Development Department
Notes: EV and battery manufacturing are covered together		
Lead department		

Source: Authors' analysis

Acronyms

AF	agroforestry
AIPMA	All-India Plastics Manufacturers Association
ANR	assisted natural regeneration
APICOL	Agricultural Promotion and Investment Corporation of Odisha Limited
BBFs	biomass-based fibres
BDTCs	biogas development and training centres
BE	bio-economy
BEE	Bureau of Energy Efficiency
BESS	battery energy storage systems
BIS	Bureau of India Standards
BMTPC	Building Materials and Technology Promotion Council
BRCs	bio-input resource centres
BYPL	BSES Yamuna Power Limited
CBAM	Carbon Border Adjustment Mechanism
CBG	compressed biogas
C&D	construction and demolition
CE	circular economy
C&I	commercial and industrial
CREDAI	Confederation of Real Estate Developers' Associations of India
CSO	civil society organisation
C&T	commerce and transport
DAP	diammonium phosphate
DAFE	Department of Agriculture and Farmers' Empowerment
DIPA	District Investment Promotion Agency
DISCOM	distribution company
DoE	Department of Energy
S&TD	Science and Technology Department
DRE	decentralised renewable energy
DT	distribution transformer
EDC	eco-development committees
EIC	Engineer-in-Chief
EMR	ecological mangrove restoration
ET	energy transition
EV	electric vehicle
e-waste	electrical and electronic equipment waste
FFPM	forest fire prevention and management
FOM	fermented organic manure
FPOs	farmer-producer organisations
FRPs	fibre-reinforced polymers
FSPV	floating solar photovoltaic
GEDCOL	Green Energy Development Corporation Odisha Limited
GH2	green hydrogen
GHG	greenhouse gas
GPIL	Godawari Power and Ispat Limited
GRIDCO	Grid Corporation of Odisha
GRIHA	Green Rating for Integrated Habitat Assessment
GrOI	Green Odisha Initiative
H&UDD	Department of Housing and Urban Development
HTHD	Handlooms, Textiles & Handicrafts Department
IASM	invasive alien species management
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forestry Research and Education
IDCO	Industrial Development Corporation of Odisha

IEA	International Energy Agency
IEIDL	Indo Enviro Integrated Solutions Private Limited
IIP	Indian Institute of Packaging
IISC	Indian Institute of Science
IPICOL	Industrial Promotion and Investment Corporation of Odisha Ltd.
ITDA	Integrated Tribal Development Agency
ITI	Industrial Training Institute
LIB	lithium-ion battery
MEiTY	Ministry of Electronics and Information Technology
MKUY	Mukhyamantri Krishi Udyog Yojana
MNRE	Ministry of New and Renewable Energy
MoHUA	Ministry of Housing and Urban Affairs
MSME	micro, small, and medium enterprise
NBFC	non-banking financial company
NbS	nature-based solutions
NDMC	North Delhi Municipal Corporation
NIWE	National Institute of Wind Energy
NTFP	non-timber forest products
OAIC	Odisha Agro Industries Corporation Limited
ODSSP	Odisha Distribution System Strengthening Project
OERC	Odisha Electricity Regulatory Commission
OHPC	Odisha Hydro Power Corporation
OLM	Odisha Livelihoods Mission
O&M	operations and maintenance
OPTCL	Odisha Power Transmission Corporation Limited
OREDA	Odisha Renewable Energy Development Agency
ORMAS	Odisha Rural Development and Marketing Society
OSCB	Odisha State Cooperative Bank
OSDA	Odisha Skill Development Authority
OSIF	Odisha SDG Indicator Framework
OSPCB	Odisha State Pollution Control Board
OUAT	Odisha University of Agriculture & Technology
PALF	pineapple leaf fibre
PLI	production-linked incentive
P&CD	Planning and Convergence Department
PSUs	public sector undertakings
PUE	productive use of electricity
QPM	quality planting material
R&D	research and development
RE	renewable energy
RPO	renewable purchase obligation
RTS	rooftop solar
SDGs	Sustainable Development Goals
SD&TED	Skill Development and Technical Education Department
SERI	Sustainable Electronics Recycling International
SFM	sustainable forest management
SHGs	self-help groups
SHP	small hydropower
SOP	standard operating procedure
TPA	tonnes per annum
TPD	tonnes per day
TSDF	treatment, storage, and disposal facility
VSS	Van Suraksha Samities
WASSAN	Watershed Support Services and Activities Network
WD	Works Department

References

Government of Odisha | Topography https://odisha.gov.in/odisha-profile/topography#:~:text=It per cent20is per cent20bounded per cent20by per cent20the,area per cent20of per cent20155 per cent2C707 per cent20square per cent20kms

Government of Odisha. "Odisha Profile Topography." Accessed July 9, 2024. https://odisha.gov.in/odisha-profile/topography

Jeyakumar, Binnu, Lee Todd, and Pembina Institute. 2017. When the Wind Is Fair: Best Practices for Responsible Wind Development in Alberta. The Pembina Institute.

MNRE and CEEW. 2024. Enabling a Circular Economy in India's Solar Industry: Assessing the Solar Waste Quantum. New Delhi: Council on Energy, Environment and Water.

Sharma, Amrita, Rupal Kulkarni, and Rajiv Khandelwal. 2014. Studies, Stories and a Canvas: Seasonal Labor Migration and Migrant Workers from Odisha. Centre for Migration and Labour Solutions, Aajeevika Bureau, Udaipur.

Tyagi, Akanksha, Deepak Rai, Arvind Poswal, Charu Lata, Sameer Kwatra, and Praveen Saxena. 2022. India's Expanding Clean Energy Workforce 2022 Update. Council on Energy, Environment and Water, Natural Resources Defense Council, and Skill Council for Green Jobs.

Tyagi, Akanksha, Dhruv Warrior, Disha Agrawal, Hemant Mallya, Karthik Ganesan, Rishabh Jain, Rishabh Patidar, and Sonali Bhaduri. 2023. Developing Resilient Renewable Energy Supply Chains for Global Clean Energy Transition. New Delhi: Council on Energy, Environment and Water.

Warrior, Dhruv, Akanksha Tyagi, and Rishabh Jain. 2023. How Can India Indigenise Lithium-ion Battery Manufacturing? Formulating Strategies across the Value Chain. New Delhi: Council on Energy, Environment and Water.

World Bank (b). "Sembcorp Tengeh Floating Solar Farm, Singapore. Public-Private-Partnership" Legal Resource Centre, accessed May 16, 2024 https://ppp.worldbank.org/public-private-partnership/energy-and-power/sembcorp-tengeh-floating-solar-farm-singap

Abeysinghe, Nisansala, Angela M. Guerrero, Jonathan R. Rhodes, Eve McDonald-Madden, and Christopher J. O'Bryan. 2023. "How Success is Evaluated in Collaborative Invasive Species Management: A Systematic Review." *Journal of Environmental Management* 348: 119272. https://doi.org/10.1016/j.jenvman.2023.119272.

Abraham, Sijo, Shanal Pradhan, and Apoorve Khandelwal. 2022. *Policy Study on Sustainable Agriculture*. Chief Minister's Rajasthan Economic Transformation Advisory Council (CMRETAC) and Council on Energy, Environment and Water (CEEW). https://www.ceew.in/sites/default/files/CEEW-Policy-Study-On-Sustainable-Agriculture-India.pdf.

Acharya, Mohit, and Sarvesh Devraj. 2019. *Floating Solar Photovoltaic (FSPV): A Third Pillar to Solar PV Sector?* TERI Discussion Paper, The Energy and Resources Institute (TERI). https://www.teriin.org/sites/default/files/2020-01/floating-solar-PV-report.pdf.

Agarwal, S., K. Banerjee, N. Pal, K. Mallik, G. Bal, P. Pramanick, and A. Mitra. 2017. "Carbon Sequestration by Mangrove Vegetations: A Case Study from Mahanadi Mangrove Wetland." *Journal of Environmental Science, Computer Science, and Engineering & Technology* 7 (1): 16–29. http://www.jecet.org/download_frontend.php?id=373&table=Env%20Science.

Aggarwal, Anubha. 2023. "Biomass Pellets: CPCB's Revised Grants Highly Inadequate to Close Demand-Supply Gap." *Down to Earth*, April 20, 2023. https://www.downtoearth.org.in/pollution/biomass-pellets-cpcb-s-revised-grants-highly-inadequate-to-close-demand-supply-gap-88875.

Agrawal, Shalu, Sunil Mani, Abhishek Jain, and Karthik Ganesan. 2020. *State of Electricity Access in India: Insights from the India Residential Energy Consumption Survey (IRES)*. Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-research-on-state-of-electricty-access-and-coverage-in-india.pdf.

Ali, S., Stewart, R. A., and Sahin, O. 2021. "Drivers and Barriers to the Deployment of Pumped Hydro Energy Storage Applications: Systematic Literature Review." *Cleaner Engineering and Technology* 5: 100281. https://doi.org/10.1016/j.clet.2021.100281.

ANI. 2024. "Eco Recycling's Standalone FY24 Profit Rises by 163 Percent." ANI, May 16, 2024. https://www.aninews.in/news/business/eco-recyclings-standalone-fy24-profit-rises-by-163-percent20240516125606/.

Anilkumar, P. K. 2022. *Mapping of Technologies for Value-Addition of Seaweeds in India*. Technology Information, Forecasting and Assessment Council. https://www.tifac.org.in/images/latestreports/Seaweed_Study_Report.pdf.

Ansari, Arbiya Naseem, and Zeba Sheereen. 2022. "An Analysis of Fertiliser Subsidies in India." *Saudi Journal of Economics and Finance*, 6 (12): 406–412. https://doi.org/10.36348/sjef.2022.v06i12.001.

APN-GCR. 2020. "Bamboo: Green Construction Material." Asia Pacific Network for Global Change Research. https://www.apn-gcr.org/wp-content/uploads/2020/09/1654f846a58279adea4aeb44a881321b.pdf.

APOWA. 2013. "Community Stewardship in Conservation, Restoration and Sustainable Management of Mangroves in Orissa." Action for Protection of Wild Animals (APOWA). https://www.mangrovesforthefuture.org/assets/Repository/Documents/Community-Stewardship-in-Conservation-Restoration-and-Management-of-Mangroves-in-Orissa.pdf.

Awasthi, Mukesh Kumar, Surendra Sarsaiya, Anil Patel, Ankita Juneja, Rajendra Prasad Singh, Binghua Yan, Sanjeev Kumar Awasthi et al. 2020. "Refining Biomass Residues for Sustainable Energy and Bio-Products: An Assessment of Technology, its Importance, and Strategic Applications in Circular Bio-Economy." *Renewable and Sustainable Energy Reviews* 127: 109876. https://doi.org/10.1016/j.rser.2020.109876.

Bansal, Arun. K. 2020. "Unlocking the Potential of Bamboo Sector in India." NCCF Working Paper No. 2/2020., Network for Certification and Conservation of Forests. https://nccf.in/wp-content/uploads/2022/09/Unlocking-the-Potential-of-Bamboo-Sector-in-India-by-Mr-A.-K.-Bansal-Chairperson-SDG-NWFR-and-PCA-Group-of-NCCF.pdf.

Banyan Nation. n.d. "Banyan Nation." Banyan Nation. Accessed September 20, 2024. https://www.banyannation.com/.

Beetles, J., D. S. Battisti, S. C. Cook-Patton, T. Kroeger, J. T. Spector, N. H. Wolff, and Y. J. Masuda. 2021. "Agroforestry and Non-State Actors: A Review." *Forest Policy and Economics* 130: 102538. https://doi.org/10.1016/j.forpol.2021.102538.

Bhattacharyya, Subhes C., and Debajit Palit. 2016. "Mini-Grid Based Off-Grid Electrification to Enhance Electricity Access in Developing Countries: What Policies May Be Required?" *Energy Policy* 94: 166–78. https://doi.org/10.1016/j.enpol.2016.04.010.

Bhutta, M. Khurrum S., Adnan Omar, and Xiaozhe Yang. 2011. "Electronic Waste: A Growing Concern in Today's Environment", *Economics Research International* 2011: 474230. https://doi.org/10.1155/2011/474230.

BIRAC. 2021. "India BioEconomy Report 2021." Biotechnology Industry Research Assistance Council (BIRAC). https://birac.nic.in/webcontent/1615182060_Indian_BioEconomy_Report_2021.pdf.

Biswas, Atin, Kuldeep Chaudhary, Richa Singh, Shailshree Tewari, Siddharth Singh, and Subhasish Parida. 2021. "Waste-Wise Cities: Best Practices in Municipal Solid Waste Management." Centre for Science and Environment and Niti Aayog. https://www.niti.gov.in/sites/default/files/2021-12/Waste-Wise-Cities.pdf.

Biswas, Tirtha, Deepak Yadav, and Ashish Guhan Baska. 2020. "A Green Hydrogen Economy for India." Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/CEEW-A-Green-Hydrogen-Economy-for-India-14Dec20.pdf.

Blakers, Andrew, Matthew Stocks, Bin Lu, and Cheng Cheng. 2021. "A Review of Pumped Hydro Energy Storage." *Progress in Energy* 3(2): 022003. https://doi.org/10.1088/2516-1083/abeb5b.

BloombergNEF. 2023. "Lithium-Ion Battery Pack Prices Hit Record Low of $139/KWh." BloombergNEF, November 22, 2023. https://about.bnef.com/blog/lithium-ion-battery-pack-prices-hit-record-low-of-139-kwh/#:~:text=Given%20this%2C%20BNEF%20expects%20average,and%20%2480%2FkWh%20in%202030.

Bowyer, Jim, Kathryn Fernholz, Matt Frank, Jeff Howe, Steve Bratkovich, and Ed Pepke. 2014. "Bamboo Products and Their Environmental Impacts: Revisited." Dovetail Partners. http://www.unecefaoiufro.lsu.edu/certificate_eccos/documents/2015Mar/ce15-06.pdf.

Bull, E. G., C. de L. da N. Cunha, and A. C. Scudelari. 2021. "Water Quality Impact from Shrimp Farming Effluents in a Tropical Estuary." *Water Science and Technology* 83 (1): 123–36. https://doi.org/10.2166/wst.2020.559.

Bureau of Energy Efficiency. 2024. "Public Charging Stations." Bureau of Energy Efficiency. https://evyatra.beeindia.gov.in/public-charging-stations/.

CAFRI. 2020. "Agroforestry for Income Enhancement, Climate Resilience and Ecosystem Services." Technical Bulletin No. CAFRI/01/2020, Indian Council of Agricultural Research. https://cafri.icar.gov.in/html/Technical_Bulletins/Agroforestry-for-Income-enhancement-Climate-resilience-and-Ecosystem-services.pdf.

CID 2024. "Import of Solar PV Cells and Modules from China Decline : Chemical Industry Digest." Chemical Industry Digest. https://chemindigest.com/import-of-solar-pv-cells-and-modules-from-china-decline/#:~:text=In%20FY24%2C%20China's%20share%20of,by%20ICRA%20in%20February%202024.

CEA and DEA. 2022. *Indian Technology Catalogue: Generation and Storage of Technology*. Central Electricity Authority (CEA) and Danish Energy Agency (DEA). https://cea.nic.in/wp-content/uploads/irp/2022/02/First_Indian_Technology_Catalogue_Generation_and_Storage_of_Electricity-2.pdf.

CEA. 2024. "All India Installed Capacity (in MW) of Power Stations (As on 31.01.2024)." Central Electricity Authority. https://cea.nic.in/wp-content/uploads/installed/2024/01/IC_Jan_2024_allocation_wise-1.pdf.

CEEW. 2023. "Developing Resilient Renewable Energy Supply Chains for Global Clean Energy Transition." Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/developing-resilient-renewable-energy-supply-chains-for-global-clean-energy-transition.pdf.

Central Horticultural Experiment Station. 2021. "Establishment of a Post-Harvest cum Quality Analysis Laboratory for Enhancing Market Value of Fruits. Success Story of RKVY Post Harvest Project." ICAR-Indian Institute of Horticultural Research. https://rkvy.nic.in/Uploads/SucessStory/ORISSA/2022/2022124122Success%20Story%20%20CHES%20Post%20Harvest%20-RKVY%20(1).pdf.

CFLI India and CEEW. 2024. Financing Green Hydrogen in India: Private Sector Considerations to Strengthen India's Enabling Environment for a Competitive Green Hydrogen Economy. Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/how-can-india-boost-investments-for-financing-domestic-green-hydrogen-production.pdf.

Chakraborty, Nilanjan, Rusha Mitra, Somrhita Pal, Retwika Ganguly, Krishnendu Acharya, Tatiana Minkina, Anik Sarkar et al. 2023. "Biopesticide Consumption in India: Insights into the Current Trends." *Agriculture* 13 (3): 557. https://doi.org/10.3390/agriculture13030557.

Charyulu, D. Kumara, and Subho Biswas. 2011. *Organic Input Production and Marketing in* India: Efficiency, Issues and Policies. Chennai, India: Allied Publishers.

Chazdon, Robin L., and Manuel R. Guariguata. 2016. "Natural Regeneration as a Tool for Large-Scale Forest Restoration in the Tropics: Prospects and Challenges." Biotropica 48 (6): 716–30. https://doi.org/10.1111/btp.12381.

Chazdon, Robin L., Danielle Celentano, Djibril S. Dayamba, Patrick Durst, Joice Ferreira, Mawa Karambiri, Rowena Soriaga, et al. 2023. "A Status Report on Assisted Natural Regeneration: What, Why, Who, Where, and How?" Assisted Natural Regeneration and World Resources Institute. https://static1.squarespace.com/static/621d10076f3b6e76b2619f78/t/650a1dd15244170460681efa/1695161821889/WRI_Alliance_executive+summary_web.pdf.

Chen, Xiao, Chuanfeng Li, and Jing Tang. 2016. "Structural Integrity of Wind Turbines Impacted by Tropical Cyclones: A Case Study from China." Journal of Physics: *Conference Series* 753 (4): 042003. https://doi.org/10.1088/1742-6596/753/4/042003.

Colthrope, Andy. 2023. “Tata AutoComp-Gotion JV Supplies First BESS Units to Tata Power Project in Pune, India.” *Energy Storage News*, November 20, 2023. https://www.energy-storage.news/tata-autocomp-gotion-jv-supplies-first-bess-units-to-tata-power-project-in-pune-india/.

CPCB. 2017. “Guidelines on Dust Mitigation Measures in Handling Construction Material and C&D Waste.” Central Pollution Control Board. https://cpcb.nic.in/openpdffile.php?id=UmVwb3JoRmlsZXMvNTYxXzE1MTE5MzMzNzJfbWVkaWFwaG90bzEyNjcxLnBkZg==

CPCB. 2021. . Central Pollution Control Board. https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2020-21_PWM.pdf.

CPCB. 2022. “E-Waste (Management) Rules, 2022.” November 2, 2022. https://cpcb.nic.in/uploads/Projects/E-Waste/e-waste_rules_2022.pdf.

Cruz-Romero, Malco. C., and Joe P. Kerry. 2009. “Crop-Based Biodegradable Packaging And Its Environmental Implications.” 3 (74). http://dx.doi.org/10.1079/PAVSNNR20083074.

CSE. 2020. “Managing Plastic Waste in India.” Centre for Science and Environment. https://www.cseindia.org/managing-plastic-waste-in-india-10352.

CSTEP. 2021. “Study on Pricing Mechanism for Energy Generated by Pumped Hydro Energy Storage (PHES) in India.” Centre for Study of Science, Technology and Policy. https://cstep.in/drupal/sites/default/files/2021-11/PHES_Full_report_Final_301121.pdf

Dahlgren, Sofia. 2022. “Biogas-Based Fuels as Renewable Energy in the Transport Sector: An Overview of the Potential of Using CBG, LBG and Other Vehicle Fuels Produced from Biogas.” 13 (5): 587–99. https://doi.org/10.1080/17597269.2020.1821571.

Das, Binit, Batra Aditya and Bhatti Jasleen 2019 Cseindia.org https://www.cseindia.org/mini-grids-a-just-and-clean-energy-transition-11276#:~:text=INDIA%3A%20A%20SCOPING%20STUDY,capacities%20less%20than%2010%20kW.

Dasgupta, Alakananda, and Subhra Priyadarshini. 2019. “Why Odisha is a Sitting Duck for Extreme Cyclones.” , May 28, 2019. https://www.nature.com/articles/nindia.2019.69#:~:text=It%20is%20a%20core%20area,cooler%2C%20resulting%20in%20fewer%20storms.

Datta, Jayasree, J. K. Das, Amit Debnath, Ajay Ram, and Sourav Haldar. 2016. “Entrepreneurial Behaviour of Rural Women On Bamboo Handicrafts in Tripura, North-East India.” 61 (4): 653–58. https://doi.org//10.5958/0976-4666.2016.00080.2.

Department of Commerce and Transport. 2022. “Odisha Port Policy 2022.” Department of Commerce and Transport, Government of Odisha. https://investodisha.gov.in/download/Port-Policy-2022.pdf

DoE. 2023. “Annual Activity Report 2022-23.” Department of Energy, Government of Odisha. https://energy.odisha.gov.in/sites/default/files/2023-11/AnnualActivityReport-2022-23.pdf

Deshmukh, Ranjit, Grace Wu, and Amol A. Phadke. 2017. “Renewable Energy Zones for Balancing Siting Trade-Offs in India.” Office of Scientific and Technical Information, US Department of Energy. https://doi.org/10.2172/1366450.

Dey, Akashdeep, and R Camilla. Thomson. 2023. “India’s Biomethane Generation Potential from Wastes and the Corresponding Greenhouse Gas Emissions Abatement Possibilities Under Three End-Use Scenarios: Electricity Generation, Cooking, and Road Transport Applications.” , 7(1): 209–41. https://doi.org/10.1039/D2SE01028C.

Dhir, Yamini Jhanji. 2022. “Natural Fibers: The Sustainable Alternatives for Textile and Non-Textile Applications.” In , edited by Han-Yong Jeon 1-22. Rijeka: IntechOpen. https://doi.org/10.5772/intechopen.106393.

Directorate of Textiles and Handlooms. n.d. “Finest and Hand Crafted.” Directorate of Textiles and Handlooms, Government of Odisha. Accessed September 20, 2024. https://textiles.odisha.gov.in/page.php?link=Y6R6vDsaTvouAVuibUA1Y8clPH$9fjXsvryIDDK6JIc_.

Doshi, Pratik, James Brockington, and Robert Brook. 2015. "Assessing Agroforestry Adoption in Tribal Areas of Maharashtra, India." BAIF Development Research Foundation. https://www.bangor.ac.uk/natural-sciences/courses/distancelearning/documents/AssessingAgroforestryWeb.pdf.

Doso, Oying, and Sarsing Gao. 2020. "An Overview of Small Hydro Power Development in India." 8(5): 896–17. https://doi.org/10.3934/energy.2020.5.896.

DQI Bureau. 2022. "Robotic Cleaning of Solar Modules Gaining Attraction in India." Dataquest, December 26, 2022. https://www.dqindia.com/robotic-cleaning-of-solar-modules-gaining-attraction-in-india/.

Du, Lei, Yingbin Feng, Wei Lu, Lingkai Kong, and Zhi Yang. 2020. "Evolutionary Game Analysis of Stakeholders' Decision-Making Behaviours in Construction and Demolition Waste Management." 84 (2020): 106408. https://doi.org/10.1016/j.eiar.2020.106408.

EAC. 2023. "Enablers and Challengers: Indian Compressed Biogas (CBG) Industry." EAC International Consulting. https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2023/05/Knowledge-Paper_Indian-CBG-Industry_IFGE_EAC_April-2023_18042023-1.pdf.

Ecologi. n.d. "Converting Waste Rice Husks into 20MW of Power, India." Ecologi. Accessed September 20, 2024. https://ecologi.com/projects/biomass-power-project-raipur-india.

Ecoreco. 2018. "Eco Recycling Limited Q4 FY-24 Earnings [Conference Transcript]." Eco Recycling Limited. https://ecoreco.com/wp-content/uploads/2024/05/Eco-Recycling-Q4-FY24-Earnings-Call-Transcript.pdf.

Ecoreco. 2023. "Announcement Under Regulation 30 of Securities and Exchange Board of India (Listing Obligations and Disclosure Requirements) Regulations, 2015." Eco Recycling Limited. https://www.bseindia.com/xml-data/corpfiling/AttachHis/755a472a-3794-4a37-986b-a345080911f1.pdf.

Ellen MacArthur Foundation. n.d. "Circular Economy Introduction: Overview." Ellen MacArthur Foundation. Accessed September 20, 2024. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview.

Elshaboury, Nehal, Abobakr Al-Sakkaf, Eslam Mohammed Abdelkader, and Ghasan Alfalah. 2022. "Construction and Demolition Waste Management Research: A Science Mapping Analysis." 19 (8):4496. https://doi.org/10.3390/ijerph19084496.

EY India. 2023. "Reaping the Demographic Dividend." Ernst & Young Global Limited. https://www.ey.com/en_in/india-at-100/reaping-the-demographic-dividend.

FAO. 1985. "Appendix 1: The Structure of the FAO Framework Classification." Food and Agriculture Organization. https://www.fao.org/4/x5648e/x5648e0j.htm#appendix%201%20%20%20the%20structure%20of%20the%20fao%20framework%20classification.

FAO. 2008. "Agroforestry." Food and Agriculture Organization. https://www.fao.org/sustainable-forest-management/toolbox/modules/agroforestry/basic-knowledge/en/?type=111.

FAO. 2012. "Koraput Traditional Agriculture." Food and Agriculture Organization. https://www.fao.org/giahs/giahsaroundtheworld/designated-sites/asia-and-the-pacific/koraput-traditional-agriculture/en/.

FAO. n.d.a. "Enhanced Mulching in Banana and Coffee Plantations." Food and Agriculture Organization. Accessed September 20, 2024. https://openknowledge.fao.org/server/api/core/bitstreams/ea57bd07-734b-4106-a43b-47f5980a60b7/content.

FAO. n.d.b. "Regional Seminar. Bioinputs: Investment Opportunities to Promote the Development of Sustainable Agri-Food Systems in Latin America." Food and Agriculture Organisation. Accessed September 20, 2024. https://www.fao.org/americas/events/event-detail/Regional-Seminar-Bioinputs-Investment-Opportunities-to-Promote-the-Development-of-Sustainable-Agri-Food-Systems-in-Latin-America/.

FAO. n.d.c "Sustainable Forest Management (SFM) Toolbox." Food and Agriculture Organization. Accessed September 20, 2024. https://www.fao.org/sustainable-forest-management/toolbox/background/ru.

Fernandes, Jocelyn. 2024. “Unemployment Crisis: 83% of Jobless Indians are Youth, says International Labour Organisation Report.” , March 27, 2024. https://www.livemint.com/news/india/unemployment-crisis-83-of-jobless-indians-are-youth-says-international-labour-organisation-report-11711517084127.html.

Finance Department. 2021. “SDG Budget 2021–22.” Finance Department, Government of Odisha. https://finance.odisha.gov.in/sites/default/files/2021-02/20-SDG%20Budget.pdf.

Finance Department. 2023. “Climate Budget 2023–24.” Finance Department, Government of Odisha. https://finance.odisha.gov.in/sites/default/files/2023-02/Climate%20Budget%20final.pdf.

Finance Department. 2023. “Economic Survey 2022–23.” Finance Department, Government of Odisha. https://finance.odisha.gov.in/sites/default/files/2023-02/Odisha%20Economic%20Survey-2022-23%20%28Digital%20Version%29%20Final.pdf.

Finance Department. 2024. “Highlights of Annual Budget Estimates (VOA) for 2024–25.” Finance Department, Government of Odisha. https://finance.odisha.gov.in/sites/default/files/2024-02/11.Budget%202024-25%20English%20Highlights%20%28VoA%29.pdf.

Forest Survey of India. 2021a. “Forest and Tree Resources in States and Union Territories.” In , 257–557. Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India. https://fsi.nic.in/isfr-2021/chapter-13.pdf.

Forest Survey of India. 2021b. “Mangrove Cover.” In , 64–76. Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India. https://fsi.nic.in/isfr-2021/chapter-3.pdf.

Forest, Environment and Climate Change Department. 2023. “Environmental Synthesis Report of Odisha.” Forest, Environment and Climate Change Department, Government of Odisha. https://stsc.odisha.gov.in/sites/default/files/2023-08/Environmental%20Synthesis%20Report%20of%20Odisha.pdf.

Forest, Environment and Climate Change Department. 2020. . Forest, Environment and Climate Change Department, Government of Odisha. https://forest.odisha.gov.in/sites/default/files/2022-03/FE%20Dept_AAR%20Book-2019-20_English%20%5B1%5D_compressed.pdf

Forest, Environment and Climate Change Department. n.d. . Forest, Environment and Climate Change Department, Government of Odisha. Accessed September 20, 2024. https://climatechangecellodisha.org/pdf/Odisha_SAPCC_2021-30..pdf.

Foundation for Ecological Security. 2016. “Community-Led Restoration of Forest Resources Improves Community Cohesion and Livelihoods.” Foundation for Ecological Security (FES). https://d303cb4w253x5q.cloudfront.net/media/documents/ilc_case_study_0055_india_en.pdf.

Fuentes, Keyla. M., Melissa Gomez, Hernan Rebolledo, José M. Figueroa, Pablo Zamora, and Leopoldo Naranjo-Briceño. 2022. “Nanomaterials in the Future Biotextile Industry: A New Cosmovision to Obtain Smart Biotextiles.” , 4: 1056498. https://doi.org/10.3389/fnano.2022.1056498.

Garg, Shreyas and Rishabh Jain. 2022. “Making India a Leader in Solar Manufacturing: Ways to Achieve Technology Leadership and Global Competitiveness.” Centre for Energy Finance, Council on Energy, Environment and Water. https://www.ceew.in/cef/solutions-factory/publications/CEEW-Making-India-a-Leader-in-Solar-Manufacturing.pdf.

Gaur, Divya, Priyatam Yasaswi, and Abhishek Jain. 2023. “How Decentralised Renewable Energy-Powered Technologies Impact Livelihoods: Findings from the Ground.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/How-Decentralised-Renewable-Energy-Powered-Technologies-Impact-Livelihoods.pdf.

Gaur, Divya, Saipriya Salla, Priyatam Yasaswi, Ananya Saini, Simrin Chhachhi, and Rachita Misra . 2023. “Unlocking Finance to Scale Decentralised Renewable Energy for Clean Energy Transitions: Learnings from India.” Task Force 4 Refuelling Growth: Clean Energy and Green Transitions, T20 India. https://t20ind.org/wp-content/uploads/2023/07/T20_PB_TF4_418_FinanceToScaleDRE_ForUpload.pdf

Global Green Growth Institute. n.d. “Green Growth Index Simulation Tool.” Global Green Growth Institute. Accessed September 20, 2024. https://ggindex-simtool.gggi.org/.

Goswami, Sweta. 2022. “Government Identifies 10 States for Green Hydrogen Manufacturing: MNRE Officials.” MoneyControl. https://www.moneycontrol.com/news/business/economy/government-lists-10-states-for-green-hydrogen-manufacturing-9439561.html.

Government of Odisha. n.d.a. “Topography.” Government of Odisha. Accessed September 20, 2024. https://odisha.gov.in/odisha-profile/topography

Government of Odisha. n.d.b. “List of Large Dams in Odisha.” Government of Odisha. Accessed September 20, 2024. https://dowr.odisha.gov.in/sites/default/files/2021-11/Complete%20list%20of%20Large%20Dams.pdf.

Graber, Sachiko, Tara Narayanan, Jose Alfaro, and Debajit Palit. 2019. “Perceptions Towards Solar Mini-Grid Systems in India: A Multi-Stakeholder Analysis.” 43 (4): 253–66. https://doi.org/10.1111/1477-8947.12181.

Greater Hyderabad Municipal Corporation (GHMC). 2020. “Enhancing Circular Economy Perspectives - Plastic Waste Management Strategy and Action Plan for Greater Hyderabad Municipal Corporation.” Greater Hyderabad Municipal Corporation. https://www.iges.or.jp/en/publication_documents/pub/policysubmission/en/11152/Plastic+Waste+management+Strategy+and+Action+Plan+2020_18Jan2021.pdf.

Green Economy Coalition. “The 5 Principles of Green Economy.” Green Economy Coalition. Last modified June 7, 2019. https://www.greeneconomycoalition.org/news-and-resources/the-5-principles-of-green-economy.

GT. 2024. “Alternate Energy: How It Can Shape the Vibrant Future of India.” Grant Thornton. https://www.grantthornton.in/globalassets/1.-member-firms/india/assets/pdfs/alternate_energy_how_can_it_shape_the_vibrant_future_of_india.pdf

Gulia Jyoti, Garg Vibhuti, Sharma Prabhakar, and Thayillam Akhil, 2022. “Photovoltaic Manufacturing Outlook in India: Ambitious Targets and Incentives Brighten the Future for the Solar Industry.” Institute for Energy Economics and Financial Analysis (IEEFA) and JMK Research and Analytics. https://jmkresearch.com/renewable-sector-published-reports/photovoltaic-manufacturing-outlook-in-india/.

Gupta, Niti, Saurabh Tripathi, and Hem Himanshu Dholakia. 2020. “Can Zero Budget Natural Farming Save Input Costs and Fertiliser Subsidies? Evidence from Andhra Pradesh.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/can-zero-budget-natural-farming-save-input-costs-and-fertilizer-subsidies.pdf.

Gupta, Niti, Shanal Pradhan, Abhishek Jain, and Nayha Patel. 2021. “Sustainable Agriculture in India 2021: What We Know and How to Scale Up.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/CEEW-Sustainable-Agricultre-in-India-2021-ES-21May21.pdf.

Gupta, Urvashi, 2024. “India added 1.2 GW wind capacity in Q1 2024, 56% YoY increase”. . https://www.mercomindia.com/india-added-wind-capacity-yoy-increase

Gutiérrez, Marina Vara. 2022. “Promoting Bio-Resource Centres as a Model to Improve Soil Health and Fertility.” https://aidenvironment.org/promoting-bio-resource-centers-as-a-model-to-improve-soil-health-and-fertility/.

Strega. 2023. “Porsche plans to use CO_2-reduced steel from H2 Green Steel in sports cars from 2026.” Strega, October 31, 2023. https://stegra.com/news-and-stories/porsche-plans-to-use-co2-reduced-steel-from-h2-green-steel-in-sports-cars-from-2026

Harikumar, Aravind, Anand RM, Himani Jain, and Sowmia Philip. 2022. “India’s EV Transition: Catalysing Kochi’s Electric 3-Wheeler Market Through Local Policy.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-research-on-electrification-of-3-wheeler-auto-rickshaw-market-through-local-policy-in-kochi.pdf.

Harikumar, Aravind, Himani Jain, and Abhinav Soman. 2022. “India’s EV Transition: Managing Fuel Tax Revenue Loss.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-research-on-recovering-fuel-tax-revenue-loss-from-ev-transition-in-india.pdf.

Hopewell, Jefferson, Robert Dvorak, and Edward Kosior. 2009. “Plastics Recycling: Challenges and Opportunities.” 364 (1526): 2115–2126. https://doi.org/10.1098/rstb.2008.0311.

Hutchinson, Mark, and Zhao Feng. 2023. . Global Wind Energy Council. https://gwec.net/globalwindreport2023/.

IASS, TERI, CEEW, and SCGJ. 2019. “Future Skills and Job Creation with Renewable Energy in India: Assessing the Co-benefits of Decarbonising the Power Sector.” Institute for Advanced Sustainability Studies (IASS, Renewables Academy (RENAC), Independent Institute for Environmental Issues (UfU), International Energy Transition GmbH (IET), and The Energy and Resources Institute (TERI). https://www.ceew.in/sites/default/files/future.pdf.

ICAR–CAFRI. 2015. . ICAR-Central Agroforestry Research Institute. https://cafri.icar.gov.in/html/CAFRI-AR/AR(2015-16)_English.pdf.

ICAR. 2018. “Promising Technologies: Seaweed-Based Nutraceutical to Boost Immunity Related to Post-COVID Complications.” 29 (3). https://icar.org.in/sites/default/files/2023-11/ICAR%20News%20July%20Sep%202023%2021%20Nov%20%281%29.pdf.

IEA Bioenergy. 2024. “Emissions from Biomass Combustion.” In , developed by IEA Bioenergy Task 32, 18–29. International Energy Agency. https://www.ieabioenergy.com/blog/publications/emissions-from-biomass-combustion/.

IEA. 2023. “Global EV Outlook 2023 - Trends in Batteries.” International Energy Agency. https://www.iea.org/reports/global-ev-outlook-2023/trends-in-batteries.

IEA. 2024. “Electrolysers - Energy System.” International Energy Agency. https://www.iea.org/energy-system/low-emission-fuels/electrolysers.

IndiaMART. n.d. “Rice Husk Pellet at Best Price in India.” IndiaMART. Accessed September 20, 2024. https://dir.indiamart.com/impcat/rice-husk-pellet.html.

Indian Green Building Council. n.d. “Government Incentives to IGBC-rated Green Building Projects.” Indian Green Building Council. Accessed September 20, 2024. https://igbc.in/government-incentives-to-igbc-rated-green-building-projects.php

Industries Department, 2023. “Activities Report of Industries Department 2022–2023.” Industries Department, Government of Odisha. https://industries.odisha.gov.in/sites/default/files/2023-09/ACTIVITY per cent20REPORT_2022-23.pdf.

InfoLink Consulting. n.d. “Spot Price.” InfoLink Consulting. Accessed September 20, 2024. https://www.infolink-group.com/spot-price/.

International Labour Organization. n.d. “Green Jobs.” International Labour Organization. Accessed September 20, 2024. https://libguides.ilo.org/green-jobs-en.

International Trade Administration. 2023. “India Solid Waste Management.” International Trade Administration. https://www.trade.gov/market-intelligence/india-solid-waste-management.

IRENA, 2017. . International Renewable Energy Agency, Abu Dhabi.

Irrigation Census. n.d. “Odisha: Micensus Year-Wise Reports – Water Bodies Report.” Ministry of Jal Shakti, Department of Water Resources, RD & GR, Government of India. Accessed September 20, 2024. https://micensus.gov.in/odisha.

IUCN. 2020. “Global Standard for Nature-Based Solutions. A User-Friendly Framework for the Verification, Design and Scaling Up of NbS.” International Union for Conservation of Nature. https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf.

IUCN. n.d.a. “Forest Landscape Restoration.” International Union for Conservation of Nature. Accessed September 20, 2024. https://www.iucn.org/our-work/topic/forests/forest-landscape-restoration.

IUCN. n.d.b. “Invasive Alien Species.” International Union for Conservation of Nature. Accessed September 20, 2024. https://www.iucn.org/our-work/topic/invasive-alien-species.

Jackson, Laura L., Nikita Lopoukhine, and Deborah Hillyard. 1995. "Ecological Restoration: A Definition and Comments." 3 (2): 71–75. https://doi.org/10.1111/j.1526-100X.1995.tb00079.x

Jagtap, Nipun Jaikrishna, and Vishwanath Haily Dalvi. 2021. "Feasibility Study of Bio-Methane Economy in India." 149: 106059. https://doi.org/10.1016/j.biombioe.2021.106059.

Jain Sidharth, Swarnim Srivastava, Disha Sodani, Feng Zhao, Martand Shardul, Francis Jayasurya, Anjali Lathigara et al. 2023. "From Local Wind Power to Global Exhort Hub: India Wind Energy Market Outlook 2023-2027." Global Wind Energy Council. https://gwec.net/india-wind-energy-market-outlook-2023-2027-report/

Jain, Abhishek, Arunabha Ghosh, and Sanjana Chhabra. 2021. "Powering Livelihoods Globally Through Clean Energy." Global Challenges Foundation (GCF) and Council on Energy, Environment and Water (CEEW). https://www.ceew.in/sites/default/files/ceew-study-on-powering-livelihoods-with-distributed-renewable-energy-systems.pdf.

Jain, Abhishek, Wase Khalid, and Shruti Jindal. 2023. "Decentralised Renewable Energy Technologies for Sustainable Livelihoods: Market, Viability and Impact Potential in India." Council on Energy, Environment and Water and Villgro Innovations Foundation. https://www.ceew.in/sites/default/files/Decentralised-Renewable-Energy-Technologies-Market-Impact-Potential-For-Sustainable-Livelihoods.pdf.

Jain, Niveta, Arti Bhatia, and Himanshu Pathak. 2014. "Emission of Air Pollutants from Crop Residue Burning in India." 14 (1): 422–30. https://doi.org/10.4209/aaqr.2013.01.0031.

Jain, Saloni. 2021. "What Is Green Hydrogen?" Centre for Energy Finance, Council on Energy, Environment and Water. https://www.ceew.in/cef/quick-reads/explains/what-is-green-hydrogen.

Jain, Sourabh, Shaleen Singhal, and Nikunj Kumar Jain. 2019. "Construction and Demolition Waste Generation in Cities in India: An Integrated Approach." 12 (5): 333–40. doi:10.1080/19397038.2019.1612967.

Jayakumar, Binnu and Lee Todd. 2017. "When the Wind is Fair: Best Practices for Responsible Wind Development in Alberta." Pembina Institute. https://www.pembina.org/reports/wind-best-practices-report-final.pdf.

Jayaprakash, Kuzhandaivel, Atieh Osama, Rajinikanth Rajagopal, Bernard Goyette, and Obulisamy Parthiba Karthikeyan. 2022. "Agriculture Waste Biomass Repurposed into Natural Fibers: A Circular Bioeconomy Perspective" 9 (7): 296. https://doi.org/10.3390/bioengineering9070296

Jha, Sumit. 2023. "Higher Generation and Lower Landed Cost Make Floating Solar Appealing: Interview." Mercom India. https://www.mercomindia.com/floating-solar-appealing-interview.

Jiménez, Oswalt R., Amalia C. Bornemann, Yelzen E. Medina, Kendipher Romero, and Juan R. Bravo. 2023. "Prospects of Biological Inputs as a Measure for Reducing Crop Losses Caused by Climate Change Effects." 14: 100689. https://doi.org/10.1016/j.jafr.2023.100689

Joshi, Madhura, Marie McNamara, Akanksha Tyagi, Sameer Kwatra, Neeraj Kuldeep. 2021. "Creating Jobs and Income: How Solar Mini-Grids Are Making a Difference in Rural India." Council on Energy, Environment, and Water; Natural Resources Defense Council; and Skill Council for Green Jobs. https://www.ceew.in/sites/default/files/CEEW-NRDC-solar-minigrids-rural-india.pdf

K. N. Shivaprakash. 2022. "Degraded Lands Can Aid Achieve Four Times India's 2030 Renewable Energy Targets." The Nature Conservancy India. https://www.tncindia.in/what-we-do/our-insights/stories-in-india/renewableenergy/.

Kar, Surajit, Trude Sundberg, Lakshminarayan Satpati, and Subham Mukherjee. 2024. "Reappraising Natures and Perspectives of Wasteland in the Developing World with a Focus on India." 11 (6): 111. https://doi.org/10.3390/environments11060111.

Kathiresan, K. 2010. "Globally Threatened Mangrove Species in India." 98 (12): 1551. http://admin.indiaenvironmentportal.org.in/files/Globally%20threatened%20mangrove%20species%20in%20India.pdf.

Kaur, Perminder Jit, Santosh Satya, Kamal Kishore Pant, and Satya Narayan Naik. 2016. "Eco-Friendly Preservation of Bamboo Species: Traditional to Modern Techniques." 11 (4): 10604–24. https://doi.org/10.15376/biores.11.4.Kaur.

Khan, Rakshanda. 2015. “Small Hydro Power in India: Is it a sustainable business?” 152: 207–16. https://doi.org/10.1016/j.apenergy.2014.11.063

Khanna, Naresh. 2023. “Banyan Nation Pioneers Digital Eco-System for Plastic Recycling in India.” Packaging South Asia. https://packagingsouthasia.com/she-safety-health-and-environment/sustainability-health/banyan-nation-plastic/.

Kishore, Teegala Srinivasa, Epari Ritesh Patro, V. S. K. V. Harish, and Ali Torabi Haghighi. 2021. “A Comprehensive Study on the Recent Progress and Trends in Development of Small Hydropower Projects.” 14 (10): 2882. https://doi.org/10.3390/en14102882.

Koohi-Fayegh, S., and M. A. Rosen. 2020. “A Review of Pumped Hydro Energy Storage.” 27: 101047. https://doi.org/10.1016/j.est.2019.101047.

Koundal, Aarushi. 2024. “Government Approves Rs 200 Cr Fund for Green Hydrogen Valley Projects in Four States.” June 2, 2024. https://energy.economictimes.indiatimes.com/news/renewable/govt-approves-rs-200-cr-fund-for-green-hydrogen-valley-projects-in-four-states/110596653.

Krishnan, M., and R. Narayanakumar. 2013. “Social and Economic Dimensions of Carrageenan Seaweed Farming.” FAO Fisheries and Aquaculture Technical Paper 580: 163–84. https://www.fao.org/4/i3344e/i3344e.pdf

KSPDCL. 2018. “Implementation and Support Agreement for Grid Connected Solar Photo Voltaic Projects for Block No. -- 2000 MW Pavagada Ultra Mega Solar Park in Karnataka.” Karnataka Solar Power Development Corporation Limited (KSPDCL). https://kspdcl.karnataka.gov.in/storage/pdf-files/2000%20MW%20Pavagada%20Solar%20Park/FINAL%20ISA.pdf.

Kuldeep, Neeraj, Kanika Chawla, Arunabha Ghosh, Anjali Jaiswal, Nehmat Kaur, Sameer Kwatra, Karan Chouksey. 2017 Council on Energy, Environment and Water and Natural Resources Defense Council

Kumar, Anil, M. S. Hooda, and Raj Bahadur. 2016. “Impact of Multipurpose Trees on Productivity of Barley in Arid Ecosystem.” 37 (2): 153–57. https://epubs.icar.org.in/index.php/AAZ/article/view/65483.

Kumar, Arun. 2022. “Need of Paradigm Shift for Pump Storage Development [Conference Paper].” International Conference on Hydropower and Dams Development for Water and Energy Security Under Changing Climate, April 7–9, 2022, Rishikesh, India. https://www.cbip.org/ISRM-2022/images/7-8%20April%2022%20Rishikesh/Data/Session%205/TS5-4.pdf.

Kumar, D., and S. S. Katoch. 2016. “Environmental Sustainability of Run of the River Hydropower Projects: A Study from Western Himalayan Region of India.” 93: 599–607. https://doi.org/10.1016/j.renene.2016.03.032.

Kumar, Harsh. 2024. “MSMEs Contribute 62% to Employment in India: McKinsey Global Institute.” , May 3, 2024. https://www.business-standard.com/economy/news/msmes-contribute-62-to-employment-in-india-mckinsey-global-institute-124050301240_1.html.

Kumar, Ranjit, Sanjiv Kumar, B. S. Yashavanth, P. C. Meena, P. Ramesh, A. K. Indoria, Sumanta Kundu, et al. 2020. “Adoption of Natural Farming and Its Effect on Crop Yield and Farmers’ Livelihood in India.” ICAR-National Academy of Agricultural Research Management. https://www.niti.gov.in/sites/default/files/2023-03/Adoption%20of%20Natural%20Farming%20and%20its%20Effect%20on%20Crop%20Yield%20and%20Farmers%27%20Livelihood%20in%20India.pdf.

Lohum. n.d. “Safeguarding Earth’s Tomorrow, Today.” Lohum. Accessed September 20, 2024. https://lohum.com

Lomartire, Silvia, and Ana MM Gonçalves. 2022. “An Overview of Potential Seaweed-Derived Bioactive Compounds for Pharmaceutical Applications.” 20 (2): 141. https://doi.org/10.3390%2Fmd20020141.

Lu, Bin, Matthew Stocks, Andrew Blakers, and Kirsten Anderson. 2018. “Geographic Information System Algorithms to Locate Prospective Sites for Pumped Hydro Energy Storage.” 222: 300–12. https://doi.org/10.1016/j.apenergy.2018.03.177.

Lu, Zhiming, Yan Gao, and Wenhui Zhao. 2020. “A TODIM-Based Approach for Environmental Impact Assessment of Pumped Hydro Energy Storage Plant.” 248: 119265. https://doi.org/10.1016/j.jclepro.2019.119265.

Mahesh, Priti Banthia, Anjali S. Nair, and Vinod Kumar. 2024. “Is Plastic Recycling Safe?” Toxics Link. https://toxicslink.org/wp-content/uploads/2024/03/Is%20Plastic%20Recycling%20Safe-%20Report%20by%20Toxics%20Link.pdf.

Malin, Sophie and Ashima Tyagi. 2023. “India’s Demographic Dividend: The Key to Unlocking its Global Ambitions.” S&P Global. https://www.spglobal.com/en/research-insights/featured/special-editorial/look-forward/india-s-demographic-dividend-the-key-to-unlocking-its-global-ambitions.

Mantri, Vaibhav A., Arup Ghosh, K. Eswaran, and M. Ganesan. 2022. “Notes on Recommendations for Enabling Policy Interventions in the Seaweed Cultivation and Processing Domain in India.” 14 (16): 10416. https://doi.org/10.3390/su141610416.

Mantri, Vaibhav A., Monica Gajanan Kavale, and Mudassar Anisoddin Kazi. 2019. “Seaweed Biodiversity of India: Reviewing Current Knowledge to Identify Gaps, Challenges, And Opportunities.” 12 (1): 13. https://doi.org/10.3390/d12010013.

Mapa, Ranjith. 1996. “Coconut Fibre: A Biodegradable Soil Erosion Control.” 13(2): 149–60. http://dx.doi.org/10.1080/01448765.1996.9754774 .

Marine Stewardship Council. n.d. “Seaweeds and Microalgae.” Marine Stewardship Council. Accessed September 20, 2024. https://www.msc.org/what-you-can-do/eat-sustainable-seafood/fish-to-eat/seaweed.

Mastroianni, Kristina, Line Sofie Adser, and Samira Loibl. 2020. “Agroforestry Value Chains and Market Systems – 2020.” Agroforestry Network. https://agroforestrynetwork.org/wp-content/uploads/2020/05/Agroforestry-Value-Chains-and-Market-Systems.pdf

Mathijssen, Dirk, Bas Hofs, E. Spierenburg-Sack, R. van Asperen, B. van der Wal, J. Vreeburg, and H. Ketelaars. 2020. “Potential Impact of Floating Solar Panels on Water Quality in Reservoirs; Pathogens and Leaching.” 15 (3): 807–811. https://doi.org/10.2166/wpt.2020.062.

Mathur, Ajay, JV Sharma, Yogesh Gokhale, Priya Sharma , and Aparna Tyagi. 2020. “Designing the Methodology to Establish Minimum Support Prices of Trees outside of Forests”. Policy Brief Edited by Sumita Ghosh and RK Jha. The Energy and Resources Institute (TERI). https://www.teriin.org/sites/default/files/2021-02/agroforestery-species.pdf.

Medina, Gabriel da Silva, Rosana Rotondo, and Gustavo Rubén Rodríguez. 2023. “Agricultural Bio-Inputs as an Innovative Area of Opportunity for Agro-Industrial Growth in Developing Countries: Lessons from Argentina.” World 4 (4): 709–25. https://doi.org/10.3390/world4040045.

MEiTY. n.d. “CoE on E-waste.” Ministry of Electronics and Information Technology. Accessed September 20, 2024. https://www.meity.gov.in/test-emcdd.

Michon, Geneviève, Hubert De Foresta, Patrice Levang, and Francois Verdeaux. 2007. “Domestic Forests: A New Paradigm for Integrating Local Communities’ Forestry into Tropical Forest Science.” 12 (2). http://www.ecologyandsociety.org/vol12/iss2/art1/.

Minchinton, Todd E., Hannah T. Shuttleworth, Justin A. Lathlean, Russell A. McWilliam, and Trevor J. Daly. 2019. “Impacts of Cattle on the Vegetation Structure of Mangroves.” 39: 1119–27. https://doi.org/10.1007/s13157-019-01143-0.

Ministry of Agriculture and Farmers Welfare. 2023. “5-Year Estimates of Food Grains (2017-18 to 2021-22)”. Ministry of Agriculture and Farmers Welfare, Government of India. https://desagri.gov.in/statistics-type/five-year-estimates/

Ministry of Finance, Government of India. “Economic Survey 2023-24.” Government of India, 2024. https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf.

Ministry of Textiles. 2023. “Unstarred Question – 1113, Rajya Sabha. Digital Sansad Ministry of Textiles, Government of India. https://sansad.in/getFile/annex/260/AU1113.pdf?source=pqars.

Mishra, Amit K., Sandip K. Mohakud, Syed H. Farooq, Anjali Mishra, and Arindam Dey. 2024. “Mono-Specific Data Deficient Saltmarsh Species Has Climate Relevant Carbon Stocks from the East Coast of India.” 2024: 2024020653. https://doi.org/10.20944/preprints202402.0653.v1.

Mishra, Jitendra, Venkatesh Dutta, and Naveen Kumar Arora. 2020. “Biopesticides in India: Technology and Sustainability Linkages.” 10 (5): 210. https://doi.org/10.1007/s13205-020-02192-7.

Mishra, Mukesh Kumar, Nilay Khare, and Alka Bani Agrawal. 2015. “A Small Hydro Power in India: Current Status and Future Perspectives.” 51: 101–15. https://doi.org/10.1016/j.rser.2015.05.075.

MNRE and ASCI. 2021. . New Delhi: Ministry of New and Renewable Energy, Government of India.

MNRE and CEEW. 2024. “Enabling a Circular Economy in India’s Solar Industry: Assessing the Solar Waste Quantum.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/how-can-india-enable-circular-economy-with-solar-waste-management.pdf.

MNRE and ISA. 2024. . Ministry of New and Renewable Energy and International Solar Alliance. https://isolaralliance.org/uploads/docs/540dc1da191598c88320bf07b42e8d.pdf.

MNRE. 2024. “Physical Achievements.” Ministry of New and Renewable Energy, Government of India. https://mnre.gov.in/physical-progress/.

MNRE. n.d. “Overview.” Ministry of New and Renewable Energy, Government of India. Accessed September 20, 2024. https://mnre.gov.in/small-hydro-overview/.

MoEF. 2006. . New Delhi. Ministry of Environment and Forests, Government of India.

MoEFCC. 2014. . New Delhi: Ministry of Environment, Forests and Climate Change, Government of India.

MOEFCC. 2018. . Ministry of Environment, Forest and Climate Change, Government of India. https://moef.gov.in/uploads/2019/10/Climate-Change-and-the-Vulnerable-Indian-Coast_compressed.pdf.

Mohanty, Abinash, and Shreya Wadhawan. 2021. “Mapping India’s Climate Vulnerability – A District Level Assessment.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-study-on-climate-change-vulnerability-index-and-district-level-risk-assessment.pdf.

MoHUA. 2021. “Circular Economy in Municipal Solid and Liquid Waste.” Ministry of Housing and Urban Affairs. https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf.

MOP. 2022. “Renewable Purchase Obligation and Energy Storage Obligation Trajectory till 2029–30.” Ministry of Power, Government of India. https://powermin.gov.in/sites/default/files/Renewable_Purchase_Obligation_and_Energy_Storage_Obligation_Trajectory_till_2029_30.pdf.

MOP. 2023. “Guidelines to Promote Development of Pump Storage Projects (PSP).” Ministry of Power, Government of India. https://powermin.gov.in/sites/default/files/Guidelines_to_Promote_Development_of_Pump_Storage_Projects.pdf.

MSME Department. n.d. “Odisha MSME Development Policy 2022.” https://investodisha.gov.in/download/Odisha-MSME-Policy-2022.pdf.

Muchane, Mary N., Gudeta W. Sileshi, Sofia Gripenberg, Mattias Jonsson, Lorena Pumariño, and Edmundo Barrios. 2020. “Agroforestry Boosts Soil Health in the Humid and Sub-Humid Tropics: A Meta-Analysis.” 295: 106899. https://doi.org/10.1016/j.agee.2020.106899.

Muzyczek, M. 2012. “The Use Of Flax And Hemp For Textile Applications.” In , edited by R.M. Kozłowski and M. Mackiewicz-Talarczyk, 312–28. Woodhead Publishing Series in Textiles. https://www.sciencedirect.com/science/article/abs/pii/B9781845696986500103.

NAAS. 2003. “Seaweed Cultivation and Utilisation” Policy Paper 22. National Academy of Agricultural Sciences. https://naas.org.in/Policy%20Papers/policy%2022.pdf.

Nandigama, Chandrasekhar. 2023. “CBG is Not a Priority Sector Lending to the Banks.” India Business & Trade, August 29, 2023. https://www.indiabusinesstrade.in/blogs/cbg-is-not-a-priority-sector-lending-to-the-banks/.

NDMA. 2022. “Proceedings of the Consultative Meetings with FRI, FSI, Uttarakhand Forest Department, IGNFA, CASFoS, DFE, WII and SDRF by ‘Project Drafting Committee’ of National Programme on Forest Fire Management’, Dehradun.” National Disaster Management Authority. https://ndma.gov.in/sites/default/files/PDF/Reports/MoM_%20Dehradun_final%2009%20Feb%202023.pdf.

Netto, Sebastião V., Marcos F. Sobral, Ana R. Rebiero, and Gleibson R. Soares. 2020. “Concepts and Forms of Greenwashing: A Systematic Review.” 32 (19). https://doi.org/10.1186/s12302-020-0300-3.

NIEIT. 2022. “Paid Course on E-Waste Management.” National Institute of Electronics & Information Technology. https://nielit.gov.in/gangtok/content/paid-course-e-waste-management.

Nigam, Saumya. 2024. “Tata Power’s Electric Vehicle Charging Network Surpasses 10 Crore Environmentally Friendly Kilometers.” April 15, 2024. https://www.indiatvnews.com/auto/tata-power-s-electric-vehicle-charging-network-surpasses-10-crore-environmentally-friendly-kilometers-2024-04-15-926400.

Niti Aayog. 2018. “Draft Strategy for Promoting Processing of Construction and Demolition (C&D) Waste and Utilisation of Recycled Products.” Niti Aayog. https://www.niti.gov.in/sites/default/files/2019-03/CDW_Strategy_Draft%20Final_011118.pdf.

NITI Aayog. 2023. NITI Aayog. https://www.niti.gov.in/sites/default/files/2023-08/India-National-Multidimentional-Poverty-Index-2023.pdf.

NITI Aayog. n.d. . NITI Aayog, Ministry of Power, Department of Science and Technology, Bureau of Energy Efficiency, and World Resource Institute. Accessed September 20, 2024. https://www.niti.gov.in/sites/default/files/2021-08/HandbookforEVChargingInfrastructureImplementation081221.pdf

NIWE. 2023. “Indian Wind Potential Map at 150m agl.” National Institute of Wind Energy, Ministry of New and Renewable Energy, Government of India. https://maps.niwe.res.in/media/150m-report.pdf.

NPC. 2019. “Capacity Building Programme on Implementation of Hazardous Waste Management Rules, 2016.” National Productivity Council, Ministry of Environment, Forest and Climate Change, Government of India. https://www.npcindia.gov.in/NPC/Files/delhiOFC/EM/Hazardous-waste-management-rules-2016.pdf.

NS Energy. 2020. “Pavagada Solar Park.” NS Energy. https://www.nsenergybusiness.com/projects/pavagada-solar-park/.

OECD. 2018. . Organisation for Economic Co-operation and Development. https://doi.org/10.1787/9789264301016-en.

OERC. 2015. “Application for Seeking Approval of the Commission Under Condition 10 of the License Conditions As Per Order Dated 27.10.2006 Passed in Case No. 22 of 2006 for approval of the Projects Being Implemented by OPTCL under ODSSP Scheme.” Odisha Electricity Regulatory Commission. https://www.orierc.org/Orders/2015/C-38-2015.pdf.

OSPCB. 2023. “Annual Report for the Period 2022–23 on Implementation of Construction and Demolition Waste Management Rules, 2016 in the State of Odisha.” Odisha State Pollution Control Board. https://ospcboard.org/wp-content/uploads/2023/07/10993-13.07.2023-Annual-CD-Waste-2022-23.pdf.

Paliath, Shreehari. 2022. “In Andhra Pradesh, Women Are Taking a Lead Role in the Transition to Natural, Sustainable Farming.” , October 9, 2022. https://scroll.in/article/1034434/in-andhra-pradesh-women-are-taking-a-lead-role-in-the-transition-to-natural-sustainable-farming.

Patel, Beena, Bharat Gami, Akash Patel, and Pankaj Patel. 2019. “Wasteland Utilisation for B. Balcooa Cultivation: Socio-Economic and Environmental Impacts Through Bamboo-Based Product Development.” 3 (4): em0103. https://doi.org/10.29333/ejosdr/5957.

Patel, Himmat, Chandrabhan Kakoty, Ashutosh Samal, Anijit Bhattacharya, Pratap Goswami, Dilip Panigrahi, Kshitij Thakur. 2022. "Bamboo Resource Status & Business Opportunities in Odisha." Foundation for MSME Clusters. https://www.switch-asia.eu/site/assets/files/3662/bamboo_case_study_-_odisha-v2.pdf

Patidar, Rishabh, Kartheek Nitturu, Deepak Yadav, and Hemant Mallya. 2024. "Evaluating Net-zero Trajectories for the Indian Fertiliser Industry: Marginal Abatement Cost Curves of Carbon Mitigation Technologies." Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/how-can-sustainable-fertilisers-production-achieve-the-net-zero-carbon-emissions.pdf.

PIB. 2023a. "Net Zero Emissions Target [Press Release]." Ministry of Environment, Forest and Climate Change, Government of India. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1945472#:~:text=India%2C%20at%20the%2026th%20session,achieve%20net%20zero%20by%202070.

PIB. 2023b. "Generation of E-waste [Press Release]." Ministry of Environment, Forest and Climate Change, Government of India. https://pib.gov.in/PressReleasePage.aspx?PRID=1943201.

PIB. 2023c. "Union Minister of State for Chemicals and Fertilisers Launches 400 CBG Plants Under the GOBARdhan Initiative [Press Release]." Ministry of Jal Shakti, Government of India. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1960589.

PIB. 2024. "India's solar energy potential is estimated to be 748 GWp: Union Power and New & Renewable Energy Minister [Press Release]." Ministry of New & Renewable Energy, Government of India. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2003561

Planning and Convergence Department. n.d.a. "Chapter 4 - Agriculture." Economic Survey. Planning and Convergence Department, Government of Odisha. https://pc.odisha.gov.in/sites/default/files/2020-03/eco-4.pdf

Planning and Convergence Department. 2023. Planning and Convergence Department, Government of Odisha. https://pc.odisha.gov.in/sites/default/files/2023-03/Odisha_SDG_Indicator_Framework2.0.pdf.

Power Technology. 2023. "Vestas Wins 140MW Turbine Contract for Canada's Halkirk II Project." Power Technology. https://www.power-technology.com/news/vestas-turbine-order-halkirk-ii/?cf-view.

Protergium. n.d. "Bio Inputs." Protergium. Accessed September 20, 2024. https://www.protergium.com/bio-inputs.

PTI. 2023. "Odisha's Economy to Grow by 7.8 % During 2022–23: Economic Survey Report." , February 23, 2023. https://economictimes.indiatimes.com/news/economy/indicators/odishas-economy-to-grow-by-7-8-during-2022-23-economic-survey-report/articleshow/98184891.cms

PTI. 2023a. "Adani Plans to Build 10 GW Integrated Solar Manufacturing Capacity by 2027." , October 2, 2023. https://www.business-standard.com/companies/news/adani-plans-to-build-10-gw-integrated-solar-manufacturing-capacity-by-2027-123100200723_1.html.

Pulse Energy. 2024. "Cost of Electric Vehicle Charging Station in India." Pulse Energy. https://pulseenergy.io/blog/electric-car-charger-price-in-india.

PV Insights. n.d. "PV spot price." PV Insights. Accessed September 20, 2024. https://pvinsights.com/

Raghupathy, Lakshmi, Christine Krüger, Ashish Chaturvedi, Rachna Arora, and Mikael P. Henzler. 2018. "E-Waste Recycling in India – Bridging the Gap Between the Informal and Formal Sector." GREENE, Ministry of Electronics and Information Technology, Government of India. https://greene.gov.in/wp-content/uploads/2018/01/Krueger.pdf.

Raj, Kowtham, Pranav Lakhina, and Clay Stranger. 2022. . NITI Aayog and RMI. https://www.niti.gov.in/sites/default/files/2022-06/Harnessing_Green_Hydrogen_V21_DIGITAL_29062022.pdf.

Ravichandran, Nagananthini, and Ravichandran Nagavinothini. 2021. "Investigation on Floating Photovoltaic Covering System in Rural Indian Reservoir to Minimize Evaporation Loss." 40 (8): 781–805. https://doi.org/10.1080/14786451.2020.1870975.

Renewable Watch. 2020. "Waterless Way: Dry Cleaning Solutions for Solar Panels." Renewable Watch, December 3, 2020. https://renewablewatch.in/2020/12/03/waterless-way/.

Reuters. 2023. "Sweden's H2 Green Steel Raises $1.6 Billion for Boden Plant." Reuters, September 7. https://www.reuters.com/business/finance/swedens-h2-green-steel-raises-16-bln-private-placement-2023-09-07/.

Roychowdhury, Anumita, Avikal Somvanshi, and Anurag Verma. 2020. "Another Brick off the Wall: Improving Construction and Demolition Waste Management in Indian Cities." Centre for Science and Environment. https://www.cseindia.org/another-brick-off-the-wall-10325.

Roychowdhury, Anumita, Rajneesh Sareen, and Mitashi Singh. 2023. "Construction and Demolition Waste: Closing the Waste Loop for Sustainability." Centre for Science and Environment. https://www.cseindia.org/construction-and-demolition-waste-11992.

Sahdev, Garvit, Shruti Jindal, and Abhishek Jain. 2021. "Energy-Efficient Silk Spinning and Reeling Machines: How Big is the Opportunity?" Council on Energy, Environment and Water. https://www.ceew.in/publications/energy-efficient-silk-spinning-and-reeling-machines-how-big-opportunity.

Sakthivel, P., Neeraj Mittal, Prabhakar Sinha, M. Sithananthan, and Mukul Maheshwari. 2024. "Assessing the Potential of CBG as an Alternative Fuel: An Experimental Study on Vehicle Performance and Emissions in BS VI Compliant Three-Wheeler and Passenger Car." SAE Technical Paper, no. 2024-26-0076. https://doi.org/10.4271/2024-26-0076.

Sardar Swaran Singh National Institute of Bio-Energy. n.d. "National Biomass Atlas: Odisha." Ministry of New and Renewable Energy, Government of India. Accessed September 20, 2024. https://nibe.res.in/pdf/Odisha.pdf

Searchinger, Tim. and Ralph Heimlich. 2015. "Avoiding Bioenergy Competition for Food Crops and Land." Instalment 9 of , World Resources Institute. https://www.wri.org/research/avoiding-bioenergy-competition-food-crops-and-land.

SCGJ. n.d. Assessment of biomass demand-supply value chain and entrepreneurship development for pellet production in selected clusters/districts. Skill Council for Green Jobs. https://sscgj.in/wp-content/uploads/2016/06/Assessment-of-biomass-demand-supply-value-chain.pdf

Schroth, G., Krauss, U., Vohland, K., & Gasparotto, L. 2000. "Pests and Diseases in Agroforestry Systems of the Humid Tropics". https://doi.org/10.1023/A:1006468103914

Shankar Ajay, A. K. Saxena, and Robin Mazumdar. 2023. "Pumped Storage Plants – Essential for India's Energy Transition." The Energy and Resources Institute. https://www.teriin.org/sites/default/files/2024-01/Pumped_Storage%20_Plants_Discussion_Paper_2023.pdf

Sharma, Ameesh Kumar, and N. S. Thakur. 2017. "Assessing the impact of Small Hydropower Projects in Jammu and Kashmir: A Study from North-Western Himalayan Region of India." 80: 679–693. https://doi.org/10.1016/j.rser.2017.05.285.

Sharma, Amrita, Rupal Kulkarni, and Rajiv Khandelwal. 2014. . Udaipur, Rajasthan: Centre for Migration and Labor Solutions, Aajeevika Bureau.

Sharma, Prashant, Prabhat Tiwari, Kamlesh Verma, and Manoj Singh. 2017. 'Agroforestry Systems: Opportunities and Challenges in India'. Journal of Pharmacognosy and Phytochemistry S1 (01 2017): 953–57.

Shekhar, Jai, Selna Saji, Disha Agarwal, Asim Ahmed, and Tarun Joseph. 2021. . Council on Energy, Environment and Water. https://www.ceew.in/publications/studying-the-impact-of-unexpected-climate-change-on-wind-energy-sector-in-india.

Singh, Chaudhari, and Mukherjee. 2023. "Odisha Renewable Energy Potential Re-Assessment: Focus on Solar, Wind and Biomass." iFOREST - International Forum for Environment, Sustainability and Technology. https://iforest.global/research/odisha-renewable-energy-potential-re-assessment-focus-on-solar-wind-and-biomass_request-download/.

Singh, Narendra, and Oladele A. Ogunseitan. 2022. "Disentangling the Worldwide Web of E-Waste and Climate Change Co-Benefits." 1 (2): 100011. https://doi.org/10.1016/j.cec.2022.100011.

Singh, Siddharth Ghanshyam. 2021. "Plastic Recycling: Decoded." Centre for Science and Environment. https://www.cseindia.org/plastic-recycling-decoded-10885.

Singh, Vaibhav Pratap, Kanika Chawla, and Saloni Jain. 2020. “Financing India’s Transition to Electric Vehicles.” Centre for Energy Finance, Council on Energy, Environment and Water. https://www.ceew.in/cef/solutions-factory/publications/CEEW-CEF-financing-india-transition-to-electric-vehicles.pdf

Smith, Jo, Jagadeesh Yeluripati, Pete Smith, and Dali Rani Nayak. 2020. “Potential yield challenges to scale-up of zero budget natural farming.” 3: 247–52. https://doi.org/10.1038/s41893-019-0469-x.

Snowy Hydro. n. d. “About.” Snowy Hydro. Accessed September 20, 2024. https://www.snowyhydro.com.au/snowy-20/about/

Sripathy, Pratheek, Deepak Yadav, Aditi Bahuguna, and Hemant Mallya. 2023. “Accelerating the Implementation of India’s National Green Hydrogen Mission: Assessment of Standards to Enable the Ecosystem.” Council on Energy, Environment and Water. https://www.ceew.in/publications/how-can-india-adopt-international-standards-for-national-green-hydrogen-mission

STAAI. n. d. “About STAAI.” Solar Technology and Application Atlas of India. Accessed September 20, 2024. https://staai.cstep.in/staai/#/home

Stegmann, Paul, Marc Londo, and Martin Junginger. 2020. “The Circular Bioeconomy: Its Elements and Role in European Bioeconomy Clusters.” : 6: 100029. https://doi.org/10.1016/j.rcrx.2019.100029.

The Hindu Bureau. “Odisha to Add 100 MW of Green Energy with Fresh Investments.” , June 28, 2024. https://www.thehindu.com/news/national/odisha/odisha-to-add-100-mw-of-green-energy-with-fresh-investments/article68343352.ece.

. 2024. “Pumped Hydro Storage Projects Face Land Acquisition Hurdles, Says Power Minister.” https://meghalayamonitor.com/pumped-hydro-storage-projects-hit-hurdles/#:~:text=Power%20Minister%20A%20T%20Mondal%20told,will%20explore%20non%2Dinhabitant%20areas.

The New Indian Express. 2019. “Odisha in Top 10 of Human Index: SBI.” , March 10, 2019. https://www.newindianexpress.com/odisha/2019/Mar/10/odisha-in-top-10-of-human-index-sbi-1949219.html.

TNRDPRD. 2021. “Gobardhan Waste to Wealth: Framework for implementation.” Tamil Nadu Rural Development and Panchayat Raj Department. https://tnrd.tn.gov.in/project/go_files/4_595_2021_S18017.pdf.

Tripathi, Naandika. 2021. “Nexus Power: Building an EV Future Beyond Lithium-ion Batteries.” , March 19, 2021. https://www.forbesindia.com/article/30-under-30/nexus-power-building-an-ev-future-beyond-lithiumion-batteries/66263/1.

Tripathi, Saurabh, and Abhishek Jain. 2017. “24x7 Power for All in Odisha: Strategies for On-Ground Action Based on ACCESS 2015.” Council on Energy, Environment and Water. https://www.ceew.in/publications/24x7-power-all-odisha.

Tumkuru District. n. d. “Solar Park.” Tumkuru District, Government of Karnataka. Accessed September 20, 2024. https://tumkur.nic.in/en/solar-park/.

Tyagi, Akanksha, Akanksha Golchha, Deepak Rai, Arvind Poswal, Charu Lata, Sameer Kwatra, and Praveen Saxena. 2023. “India’s Expanding Clean Energy Workforce 2022 Update.” Council on Energy, Environment and Water; Natural Resources Defense Council; and Skill Council for Green Jobs.” https://www.ceew.in/publications/indias-expanding-clean-energy-workforce-2022-update.

Tyagi, Akanksha, and Neeraj Kuldeep. 2021. “Learnings from Global Best Practices How India Can Manage Solar Photovoltaic Module Waste Better.” Centre for Energy Finance, Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/ceew-study-on-photovoltaic-solar-panel-waste-management-disposal-india.pdf.

Tyagi, Akanksha, Neeraj Kuldeep, and Madhura Joshi. 2021. “Employment Potential of Emerging Renewable Energy Technologies: Insights from the Floating Solar Industry.” Council on Energy, Environment, and Water; Natural Resources Defense Council; and Skill Council for Green Jobs. https://www.ceew.in/publications/employment-potential-emerging-renewable-energy-technologies.

Tyagi, Bhawna, Sachin Zachariah, Neeraj Kuldeep, Deepak Singh Chouhan, Shailendra Singh Chouhan, Aayush Mahajan, and Atul Kumar Jain. 2023. “kWh from kW: Achieving Optimum Energy Generation from Rooftop Solar Systems – Insights from Field Visits in Delhi.” Council on Energy, Environment and Water. https://www.ceew.in/publications/achieving-optimum-energy-generation-from-rooftop-solar-systems-in-india-ceew-bypl-study.

UNEP. 2023. “Seaweed Farming: Assessment on the Potential of Sustainable Upscaling for Climate, Communities and the Planet.” United Nations Environment Programme. https://www.unep.org/resources/report/seaweed-farming-assessment-sustainable-upscaling.

UNEP. n.d. “About Green Economy.” United Nations Environment Programme. Accessed September 20, 2024. https://www.unep.org/explore-topics/green-economy/about-green-economy.

UNIDO and ICSHP. 2022. . United Nations Industrial Development Organization (Vienna, Austria) and International Center on Small Hydro Power (Hangzhou, China). www.unido.org/WSHPDR2022.

Varma, Kalyan. 2017. “Wastelands of India.” Peepli. https://www.peepli.org/stories/wastelands-of-india/.

VoisPlanet. 2022. “Electrifying Rural India: A Case Study on Mlinda’s Solar Mini-Grids.” VoisPlanet. https://voisplanet.com/public/assets/images/casestudy/Electrifying-rural-India-A-Case-Study-on-Mlinda-solar-grids.pdf.

Wangchuk, Rinchen Norbu. 2021. “Mumbai Firm Recycles 7200 Tons of E-Waste Yearly, Launches Free App for Home Pickup.” , April 7, 2021. https://thebetterindia.com/252476/mumbai-e-waste-recycling-discard-dead-laptops-mobile-phones-computer-keyboard-ecoreco-book-my-junk-environment-india-nor41/.

Warrior, Dhruv, Akanksha Tyagi, and Rishabh Jain. 2023. “How can India Indigenise Lithium-Ion Battery Manufacturing? Formulating Strategies across the Value Chain.” Council on Energy, Environment and Water. https://www.ceew.in/sites/default/files/how-can-india-scale-lithium-ion-battery-manufacturing-sector-and-supply-chain.pdf

Watson-Capps, Jana J., and Janet Mann. 2005. “The Effects of Aquaculture on Bottlenose Dolphin (Tursiops Sp.) Ranging in Shark Bay, Western Australia.” 124 (4): 519–26. https://www.monkeymiadolphins.org/wp-content/uploads/2019/10/Watson-Capps-2005-The-effects-of-aquaculture-on.pdf

WBCSD and IESA. 2023. “Policy and Regulatory Framework to Accelerate Energy Storage in India. Recommendations from Businesses.” World Business Council for Sustainable Development and Indian Energy Storage Alliance. https://www.wbcsd.org/wp-content/uploads/2023/10/Policy-and-regulatory-framework-to-accelerate-energy-storage-deployment-in-India.pdf.

WHO. 2023. “Electronic Waste (e-waste).” World Health Organisation. https://www.who.int/news-room/fact-sheets/detail/electronic-waste-(e-waste).

Wilson, Rob. 2020. “Addressing the Risks of Pumped Storage Hydropower for a Net Zero World.” Lockton. https://global.lockton.com/gb/en/news-insights/addressing-the-risks-of-pumped-storage-hydropower-for-a-net-zero-world.

World Bank. n. d (a). “Sembcorp Tengeh Floating Solar Farm, Singapore.” World Bank. https://ppp.worldbank.org/public-private-partnership/energy-and-power/sembcorp-tengeh-floating-solar-farm-singapore.

World Resources Institute, 2021.” India: A Large-Scale Solar Park on Drought-Prone Agricultural Land.” World Resources Institute. https://www.wri.org/update/india-large-scale-solar-park-drought-prone-agricultural-land.

Yadav, Anurag, and Kusum Yadav. 2024. “Challenges and Opportunities in Biofertilizer Commercialization.” 5 (1): 1-14. https://doi.org/10.58624/SVOAMB.2024.05.037.

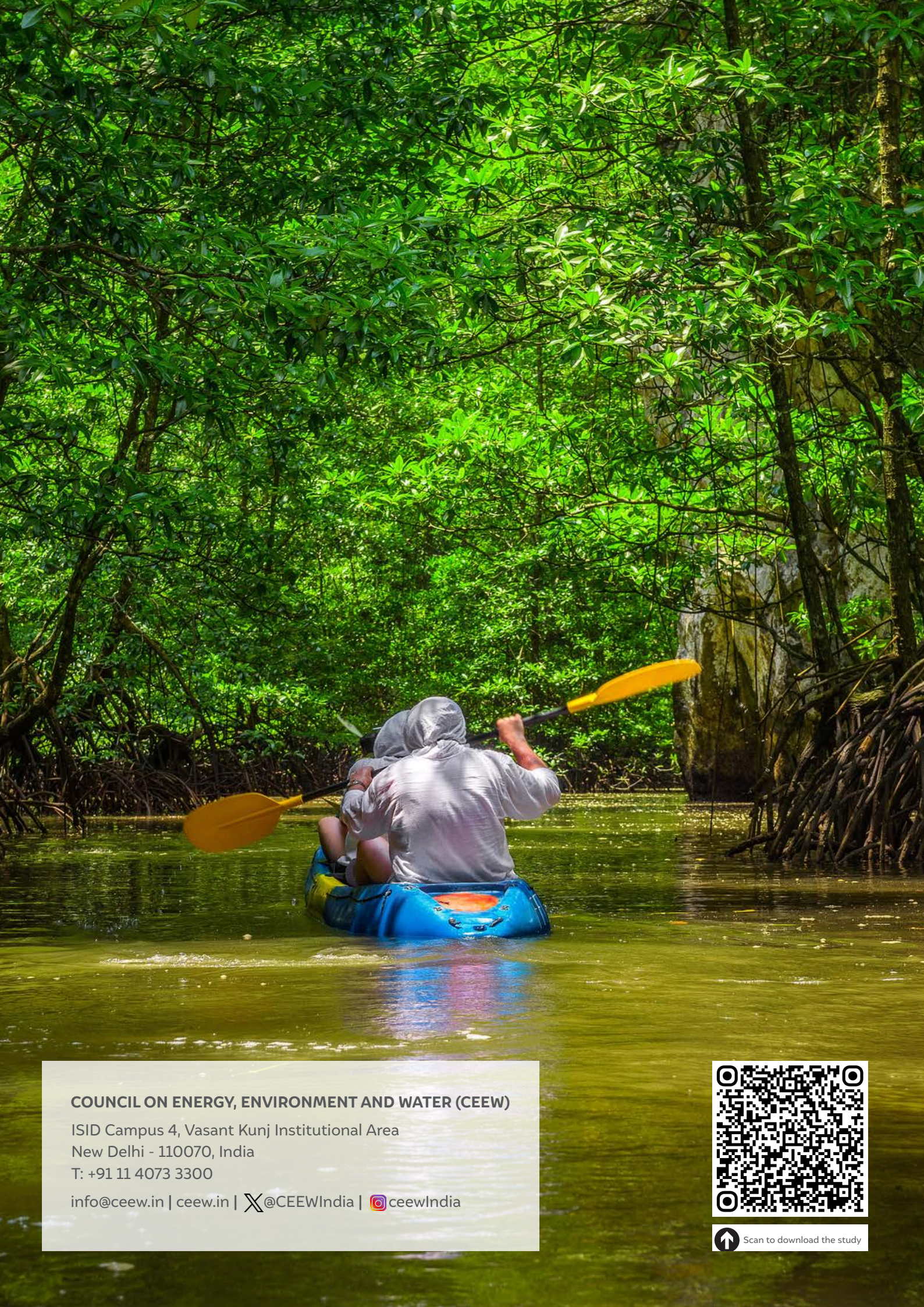
Yadav, Deepak, Ashish Guhan, and Tirtha Biswas. 2021. Council on Energy, Environment and Water https://www.ceew.in/publications/decarbonising-steel-production-using-hydrogen-and-renewable-energy-in-india

Zachariah, Sachin, Bhawna Tyagi, and Neeraj Kuldeep. 2023. “Mapping India’s Residential Rooftop Solar Potential: A Bottom-Up Assessment Using Primary Data.” Council on Energy, Environment and Water. https://www.ceew.in/publications/residential-rooftop-solar-market-potential-in-indian-households

Zhang, Kai, Jerald L. Schnoor, and Eddy Y. Zeng. 2012. “E-Waste Recycling: Where Does It Go from Here?” 46 (20): 10861–67. https://doi.org/10.1021/es303166s.

The authors

Author	Email ID	Contribution
Abhishek Jain	abhishek.jain@ceew.in	As Principal Investigator (PI) of the project, provided the conceptual and technical direction and led fundraising and senior government engagements.
Gunjan Jhunjhunwala	gunjan.jhunjhunwala@ceew.in	Project managed the whole endeavour, including shaping the project, and managing donors, fund management, government engagements and the research team.
Wase Khalid	wase.khalid@ceew.in	Led research methods for JMI estimations; built research capacity amongst the team on JMI estimations and stakeholder communications. Reviewed all value chains at all stages and report-writing.
Urwa Tul Wusqa	urwa.tulwusqa@ceew.in	Contributed to research coordination, writing, compilation, and the publication of the report; co-led research and writing for DRE technologies for livelihoods.
Aaditya Malhotra	aaditya.malhotra@ceew.in	Contributed to research coordination, donor and team management, government and stakeholder consultations, report-writing, and publication process.
Neeraj Kuldeep	neeraj2791@gmail.com	Co-developed the research plan for the energy transition (ET) value chains, including methodology for JMI and stakeholder communications. Reviewed documents at all stages.
Nicole Almeida	nicole.almeida@ceew.in	Co-led review of all ET value chains; co-led research and writing for ET-specific value chains: green hydrogen, EVs, batteries, charging infrastructure, biomass to power, BESS, DRE and rooftop solar.
Parineet Kaur Chowdhury	parineet.chowdhury@ceew.in	Co-led research and writing for ET-specific value chains: utility-scale solar deployment, wind deployment, small hydro, pumped storage hydro, RE manufacturing (wind and solar), floating solar, mini-grid deployment and rooftop solar deployment.
Akanksha Tyagi	akanksha.tyagi@ceew.in	Co-developed the research plan for the circular economy (CE) value chains, including methodology for JMI and stakeholder communications. Review of all documents at all stages.
Aishwarya Jain	aishwarya.jain@ceew.in	Co-led research and writing for CE-specific value chains: construction & demolition waste recycling, plastic waste recycling, lithium-ion battery waste recycling and e-waste recycling.
Shruti Prakash	shruti2571997@gmail.com	Conducted secondary literature review and developed models for market and investment estimations.
Apoorve Khandelwal	apoorve.khandelwal@ceew.in	Co-developed research plan for the bio-economy and nature-based solutions (BE & NbS) value chains, including methodology for JMI and stakeholder communications. Review of all documents at all stages.
Shruti Nambiar	shruti.nambiar@ceew.in	Co-guided the analysis and co-led the review of the BE & NbS value chains.
Aishwarya Joshi	aishwaryak@ceew.in	Co-led research and writing for BE & NbS specific value chains: bamboo-based products, compressed biogas, and bio-inputs.
Nikhitha Jagadeesh	nikhitha.jagadeesh@ceew.in	Co-led research and writing for BE & NbS specific value chains: bio-based packaging material manufacturing, bio-based fibre manufacturing, agroforestry and sustainable forest management.
Theres Thomas	cothomastheres@gmail.com	Co-led research and writing for BE & NbS specific value chains: mangrove management, seaweed cultivation and sustainable tourism.



COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)

ISID Campus 4, Vasant Kunj Institutional Area
New Delhi - 110070, India
T: +91 11 4073 3300

info@ceew.in | ceew.in | @CEEWIndia | ceewIndia

Scan to download the study