



Transform
Rural
India



GREEN ECONOMIC PATHWAYS: CHHATTISGARH

Towards Jobs, Growth & Sustainability 40 Value Chains ·
Three Transition Pillars

A flagship compendium of Diagnostic and
Investment summaries of Green Value Chains.

Supported By:

Department of Good Governance and Convergence
Department of Forest and Climate change
Government of Chhattisgarh

2026

GREEN ECONOMIC PATHWAYS

CHHATTISGARH

A Flagship Compendium of Diagnostic & Investment Summaries



Towards Jobs, Growth & Sustainability
40 Value Chains · Three Transition Pillars

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Supported By:

Department of Good Governance and Convergence
Department of Forest and Climate change
Government of Chhattisgarh



Contents

01	Foreword	01
02	Acknowledgements	04
03	Executive Summary	05
04	Introduction	09
05	Research Methodology	10
06	Part I — Energy Transition Value Chains	15
	E01 Rooftop Solar	16
	E02 Solar Mini/Microgrids	25
	E03 Small Hydropower (SHP)	34
	E04 Utility-Scale Solar	43
	E05 Pumped Storage Hydropower (PSH)	52
	E06 RE Manufacturing (Bio-Energy)	61
	E07 Green Transport	72
	E08 Electric Vehicle Battery Manufacturing	80





Contents

	E09 Wind & Solar Hybrid (WSH)	88
	E10 Green Hydrogen	96
	E11 Floating Solar PV (FSPV)	105
07	Part II — Circular Economy Value Chains	114
	C01 Plastic Waste Recycling	115
	C02 E-Waste Recycling	122
	C03 Lithium-ion Battery Waste Recycling	129
	C04 Tyre Recycling	136
	C05 Construction & Demolition Waste Recycling	142
	C06 Bio-Medical Waste Recycling	130
	C07 Industrial Waste Recycling	158
	C08 Household Goods & FMCG Recycling	164
	C09 Packaging using Recycled Materials	171
	C10 Solid & Liquid Waste Recycling	178



Contents

	C11 Agri-Residue Circular Economy	184
08	Part III — Bio-economy & Nature-based Solutions	191
	N01 Agroforestry	192
	N02 Sustainable Forest Management	202
	N03 Non-Timber Forest Produce (NTFP)	210
	N04 Biochar	224
	N05 Bio-Inputs	231
	N06 Bio-Feed (Nature-Based)	240
	N07 Sustainable Agriculture & IPM	247
	N08 Pasture Management	254
	N09 Small Livestock Rearing	262
	N10 Inland Fishery	269
	N11 Water Security	276
	B01 Bamboo-Based Products	283





Contents

B02 Bio-Fibre	291
B03 Bio-Textiles	299
B04 Bio-Based Feed (Bio-Economy)	306
B05 Nutraceutical Value Chain	314
B06 Sustainable Ecotourism	321
B07 Sustainable Housing	330





Foreword

Shri Vikas Sheel, IAS, Chief Secretary, Government of Chhattisgarh

विकास शील
मुख्य सचिव
Vikas Sheel
Chief Secretary



छत्तीसगढ़ शासन
Government of Chhattisgarh
अर्थशास्त्रीय पत्र क्र. :
रायपुर, दिनांक : 29 JUL 20

FOREWORD

The state of Chhattisgarh is blessed with a distinctive combination of natural resources, industrial capacity, community institutions and human potential. Harnessing these strengths for employment-intensive and environmentally sustainable growth requires a clear understanding of the sectors and value chains in which the State has a comparative advantage.

The Green Value Chains Study provides such an evidence base. It assesses 40 value chains across energy transition, circular economy, and nature-based solutions and bio-economy, examining their employment potential, market opportunities, resource availability, investment requirements, institutional readiness and environmental benefits. The study helps translate the broad idea of green growth into specific economic opportunities relevant to Chhattisgarh.

Its value lies in connecting the State's natural and productive assets with practical pathways for enterprise development, value addition and livelihood creation. The findings can support departments in identifying priority sectors, understanding systemic constraints, and designing interventions suited to different regions and communities.

The State's thinking is aligned with principles of a Green Economic Transition Mission to bring greater coherence to its green-growth efforts. This report can serve as an important analytical foundation for such thinking by enabling policies and investments to be informed by evidence, local realities and measurable development outcomes.

I commend the institutions, experts, field teams and community members who contributed to this study. I hope the report will support informed decision-making and help Chhattisgarh pursue a development pathway in which prosperity, inclusion and environmental sustainability advance together.


(Vikas Sheel)

Foreword

Shri Manoj Kumar Pingua, IAS, Additional Chief Secretary
Department of Forest & Climate Change

मनोज कुमार पिंगुआ (भा.प्र.से.)
अपर मुख्य सचिव

Manoj Kumar Pingua, (I.A.S.)
Addl. Chief Secretary



छत्तीसगढ़ शासन
वन एवं जलवायु परिवर्तन विभाग

Government of Chhattisgarh
Deptt. of Forest and Climate Change

अर्थ शास. पत्र क्र. १९
दिनांक ०३/०८/२०१८

FOREWORD

Chhattisgarh's forests and biological resources are central to the livelihoods, food security and cultural identity of a large section of its population. They also provide the foundation for several emerging economic opportunities based on sustainable natural-resource management.

The Green Value Chains Study examines a range of forest- and nature-based opportunities, including non-timber forest produce, bamboo, agroforestry, bio-inputs, biochar, nutraceuticals, sustainable ecotourism and other bio-economy value chains. It highlights the potential to move beyond the sale of raw produce by strengthening aggregation, processing, product development, certification and market linkages.

From the perspective of the Forest and Climate Change Department, the study is useful because it brings livelihood potential and ecological sustainability within a common analytical framework. It draws attention to the need for interventions that enhance incomes while safeguarding biodiversity, regeneration and the long-term productive capacity of forests.

The findings can help in identifying value chains suited to different landscapes, understanding gaps in institutions and infrastructure, and designing community-centred models involving Gram Sabhas, Van Samitis, Self-Help Groups, producer organisations and other local institutions.

As the State considers a wider Green Economic Transition Mission approach, this report provides an important basis for ensuring that nature-based solutions and the bio-economy remain integral to Chhattisgarh's development strategy.

I appreciate the contribution of all those involved in preparing this study and hope it will support scientifically informed, ecologically responsible and community-oriented interventions across the State.


(Manoj Kumar Pingua)

Foreword

Shri Rahul Bhagat, Secretary, Department of Good Governance & Convergence

राहुल भगत, आईपीएस
सचिव

Rahul Bhagat, IPS
Secretary



छत्तीसगढ़ शासन
मुख्यमंत्री सचिवालय
सुशासन एवं अभिसरण विभाग
Government of Chhattisgarh
Chief Minister Secretariat
Good Governance and
Convergence Deptt. ✓

अर्द्ध शासकीय पत्र क्रमांक 64/secy/GG&C/26

नवा रायपुर, अटल नगर, दिनांक 03-08-2026

FOREWORD

Evidence-based policymaking requires more than identifying promising sectors. It requires an understanding of the markets, institutions, skills, finance and coordination mechanisms needed to convert economic potential into measurable outcomes.

The Green Value Chains Study contributes to this understanding by assessing 40 value chains across energy transition, circular economy, and nature-based solutions and bio-economy. Each value chain has been examined through a common framework covering employment, demand, resource availability, investment feasibility, institutional support, climate resilience and scalability.

For the Good Governance and Convergence Department, the study is particularly relevant because most green value chains cut across multiple departmental mandates. Their development depends on the alignment of schemes, institutions, finance, data, markets and community organisations. The report helps identify these interdependencies and the systemic constraints that may need to be addressed.

The findings can support departments in selecting priority value chains, defining institutional roles, identifying geographical opportunities and designing coordinated interventions. They can also inform the development of common indicators and results frameworks for assessing employment, enterprise development, inclusion and environmental outcomes.

The State is thinking along the lines of a Green Economic Transition Mission as a possible framework for strengthening coherence across these efforts. This study provides an evidence-based starting point for such an approach and for designing interventions grounded in Chhattisgarh's resources, institutions and local realities.

I thank the departments, experts, research teams and community representatives who contributed to this exercise. I am confident that the report will serve as a useful reference for informed and convergent policymaking in the State.

(Rahul Bhagat)

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Acknowledgements

We express our heartfelt gratitude to the Government of Chhattisgarh for its invaluable and consistent support, constructive feedback, and belief in the promise and potential of a green economy for the state. Within the government, the Good Governance & Convergence Department has played a crucial role in anchoring and facilitating the Green Economy Transition Mission, alongside the Forest and Climate change Department, whose continued involvement has been equally vital. We also thank all the line departments for their essential inputs toward developing the green value chains.



Our deep appreciation extends to the community members across multiple villages in Chhattisgarh's three agro-climatic zones who generously gave their time to be part of the locality compact consultations. We also thank our expert peer reviewers, whose insights and expertise significantly enhanced the credibility and reliability of this assessment and to Billionnext for executing and consolidating the findings for us.

The Council on Energy, Environment and Water (CEEW) collaborated with Transform Rural India Foundation (TRIF) and the Development Intelligence Unit (DIU) to support the Government of Chhattisgarh in developing a roadmap for Green Energy Transition. CEEW served as the technical advisory and capacity-building partner, training the DIU team on identifying and assessing high-potential value chains across the energy transition, circular economy, and bio-economy sectors. This included advising on employment potential, market opportunities, investment returns, policy requirements, and the respective roles of government and private-sector stakeholders.

Finally, we thank the Rainmatter Foundation for its generous financial support and flexible learning approach. When donors act as learning partners, the output is significantly enriched.

Executive Summary

Background and Vision

Chhattisgarh stands at an inflection point. An economy in which more than 92 per cent of installed power capacity is coal-based, and which carries roughly 7 per cent of India's coal-thermal fleet and over 14 GW of coal-fired generation, faces both a decarbonisation imperative and the prospect of a managed just transition in districts such as Korba, Surguja and Raigarh. Yet the state begins this transition from a position of exceptional, and often underappreciated, strength. Forty-four per cent of its geographical area is under forest cover—among the highest of any Indian state—nearly a third of its people belong to Scheduled Tribes whose knowledge systems have long stewarded these landscapes, and it is simultaneously one of the country's densest mineral and industrial hubs. To this it adds strong renewable endowments—5.0–5.5 kWh/m²/day of solar irradiance, Mahanadi-basin reservoirs suited to floating solar and pumped storage, roughly 10,000 MW of pumped-storage potential, and a 10.9 MMT annual paddy-straw surplus—together with an unmatched last-mile institutional base of 2.7 lakh Self-Help Groups and 580 Cluster-Level Federations. The central insight of the Green Economic Transition Mission (GETM) is that these are not competing identities but complementary assets: a forest-rich, mineral-rich, community-rich economy is precisely the foundation on which a competitive green economy can be built. GETM is therefore conceived as a whole-of-government mission, aligned with the vision of a Viksit Chhattisgarh and inseparable from India's net-zero-by-2070 commitment, which states will ultimately determine whether the country meets.



The Green Economy Opportunity

GETM organises the state's green transition around three transition pillars comprising a portfolio of 40 investable value chains. The Energy Transition pillar spans 10 value chains—utility-scale, rooftop and floating solar, small hydro, pumped storage, green hydrogen and clean mobility—capable of building an estimated 9,000–22,000 MW of renewable capacity, with its decentralised, livelihood-facing end converting megawatts into rural incomes. The Circular Economy pillar comprises 11 value chains anchored in decentralised municipal solid-waste systems built on the proven Ambikapur model, Extended Producer Responsibility mandates, and industrial by-products from one of the country's densest steel, power, aluminium and cement clusters, where industrial waste alone represents a ₹5,000–15,000 crore opportunity. The Nature-Based Solutions and Bio-Economy pillar spans 18 value chains—NTFP collection and processing, bamboo, medicinal and aromatic plants, and regenerative farming, anchored in SHGs, FPOs and Van Samitis—and constitutes the portfolio's single largest source of direct job creation, with women and tribal households at its core. Together these pillars translate broad policy ambition into specific, financeable, community-anchored interventions.

Key Findings

The diagnostic identifies a portfolio of 40 value chains, of which 39 are assessed as directly investable, capable of generating an estimated five to eleven lakh direct jobs over 2030–32, with women anchoring a large share of the workforce. The nature-based and bio-economy chains offer the deepest inclusion, reaching tribal collectors, women's collectives and smallholders, while the energy and circular pillars command the largest capital markets—renewable capacity of up to 22,000 MW and an industrial-waste opportunity valued at up to ₹15,000 crore. The illustrative economics are compelling: rooftop solar alone, scaled to 1 GW, would sustain some 24,720 direct full-time-equivalent jobs, catalyse ₹4,600–5,100 crore of value-chain activity, and avoid 1.36 million tonnes of CO₂ annually. Crucially, delivery is designed to flow first to women-led community institutions, SHGs, FPOs, CLFs and Van Dhan Vikas Kendras, capturing processing and branding value within the state rather than exporting it as raw material.

Strategic Approach

The diagnostic identifies a portfolio of 40 value chains, of which 39 are assessed as directly investable, capable of generating an estimated five to eleven lakh direct jobs over 2030–32, with women anchoring a large share of the workforce. The nature-based and bio-economy chains offer the deepest inclusion, reaching tribal collectors, women's collectives and smallholders, while the energy and circular pillars command the largest capital markets—renewable capacity of up to 22,000 MW and an industrial-waste opportunity valued at up to ₹15,000 crore. The illustrative economics are compelling: rooftop solar alone, scaled to 1 GW, would sustain some 24,720 direct full-time-equivalent jobs, catalyse ₹4,600–5,100 crore of value-chain activity, and avoid 1.36 million tonnes of CO₂ annually. Crucially, delivery is designed to flow first to women-led community institutions, SHGs, FPOs, CLFs and Van Dhan Vikas Kendras, capturing processing and branding value within the state rather than exporting it as raw material.

Institutional Architecture

Implementation rests on convergence as the organising principle, since a single value chain touches multiple ministries, all three tiers of government, financial institutions and community organisations at once. GETM therefore treats value chains as the unit of planning, whole-of-government convergence under a Common Results Framework as the mechanism of delivery, and community institutions—SHGs, CLFs, FPOs and Van Samitis—as the delivery partners of first resort. Blended green finance stacks public subsidy, private capital and concessional instruments, with credit guarantees and viability-gap support making collateral-free, community-led lending bankable. The roadmap is deliberately phased: quick-win, community-anchored chains in the near term, mid-horizon infrastructure through the late 2020s, and long-horizon anchors such as pumped storage and green hydrogen towards 2032 and beyond.

Expected Outcomes

Delivered in full, GETM will generate large-scale, inclusive employment; diversify an economy away from its coal dependence; and convert climate resilience into a productive, income-generating activity that rebuilds the natural systems on which rural life depends. It will deepen women's economic empowerment through owned service lines and reserved market share, and lift tribal and forest-fringe livelihoods far beyond subsistence collection by capturing value within the state. By offering a costed, de-risked and financeable portfolio, the Mission is designed to attract substantial private and blended investment. In doing so, it positions Chhattisgarh to demonstrate that prosperity, equity and sustainability can advance together and to emerge as India's leading Green Economy State

Chhattisgarh's Green Transition: Three Sector Families, 40 Value Chains

Energy transition

ET involves adopting essential technologies to shift towards a non-fossil-fuel-based economy — a decisive transition for Chhattisgarh, where over 92% of installed capacity is coal-based. We have identified 10 value chains within ET, spanning renewable generation — utility-scale, rooftop and floating solar, small hydro and pumped storage — alongside green hydrogen and clean mobility across electric, CNG and biofuel options. Together, these could build an estimated 9,000–22,000 MW of renewable capacity, with 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 11 value chains within CE for Chhattisgarh — anchored by decentralised municipal solid-waste systems built on the Ambikapur model, waste streams governed by India's expanding EPR mandates, and industrial by-products from one of the country's densest steel, power, aluminium and cement clusters, with industrial waste alone estimated at ₹5,000–15,000 crore.

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. 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. In Chhattisgarh, where forests cover 44% of the state, this combined sector spans 18 value chains — the portfolio's largest source of direct job creation — across NTFP collection and processing, bamboo, medicinal and aromatic plants, and regenerative farming, anchored in SHGs, FPOs and Van Samitis, with women and tribal households at the core. These value chains could contribute decisively to Chhattisgarh's green transition.

1. Introduction

India is among the fastest-growing major economies in the world, and it is also among the youngest. Realising this demographic advantage requires not merely economic growth, but *job-intensive* economic growth — at a scale of several million new jobs each year. At the same time, India has committed to reaching net zero by 2070, with substantial interim decarbonisation targets, while making its economy resilient to climate impacts that are already being felt. These are not competing agendas. Meeting both requires an economic paradigm that generates employment, deepens prosperity, and regenerates natural capital at the same time. That paradigm is the green economy.

Crucially, India's green transition will not be delivered in the abstract. It will be delivered — or missed — in its states, through state departments, district administrations, panchayats, self-help groups, producer organisations, and enterprises. It is at the sub-national level that resource endowments are actually located, that livelihoods are actually created, and that policy actually meets the ground.

The **Green Economic Transition Mission (GETM)** for Chhattisgarh is an attempt to make that transition concrete: to identify which green value chains the state can realistically build, what they are worth in jobs, markets and investment, what stands in the way, and what it would take to scale them over the 2026–2036 horizon.

1.1 What is a green economy?

There is no single settled definition. The United Nations Environment Programme characterises a green economy as one that is low-carbon, resource-efficient and socially inclusive, generating income and employment growth through public and private investment. The Green Economy Coalition frames it as an economy that delivers prosperity for all within the ecological limits of the planet. The International Labour Organization emphasises the employment dimension, defining green jobs as decent work that helps preserve or restore the environment.

The common thread across these framings is that a green economy is simultaneously climate-positive and job-intensive. For this Mission, we adopt a working definition consistent with that thread: **a green economy is one that operates within ecological limits while generating job-intensive economic prosperity.**

Adopting this definition requires answering a set of practical questions:

- Which sectors and value chains actually constitute a green economy?
- Is the green economy the same thing as the energy transition?
- What is its measurable potential in terms of jobs, markets and investment?
- How can it be mainstreamed through existing state systems rather than as a parallel programme?

This report addresses these questions for Chhattisgarh. In doing so, it deliberately widens the frame beyond renewable energy to include the circular economy, the bio-economy and nature-based solutions — where much of the state's distinctive opportunity, and much of its employment potential, actually lies.

1.2 A green economy paradigm for Chhattisgarh

Chhattisgarh is an unusually instructive state in which to test this paradigm, for four reasons.

An exceptional natural capital base. The state holds 55,812 sq km of forest cover — the third largest in India — covering over 40 per cent of its geographical area. Between 2021 and 2023 it recorded the largest single gain in combined forest and tree cover of any Indian state (+684 sq km), and its forest carbon stock of approximately 505 million tonnes is the third highest nationally (Forest Survey of India, ISFR 2023). This is not a conservation statistic alone; it is a productive asset base for non-timber forest produce, agroforestry, medicinal plants, bamboo, biochar and carbon finance.

A population whose livelihoods are already nature-linked. Scheduled Tribes constitute roughly 30.6 per cent of the state's population (2011 Census), and 85 of its 146 development blocks are designated tribal development blocks. For a large share of these households, forest and farm produce is not supplementary income — it is primary income. A green economy here is therefore not a new sector to be created from scratch; it is an existing economy that is under-capitalised, under-processed and under-priced.

A concentrated exposure to the low-carbon transition. Chhattisgarh is one of India's principal coal, power and steel states, hosting major thermal generation capacity and metallurgical industry. That industrial base is a genuine strength — it supplies engineering capability, logistics and skilled labour that many states lack. But it also concentrates transition risk in a way that makes economic diversification a matter of prudence rather than preference.

A stated ambition that requires new economic engines. Chhattisgarh Vision 2047 sets out a substantially expanded state economy. Reaching it on the strength of extractive and primary sectors alone is unlikely; it will require new, value-added, employment-dense sectors of the kind this report examines.

Taken together, a green economy paradigm offers Chhattisgarh the opportunity to:

- **Diversify** its economy into sectors that will remain relevant in a low-carbon world;
- **Move up the value chain**, from raw extraction and primary produce toward processing and manufacturing within the state;
- **Retain its youth**, by creating credible economic opportunity in tribal and rural districts rather than exporting labour; and
- **Position itself** as a destination for green investment, blended finance and climate-linked capital.

2. Research Methodology

This chapter explains how the green-economy opportunity for Chhattisgarh was identified, screened and sized. The approach adapts the state-level green-economy assessment methodology developed by the Council on Energy, Environment and Water (CEEW) for Odisha, tailored to Chhattisgarh's resource base, institutions and field evidence. It follows five sequential steps.

A five-step approach to sizing the green economy



1. Selecting the sectors and value chains

Three emerging green sectors were examined — the **energy transition**, the **circular economy**, and the **bio-economy and nature-based solutions** — chosen for their rising private-sector interest, supportive policy momentum, and ability to create work across the whole economy, from primary producers to industry. Within these sectors a **long list of 40 value chains** was compiled and screened against **nine assessment criteria**. Selection rested on a small set of explicit assumptions:

- **Fit to Chhattisgarh.** A chain is prioritised only where the state has, or can readily mobilise, the underlying resource — and where scaling it does not deplete natural assets.
- **Livelihoods first.** Employment potential and market demand are treated as the most decisive tests (each carries the highest weight), so selected chains are both job-intensive and commercially durable.
- **Readiness is fixable; potential is not.** Infrastructure and finance gaps are weighted moderately because public action can close them, so emerging-but-strategic chains are not screened out prematurely.
- **Like-for-like comparison.** All 40 chains are scored on the same nine criteria (1 = low, 2 = medium, 3 = high fulfilment), producing 360 scored judgements, each with a written justification.
- **Tiers follow natural breaks.** Weighted scores are grouped into High, Medium and Low priority using cut-offs drawn from the observed clustering of scores, not fixed arbitrarily.

Assessment criterion (weight)	What it assesses
Employment potential — 0.14	Volume, quality and inclusiveness of jobs, especially for rural, tribal and women workers.
Market demand — 0.14	Credible, sustained demand and the presence of anchor buyers.
Resource availability — 0.12	A local raw-material or resource base of sufficient quantity and quality.
Climate resilience — 0.12	Ability to withstand climate risks and to strengthen adaptation.
Policy & institutional support — 0.12	Alignment with existing missions, schemes, incentives and clear departmental roles.

Infrastructure readiness — 0.10	Power, water, roads, storage and processing already in place or easily mobilised.
Investment feasibility — 0.10	Financial viability and attractiveness for public, private or blended finance.
Environmental co-benefits — 0.08	Gains in emissions, air, water, soil, waste reduction and biodiversity.
Scalability & replication — 0.08	Ease of standardising the model and expanding it across districts.

Table 1. The nine criteria used to score every value chain, with their weights (weights sum to 1.00).

How 40 value chains were screened into three priority tiers



Figure 1. Each chain's scores are multiplied by the criterion weights and pooled into a single score, then slotted into three priority tiers (15 High, 12 Medium, 13 Low).

2. Sizing the opportunity — jobs, market, investment and revenue

For each value chain, four quantities were estimated: the **direct jobs** it can create, the **market** it can serve, the **investment** it needs, and the **revenue** it can generate. The estimation rests on a common, deliberately conservative set of assumptions, summarised in Table 2.

What we estimate for each value chain



Jobs are expressed as full-time equivalents (FTE) — one FTE being a full year of work at the standard annual hours for that industry. Two routes are used: a **job-factor route** (an FTE

coefficient per unit of output or capacity, applied to the 2030 target — for example, rooftop solar is taken at roughly 24.72 FTE per MW) and a **state-share route** (Chhattisgarh's resource or output share applied to a national jobs target). Only **direct** jobs are counted.

Indirect and induced jobs are not added to the headline figures. They are real and often sizable, but they are difficult to estimate reliably at value-chain level and — crucially — one chain's indirect jobs are frequently another chain's direct jobs, so adding them would double-count. They are noted qualitatively where useful (for instance, each direct rooftop-solar job is associated with an estimated 1.5–2.0 indirect and induced jobs) but excluded from totals.

Market opportunity is sized at an ambitious-but-credible 2030 target for each chain, benchmarked to leading states or national data. **Investment** is the cumulative capital needed to reach that target — public, private and blended finance combined, built up from typical per-facility capex. **Revenue potential** is the recurring value the chain can generate: chiefly product or service sales, plus secondary layers such as EPR-credit or carbon income where a verifiable market exists, reported as a range for each value chain.

Estimate	How it is built	Key assumptions & caveats
Jobs (direct FTE)	FTE coefficient × 2030 deployment target, or Chhattisgarh's resource/output share × a national jobs target.	Direct jobs only. One FTE = a full working year (typically 220–300 days; fewer for seasonal bio-economy activities). Indirect and induced jobs are excluded to avoid double-counting.
Market (2030)	An ambitious-but-credible 2030 target, from policy targets or technical potential, benchmarked to leading states / national sector data.	Reported as the market size in 2030. Assumes the ambitious target is broadly achieved; discretionary demand treated cautiously.
Investment (to 2030)	Typical per-unit or per-facility capex ranges × the deployment needed to reach the 2030 target.	Cumulative capital to 2030, combining public outlay, private capital and blended / concessional finance. Excludes long-run replacement capex.
Revenue potential	Product or service sales plus, where they exist, secondary layers (EPR-credit, carbon, or wage income).	Reported as a range for each value chain. Secondary layers are counted only where a verifiable market exists.

Table 2. How each estimate is built, and the key assumptions and caveats behind it.

3. The evidence base

Estimates and judgements draw on four evidence streams: **(i)** secondary research and national benchmarks from government, industry and published sources; **(ii)** Chhattisgarh-specific policy and project literature; **(iii)** primary qualitative fieldwork — focus-group discussions (FGDs) with forest-, farm- and enterprise-dependent communities; and **(iv)** in-depth interviews (IDIs) with state

officials and sector practitioners. Together these ground the national benchmarks in state realities and local absorptive capacity.

4. Assumptions and limitations

- Many value chains are at an early stage in the state, so estimates lean on secondary data and stakeholder input rather than large in-state datasets.
- All figures are **conservative, benchmark-based estimates** meant to indicate scale rather than serve as precise forecasts.
- Jobs and investment are **cumulative to 2030**; market and revenue describe the **2030 position**.

Energy Transition

Part I — Energy Transition Value Chains

Renewable generation, storage, manufacturing and clean-mobility value chains that decarbonise Chhattisgarh's coal-locked energy system.

The foundational cluster — putting clean, dispatchable, and livelihood-linked energy at the point of use.

Decentralised Renewable Energy (DRE) is the energy-transition cluster of Chhattisgarh's green economy: the technologies, products and services that shift the state off a fossil-fuel base. Following CEEW's framing, it spans the **deployment of renewable generation** (utility-scale, rooftop and floating solar, wind-solar hybrid, and small hydropower), **storage** (pumped storage hydropower and battery systems), **component and fuel manufacturing** (bioenergy, green hydrogen and electrolyzers, EV batteries), and — centrally for a rural state — **decentralised RE for livelihoods**, where mini-grids and productive-use appliances place energy directly where people live and work.

Chhattisgarh's rationale is unusually strong. The state carries roughly **7% of India's coal-thermal capacity** and over **14 GW of coal-fired generation**, making a managed Just Transition in districts such as Korba, Surguja and Raigarh both necessary and opportune. It combines **5.0–5.5 kWh/m²/day of solar irradiance**, Mahanadi-basin hydro reservoirs suited to floating solar and pumped storage, and a **10.9 MMT annual paddy-straw surplus** for bioenergy — while large offtakers (SAIL Bhilai, NTPC Korba, NMDC) anchor demand for green hydrogen and round-the-clock renewable power.

Of the three clusters this is the most capital-intensive: CEEW's Odisha analysis found the energy transition creates the fewest direct jobs per rupee invested (about **1.4 per ₹ crore**, versus far higher ratios for the other two clusters), yet it commands the largest market and investment. Its inclusion payoff comes from the decentralised, livelihood-facing end — mini-grids, solar pumps and productive-use enterprise — which converts megawatts into rural incomes.

Value chains in this cluster (Chhattisgarh's GETM portfolio)

Utility-Scale Solar · Rooftop Solar · Floating Solar (FSPV) · Wind-Solar Hybrid · Small Hydropower · Pumped Storage Hydropower · Solar Mini/Micro-Grids · RE Manufacturing (Bioenergy) · Green Hydrogen · Green Transport · EV Battery Manufacturing

Chhattisgarh anchor: ~10,000 MW of pumped-storage potential across seven identified sites, a strong solar resource, and coal-transition districts that can host the next generation of clean-energy and storage assets.

E01 Rooftop Solar

ET · ENERGY TRANSITION

Decentralised photovoltaic generation installed on residential, commercial, industrial and institutional rooftops — and on adjacent distributed assets such as solar irrigation pumps and dryers — feeding consumption close to the point of generation under net-metering and productive-use models.

1 Vision & Targets

Convert Chhattisgarh's 7,300 MW of assessed rooftop-solar potential into 1 GW of installed distributed PV capacity by 2030–36 — delivered at the last mile through women-led community institutions under the DWEEPTI Yojana, with operations and maintenance (O&M) established as the permanent, income-generating spine of the value chain rather than an afterthought to installation.

Executive Dashboard · Rooftop Solar · Chhattisgarh Distributed-Solar Opportunity

ROOFTOP POTENTIAL	INSTALLED TODAY	2030 TARGET	DIRECT FTE @ 1 GW
7,300 MW	146 MW	1 GW	24,720
assessed (2,500 residential + 2,200 industry + 1,800 commercial)	just 2% penetration — the scale of the opportunity ahead	via a 390 MW-by-2027 milestone across all segments	at 24.72 FTE/MW — ~2× the intensity of utility-scale solar

Metric	2024–26 Baseline	2030–36 Target
Installed rooftop capacity	146.20 MW (2% of potential)	1,000 MW (1 GW); 7,300 MW assessed potential
Near-term milestone	—	~390 MW (~130,000 systems) by 2027
Direct FTE jobs	~3,614 (at 146.20 MW)	24,720 (at 1 GW)
Total economic impact	~₹800 crore current investment base	₹4,600–₹5,100 crore
CO₂ avoided annually	~198,000 tonnes	~1.36 million tonnes
Water saved vs thermal	indicative, scaling	650 million litres/year at 1 GW
Women-led delivery (DWEEPTI)	13 CLFs onboarded as vendors, of which 7 trained	25% of panchayats served by VO/CLF-based RESCOs; 33.3% SHG channel partners by 2031

Source: MNRE, PM-Surya Ghar, CREDA, CSPDCL, NISE Suryamitra, DWEEPTI Yojana (2026–2031).

At a glance

- **Direct FTE employment.** 24,720 direct FTEs at the 1 GW target (24.72 FTE/MW — nearly double utility-scale solar); the 390 MW-by-2027 phase alone generates ~9,650 direct jobs, split installation (50%), O&M (20%), manufacturing/supply (15%) and professional services (15%). O&M sustains ~1,930 permanent jobs with a ₹58 Cr/yr wage footprint over 25 years — precisely the segment DWEEPTI reserves for women-led RESCOs.
- **Market & investment opportunity.** 7,300 MW assessed potential (2,500 residential + 2,200 industry + 1,800 commercial); only 146 MW installed (2%). The 390 MW phase catalyses ~₹1,200 Cr of economic activity (₹1,800–2,000 Cr with indirect and induced effects); at 1 GW the total value-chain impact is ~₹4,600–5,100 Cr, backed by CREDA's ₹390 Cr supplementary subsidy (2025–27) and DWEEPTI's ₹800 Cr five-year outlay.
- **Revenue & consumer economics.** Residential payback 3.3 years at 28.5% IRR; commercial and industrial payback 2.5–3 years — under PM Surya Ghar (₹75,021 Cr national outlay) plus CREDA's ₹15,000/kW state top-up.
- **Environmental outcome.** At 1 GW, ~1.36 million tonnes of CO₂ avoided annually (≈ removing 300,000+ cars) and ~650 million litres of water saved versus thermal generation.

2 Contextual Overview

National context

- **National push:** India ranks third globally in solar; PM Surya Ghar: Muft Bijli Yojana (₹75,021 Cr) targets 30 GW of rooftop capacity by 2026-27 with large per-household subsidies.
- **Skills deficit:** nationally, rooftop solar needs 300,000–400,000 trained technicians against roughly 78,000 certified as of 2021 — a binding workforce gap that DWEEPTI's Oorja/Solar Sakhi cadre is designed to close at state level.

Chhattisgarh context

- **Vast untapped endowment:** 7,300 MW assessed potential, one of central India's largest distributed-solar opportunities, yet only 146 MW (2%) installed; residential penetration is 2.6% of technical potential and C&I/institutional segments are largely untouched.
- **Thermal-heavy base:** over 92% of installed capacity is coal-based; grid constraints (voltage fluctuation, a 40%-of-distribution-capacity transformer cap) add technical complexity to expanded deployment.
- **Phased commitment:** 390 MW by 2027 en route to 1 GW by 2030 — each phase building institutional capacity, market depth and workforce readiness.
- **Institutional readiness:** Bihan (CGSRLM) contributes a delivery network of ~2.7 lakh SHGs and 580 CLFs — the densest last-mile institutional asset available to any distributed-energy programme in the state.

3 DWEEPTI Yojana — The Overarching Institutional Instrument

The DWEEPTI Yojana (Decentralised Women Empowerment on Energy & Policy for Transformative Inclusion), 2026–2031, has been approved and taken up by the Government of Chhattisgarh and is the overarching scheme through which this value chain will be delivered. It is anchored in the Department of Panchayati Raj & Rural Development, implemented through Bihan (CGSRLM) within the Panchayati Raj framework, with CREDA and CSPDCL as technical support agencies. Its decisive contribution to rooftop solar is that it converts O&M — the value chain's most persistent failure point and its only permanent employment pool — into a contracted, women-owned service line.

Rooftop-specific provisions for women

- **Targeted capital subsidy for women-led institutions:** the State facilitates large-scale adoption of decentralised rooftop solar through capital subsidies to women-led institutions, in convergence with flagship rural housing programmes — PM Janman, PMAY-G Special Projects and the Niyad Nellanar initiative — integrating power into last-mile housing infrastructure. Deployment is prioritised in unelectrified villages, border settlements and conflict-affected geographies.
- **Virtual net metering at scale:** CSPDCL will converge with PM-AWAS for multiple women-led rooftop systems on virtual net metering; CSERC is to enable surplus-power credits for women-led initiatives to be counted as loan-repayment components — directly attacking the residual upfront-cost barrier.
- **Reserved O&M market:** 25% of all panchayats, preferably women-led panchayats, shall be allotted to VO/CLF-based RESCOs for O&M and basic maintenance against CSPDCL's minimum benchmarks. EPC agencies benefiting under the scheme are to sub-let O&M contracts to nationally certified SHG/VO RESCOs, and private suppliers must reach 10–12% SHG channel partners in the first two years and 33.3% by policy close.
- **CLF hub, SHG spoke:** CLFs operate as women-led energy cooperatives that own and manage assets and hold the state's local sales, franchise and after-sales dealerships; SHGs and VOs raise demand and run installation and service enterprises, with equipment centrally procured. Pay-per-use and pay-as-you-go models are permitted within the panchayat area.
- **Oorja / Solar Sakhi cadre:** a certified voluntary cadre of women technicians, skilled through Skill Council for Green Jobs-empanelled partners, receives preference for O&M and service contracts on DRE assets — the state-level answer to the absent district technician ecosystem.
- **Procurement and fiscal preference:** a 20% reserve/price-preference window for women-led DRE suppliers in state procurement maintained by CREDA; five-year state tax holiday for eligible women collectives; fast-track single-window clearances and simplified PPA terms via CSPDCL and CREDA.
- **Eligibility test:** minimum 51% women ownership and 51% women representation in decision-making bodies, with a woman in a key CXO-level position; or promotion and primary management by SHGs, CLFs, FPOs, women's cooperatives, RIPAs or Panchayats.

Financing architecture (₹800 Cr, 2026–31)

Instrument	Amount	Relevance to rooftop solar
Capital subsidies / grants	₹360 Cr	Tiered capex buy-down stacked on PM Surya Ghar + CREDA ₹15,000/kW top-up; closes the ₹72,000–90,000 residual on a 3 kW system
Revolving funds at CLF hub–spoke	₹90 Cr	Community lending for household and productive-use assets, capped at 50% of the CLF's existing annual revolving fund
State credit guarantee fund	₹60 Cr	Up to ~75% first-loss cover on qualified women-led loans — the mechanism that makes collateral-free lending bankable
VGF / PAYG / EaaS risk cushion	₹60 Cr	Bridges early-stage viability gaps for RESCO, pay-as-you-save and community-asset models

Interest subvention	₹30 Cr	Soft loans and moratoria with SLBC, banks and NBFCs; income-cycle-sensitive repayment
Programme management & ecosystem	₹200 Cr	Includes ₹35 Cr for the Oorja/Solar Sakhi cadre, O&M contracting, toolkits and placement; ₹60 Cr for scheme convergence and market linkages

Additional levers: ₹10 Cr seed fund for women-led DRE startups; MGNREGA (now VBGRAM-G) (now VBGRAM-G) convergence for civil works (foundations, sheds, trenches); DMF, Article 275(1) and SCA-LWE allocations for mining-affected and LWE geographies; benefit stacking with other State/Central schemes subject to caps.

Implementation progress to date

13 Cluster-Level Federations (CLFs) have been onboarded as vendors under DWEEPTI, of which **7** have been provided training. This is the first operational proof that the CLF-as-vendor model works in Chhattisgarh: it establishes the procurement pathway, the training pipeline and the institutional counterparty needed before O&M contracts can be tendered at scale. The immediate priority is to complete training for the remaining **6** onboarded CLFs, certify their technicians into the Oorja/Solar Sakhi cadre, and convert vendor registration into signed O&M contracts under the 25% panchayat allocation.

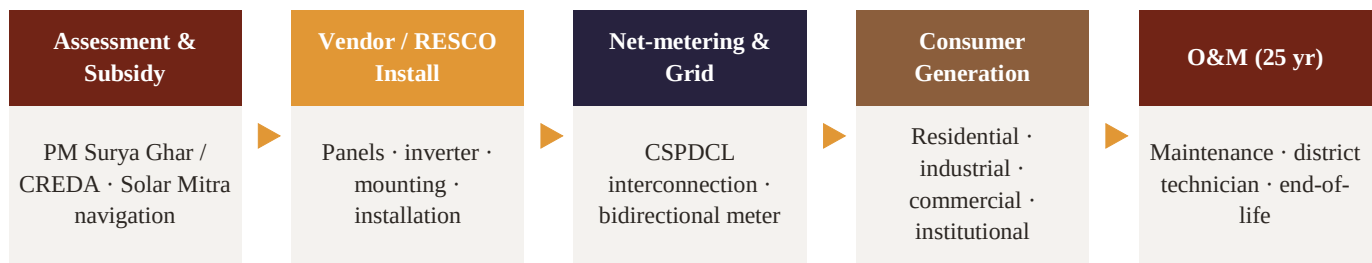
Figures highlighted above are live programme numbers and are expected to be updated as onboarding and training progress.

4 Value-Chain Scope & Market Ecosystem

Scope note — this value chain is solar photovoltaics (PV). It covers panels, inverters, mounting, net metering, grid interconnection and PV-powered productive loads (irrigation pumps, mills, cold storage, e-transport). **Solar dryers are not part of the solar PV value chain: they are solar-thermal devices that capture heat directly and do not use solar PV panels, inverters or net metering.** They sit within the Clean Cooking & Solar Thermal technology basket of DWEEPTI's eligibility list. Dryers remain a complementary livelihood application for the same SHG/CLF institutions and are referenced in this report only as adjacent demand and as a bundling opportunity — never as rooftop-PV market potential, capacity or job count.

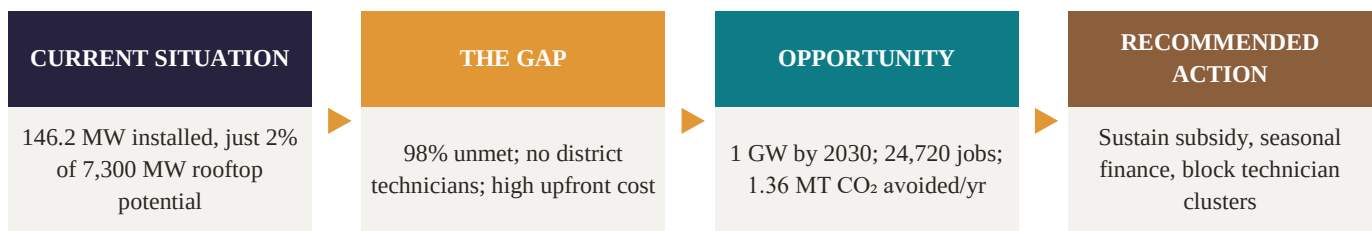
The rooftop solar value chain runs from assessment and subsidy navigation (PM Surya Ghar / CREDA / DWEEPTI), through vendor and RESCO installation, to net metering and grid interconnection (CSPDCL), consumer generation across residential, industrial, commercial and institutional segments, and 25-year O&M with end-of-life recycling. Its defining features are high employment intensity and dependence on last-mile finance, awareness and skills — each of which DWEEPTI now assigns to a named institution.

Rooftop Solar Value-Chain Architecture



5 Demand–Supply Assessment & Structural Gaps

Demand → Gap → Opportunity → Action · Distributed & Rooftop Solar

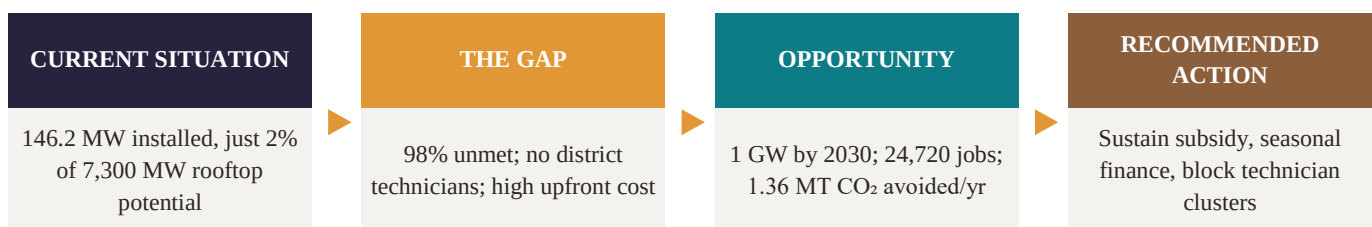


Source: MNRE, PM-Surya Ghar, CREDA, CSPDCL, NISE Suryamitra

- **Supply position:** 146 MW installed against 7,300 MW potential; vendors, RESCOs, CLF-vendors and recyclers form the delivery ecosystem. Even with a 56.4% combined central-plus-state subsidy, a 3 kW system leaves ₹72,000–90,000 upfront. There is no district-level solar-technician ecosystem, leaving consumers without reliable after-sales support and creating a persistent trust deficit.
- **Demand position:** FGDs show optimism and willingness to pay ₹150–300/month for reliable power under collective ownership. Productive-use demand — solar irrigation pumps and e-transport within the PV chain, and solar-thermal drying alongside it — is near-universal in Jashpur/LCAT villages. C&I paybacks of 2.5–3 years make commercial and industrial rooftops the fastest-converting segment; residential adoption depends on finance and awareness.
- **Four structural gaps:** (1) severe skills shortage with no district technician ecosystem; (2) upfront-cost and financing barrier even post-subsidy; (3) grid constraints (voltage fluctuation, the 40% transformer cap); (4) low subsidy awareness and weak PRI facilitation capacity.
- **Allocation constraint:** Jashpur/LCAT evidence identifies CREDA target rationing and upfront cost — not awareness or willingness — as the binding constraints on solar-pump access.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Distributed & Rooftop Solar



Source: MNRE, PM-Surya Ghar, CREDA, CSPDCL, NISE Suryamitra

6 Community & Stakeholder Insights

Field evidence draws on FGDs in Rajnandgaon and Kanker, plus a Jashpur/LCAT productive-use synthesis (May 2026). Community voice: "we have both solar and grid, but running on sunlight is better" — solar is valued instrumentally, for livelihoods.

Stakeholder group	Ground insights & core needs	Recommended action (DWEEPTI-aligned)
Rajnandgaon households	22–23 hr supply but summer voltage fluctuation and outages; thin PM Surya Ghar coverage and critically low subsidy awareness; ₹2 lakh upfront (₹1.22 lakh post-subsidy) prohibitive; no local technician; ~250 unemployed youth keen on solar work.	Deploy Solar/Oorja Sakhis and SHG-routed awareness; pilot NRLM collateral-free and RESCO/pay-as-you-save finance under the DWEEPTI credit guarantee; train PRI members — the institutional vacuum is the biggest drag.
Kanker households	24×7 grid (2 km substation) paradoxically dampens demand, but four solar pumps satisfy farmers (diesel displaced); low subsidy awareness; strong PRI coordination; community prioritises income and employment over reliability.	Lead with productive-use PV (irrigation pumps, milling, cold storage) and income framing; use existing pump adopters as peer champions; build on strong PRI coordination to formalise facilitation.
Unemployed youth & women technicians	Strong interest in installation, maintenance and entrepreneurship; no local technician — an immediate, fillable market gap.	Establish block-level technician clusters via ITI/PMKVY with vendor placement; route women candidates into the certified Oorja/Solar Sakhi cadre for preferential O&M contracts.
PRIs & District Committees	PRI solar-facilitation roles are undefined and untrained in Rajnandgaon; the ₹1,000 incentive exists but capacity to use it is absent; Kanker coordination is strong.	Train PRIs in solar governance; mainstream women-led DRE into GPDP/BPDP/DPDP; use the District-Level Implementation Committee (Collector-chaired) to compress metering and subsidy timelines.
SHGs / CLFs / financiers	276,000+ SHGs (3M+ households) and 580 CLFs provide last-mile delivery; conventional credit is inaccessible for many households.	Scale SHG group loans, income-cycle-sensitive repayment and collateral-free lending; expand the CLF-as-vendor model beyond the current cohort into franchise and O&M enterprises.

7 Triple-Bottom-Line & Feasibility

- **Economic:** residential 3.3-yr payback at 28.5% IRR; C&I 2.5–3 yr. ₹390 Cr of CREDA subsidy unlocks ~₹1,200 Cr direct (₹1,800–2,000 Cr with multipliers) and ~₹4,600–5,100 Cr total value-chain impact at 1 GW. Financing is the decisive lever: the upfront barrier persists

post-subsidy, and DWEEPTI's guarantee fund, revolving funds and PAYG cushion are the instruments that convert willingness into installations.

- **Social:** 24.72 FTE/MW — 24,720 direct jobs at 1 GW (9,650 at 390 MW), with ~1,930 permanent O&M roles. DWEEPTI's reservation of 25% of panchayats for VO/CLF RESCOs and its 33.3% SHG channel-partner target make women the primary beneficiaries of that permanent employment pool. Communities value solar as a means to secure irrigation, water and income — programmes must lead with livelihood outcomes, not hardware specifications.
- **Environmental:** ~1.36 MT CO₂/yr avoided and ~650 million litres of water saved at 1 GW; distributed generation reduces thermal dependence (92% of the base) and eases daytime supply stress. End-of-life panels and batteries fall under the E-Waste (Management) Rules, 2022, with CSPDCL to establish handling modalities and SHGs positioned in reduce–recycle–reuse operations.
- **Technical:** the technology is mature and C&I conversion is rapid where finance and net metering are smooth. Net-metering timeliness, transformer-capacity headroom and a district technician base are the binding prerequisites — the third is now institutionally assigned to the Oorja/Solar Sakhi cadre.

8 Bottlenecks, Risks & Mitigation

Risk category	Identified risk	Severity	Mitigation strategy
Market demand	/ Awareness of PM Surya Ghar and PM-KUSUM is critically low; strong 24×7 grid areas (Kanker) paradoxically dampen rooftop demand.	Med	Lead with livelihood and productive-use framing and peer champions; Solar/Oorja Sakhi navigation; SHG-routed local-language awareness under DWEEPTI's IEC allocation.
Financial affordability	/ ₹72,000–90,000 residual upfront cost post-subsidy; conventional credit inaccessible; CREDA target rationing limits pump access.	High	DWEEPTI capital subsidy stacking, ~75% credit guarantee, CLF revolving funds and interest subvention; aggregated procurement; RESCO/pay-as-you-save; expanded Saur Sujala/PM-KUSUM allocations.
Operational grid & skills	/ Voltage fluctuation, the 40% transformer cap, and no district technician base or after-sales support (trust deficit).	High	Upgrade grid and net metering; smart meters and storage; block-level ITI/PMKVY technician clusters with vendor linkage; certified Oorja/Solar Sakhi cadre holding contracted O&M.
Policy institutional	/ PRI solar-facilitation roles undefined and untrained; inter-departmental metering and subsidy timelines unclear.	Med	Train PRIs; formalise CREDA–CSPDCL–CSERC–District coordination through the DWEEPTI State-Level Steering and District-Level Implementation Committees;

			adopt solar-ready building codes.
Delivery capacity (new)	Only 13 CLFs are onboarded as vendors and 7 trained — a thin base against a 25%-of-panchayats O&M commitment.	High	Sequence CLF onboarding and certification ahead of tendering; use EPC sub-letting obligations and the 10–12% channel-partner floor to build capability while volumes ramp.

Value-Chain Trajectory: Baseline vs 2030–36 Target (bar graph → editable data table)

Indicator	Baseline 2024–25	Target 2030–36
Installed MMG Capacity (MW)	~390	890*
Direct FTE Employment ('000 jobs)	9.56	21.81
Annual O&M Revenue (₹ Cr / yr)	~78	130+

*890 MW = ~390 MW existing off-grid base + 500 MW new MMG addition by 2030. Source: value-chain document (Tables 1.1 & Snapshot).

9 Stakeholder Matrix for Scale — Recommendations & Actions

Stakeholder	Role in scale-up	Recommended action / point for action
MNRE (Central)	Policy, standards, PM-Surya Ghar subsidy and portal	Sustain 60%/40% subsidy and simplify portal UX for low-digital-literacy rural applicants
Dept. of Panchayati Raj & Rural Development (DWEEPTI nodal)	Scheme anchor; SLSC oversight; PRI enablement and GPDP integration	Notify scheme guidelines with sizing protocols, KPI framework and phase-wise targets; institutionalise women-led O&M contracting at panchayat level
Bihan / CGSRLM	Mobilisation, beneficiary identification, CLF vendor and RESCO development	Scale beyond the current 13 onboarded CLFs; complete training for the remaining 6 ; link Social, Financial and Livelihoods verticals to rooftop demand aggregation
CREDA (State Nodal)	Supplementary subsidy, technical sanction, tendering, target-setting, oversight	Expand rationed Saur Sujala/pump targets; operationalise the 20% women-led vendor preference window; anchor block-level technician clusters
CSPDCL (Discom)	Grid interconnection, net metering, subsidy disbursement	Correct voltage in Dongergaon-type blocks; accelerate smart-meter timelines; issue O&M benchmarks and allot 25% of panchayats to VO/CLF RESCOs

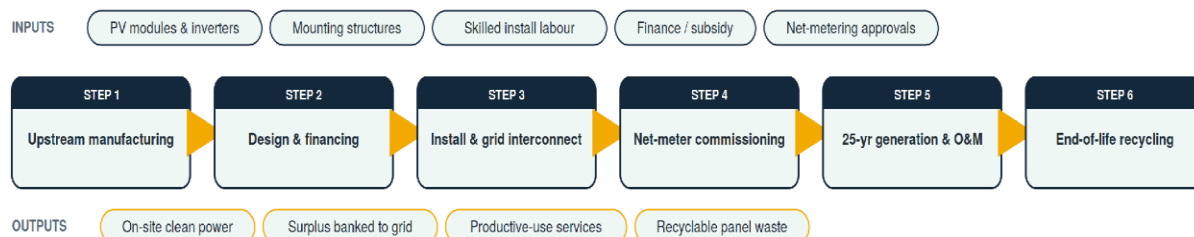
CSERC (Regulator)	Net-metering rules, tariffs, transformer caps	Periodically revise the 40% transformer cap; enable virtual net metering and surplus-credit-as-repayment for women-led systems
District Collector Committees (DLIC)	Monitoring, appraisal and inter-departmental coordination	Institutionalise coordination protocols to compress subsidy and metering timelines; clear CLF proposals within defined service levels
PRIs / Gram Panchayats	Village mobilisation under ₹1,000 incentive; land access; Gram Sabha approvals	Train members in solar facilitation and maintenance oversight; convert the incentive into active promotion; authorise rooftops on panchayat buildings, schools and health centres
SHGs / CLFs / Urja Samitis	Last-mile trust, billing, vendor and O&M enterprise	Pilot SHG group loans and CLF-operated O&M contracts across five-village clusters; take up franchise and after-sales dealerships
Banks / NRLM / SLBC / RESCOs	Consumer finance and third-party ownership	Offer collateral-free, seasonally flexible and pay-as-you-save products against the DWEEPTI credit guarantee; accord priority-sector treatment to DRE
ITIs / NISE Suryamitra / SCGJ	Workforce skilling and certification	Train 18–35-year cohorts (250+ in Rajnandgaon) with vendor-placement linkage; certify women technicians into the Oorja/Solar Sakhi cadre
Recycling start-ups / CECB / CPCB	End-of-life management, EPR	Build recycling capacity and enforce EPR ahead of the 25,350-tonne waste wave; register and collectivise SHG e-waste workers under the 2022 Rules

10 Methodology & Basis

Employment: 24,720 direct FTE = 1,000 MW × 24.72 FTE/MW ($\approx 2 \times$ utility-scale solar); the 390 MW phase yields ~9,650 direct jobs (installation 50% / O&M 20% / manufacturing-supply 15% / services 15%) and ~1,930 permanent O&M jobs (₹58 Cr/yr wages over a 25-year life); the 3,614 baseline is 146.20 MW at the same coefficient. Market: 7,300 MW potential (2,500 residential + 2,200 industry + 1,800 commercial); 146.20 MW installed (2%); the 390 MW phase ~₹1,200 Cr direct (₹1,800–2,000 Cr with multipliers); ~₹4,600–5,100 Cr total at 1 GW; CREDA ₹15,000/kW top-up, ₹390 Cr (2025–27). Returns: residential 3.3-year payback at 28.5% IRR; C&I 2.5–3 years. Environment: ~1.36 MT CO₂/yr and ~650 million litres of water saved at 1 GW. Institutional and financial provisions, targets and instrument sizing are drawn from the DWEEPTI Yojana, 2026–2031, as approved by the Government of Chhattisgarh. Field evidence is from FGDs across Rajnandgaon and Kanker districts and the Jashpur/LCAT productive-use synthesis, curated by Billion Next BoP Solutions Pvt. Ltd. for TRI.

Input / Output Flow

Value Chain Flow · Distributed & Rooftop Solar



Source: MNRE, PM-Surya Ghar, CREDA, CSPDCL, NISE Suryamitra

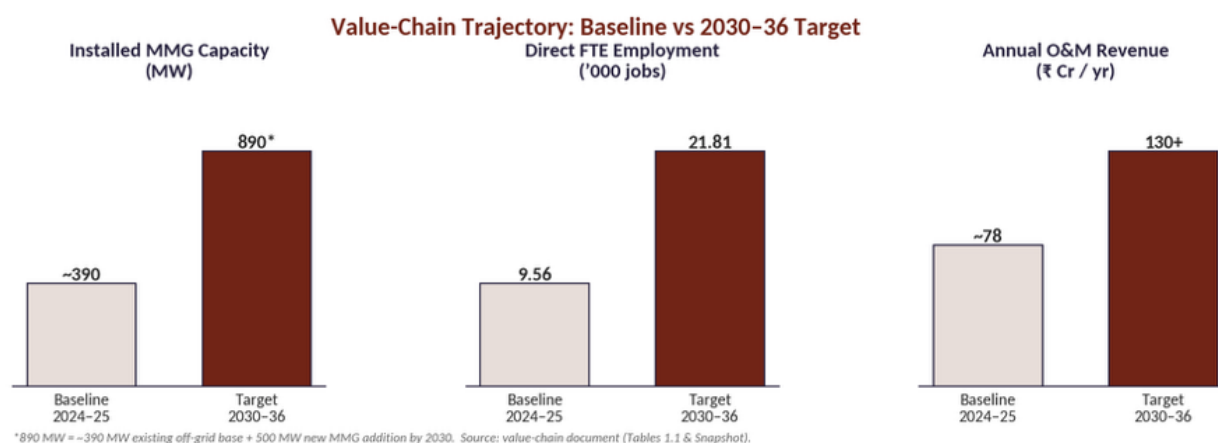
E02 Solar Mini/Microgrids

ET · ENERGY TRANSITION

Decentralised solar-plus-storage generation, digital monitoring, and last-mile distribution systems that deliver reliable, round-the-clock electricity to remote, forested, and tribal habitations where central-grid extension is uneconomic.

1 Vision & Targets

Add 500 MW of decentralised solar mini and micro-grid capacity by 2030 — taking Chhattisgarh's decentralised solar base to ~890 MW — so that forest and tribal habitations the central grid cannot economically reach receive reliable 24×7 power. Delivery runs through women-led community institutions under the DWEEPTI Yojana, with operations and maintenance (O&M) established as the permanent, contracted, income-generating spine that keeps assets alive beyond commissioning.



Metric		2024–25 Baseline	2030–36 Target
Installed capacity	MMG	~390 MW off-grid solar base	890 MW (390 MW base + 500 MW new solar MMG)
Direct employment	FTE	~9,556 (390 MW × 24.5 FTE/MW)	~21,805 total, of which 12,250 new by 2030

Annual O&M revenue	~₹78 Cr/yr	₹130+ Cr/yr, plus VPP ancillary fees from 2035
New capital requirement	—	₹2,500 Cr for 500 MW at a blended ₹5 Cr/MW
Energy monetisation	₹3.39/kWh regulated feed-in tariff	₹10–20/kWh via RESCO diesel displacement in productive use
State RE consumption share	~16% (against ~86% coal dependence)	40–45% over 5–10 years; 66% RE share by 2047
Women-led delivery (DWEPTI)	Bihan network of ~2.7 lakh SHGs and 580 CLFs	25% of panchayats served by VO/CLF-based RESCOs; 33.3% SHG channel partners by 2031

Source: MMG value-chain diagnostic, CREDA, CSERC, MNRE (PM-KUSUM, PM Surya Ghar), DWEPTI Yojana (2026–2031).

At a glance

- **Direct FTE employment.** 12,250 new direct full-time jobs by 2030; ~21,805 total including the existing base. Roles span system design, EPC, Suryamitra-trained O&M, RMS operations and last-mile service — with substantial induced employment in rice milling, cold storage and agro-processing anchor loads.
- **Market & investment opportunity.** ₹2,500 Cr of new capital for 500 MW across solar PV, Li-ion storage, smart inverters, RMS and digital infrastructure, and last-mile distribution. A Virtual Power Plant and ancillary-services market opens from 2035; the state wheeling-charge waiver opens C&I third-party sales.
- **Revenue & carbon outcome.** The O&M market alone grows from ~₹78 Cr/yr to ₹130+ Cr/yr; RESCO diesel displacement earns ₹10–20/kWh against the ₹3.39/kWh regulated feed-in tariff — the margin that makes community assets bankable. +500 MW by 2030 supports the 66%-RE-by-2047 ambition and generates tradable carbon credits.

2 Contextual Overview

National context

Solar mini and micro-grids sit at the centre of India's decentralised-renewable agenda, backed by two national frameworks: PM-KUSUM (Component A viability-gap funding for 0.5–2 MW decentralised plants) and PM Surya Ghar (rooftop and small-scale solar subsidy). The structural tailwind is a sharply falling Li-ion battery cost curve (~\$140/kWh in 2024), which makes solar-plus-storage increasingly competitive with diesel and kerosene at the last mile.

Chhattisgarh context

- **Geography as the driver:** ~44% forest cover with scattered tribal habitations across Bastar and Surguja; central-grid extension there is high-cost and low-load-density, leaving solar MMGs the only techno-economically viable path to reliable supply.
- **Strong technical fundamentals:** average solar irradiance of ~5.5 kWh/m²/day and falling battery costs underpin system viability across the state.
- **Ready execution chassis:** CREDA operates one of India's largest off-grid mini-grid portfolios (~390 MW off-grid solar base), reducing investor risk through established procurement and O&M frameworks.
- **System necessity, not just access:** a structural day-to-night PV gap (~8,000 MW daytime collapsing to ~5,000 MW at night) makes storage-backed distributed solar a grid-balancing requirement as well as an electrification tool.

- **Institutional readiness:** Bihan (CGSRLM) contributes ~2.7 lakh SHGs and 580 CLFs — the densest last-mile institutional asset available to any distributed-energy programme in the state, and the delivery chassis DWEEPTI now formalises.

3 DWEEPTI Yojana — The Overarching Institutional Instrument

The DWEEPTI Yojana (Decentralised Women Empowerment on Energy & Policy for Transformative Inclusion), 2026–2031, has been approved and taken up by the Government of Chhattisgarh and is the overarching scheme through which this value chain will be delivered. It is anchored in the Department of Panchayati Raj & Rural Development, implemented through Bihan (CGSRLM) within the Panchayati Raj framework, with CREDA and CSPDCL as technical support agencies. Its decisive contribution to mini and micro-grids is that it converts O&M — the single factor that determines whether an MMG survives past year three — from an unfunded afterthought into a contracted, certified, women-owned service line.

MMG-specific provisions

- **MMGs sit inside the eligibility basket:** solar from 1 kWp to 1 MWp including model solar villages; village and hamlet-level solar PV micro/mini-grids; and larger solar mini-grids for Rural Industrial Parks (RIPAs) managed by CLFs to power common facility centres and enterprise clusters.
- **Community service tier and tariffs:** the policy explicitly recognises VO and hamlet-level generation with fee-based services for public utility, and permits pay-per-use and pay-as-you-go charging within the panchayat area — the exact commercial model an MMG requires, now with policy cover.
- **Reserved O&M market:** 25% of all panchayats, preferably women-led panchayats, are to be allotted to VO/CLF-based RESCOs for O&M and basic maintenance against CSPDCL's minimum benchmarks. EPC agencies benefiting under the scheme must sub-let O&M contracts to nationally certified SHG/VO RESCOs, and private suppliers must reach 10–12% SHG channel partners in the first two years and 33.3% by policy close.
- **Oorja / Solar Sakhi cadre:** a certified voluntary cadre of women technicians, skilled through Skill Council for Green Jobs-empanelled partners, holds preference for O&M and service contracts. This is the direct institutional answer to the absence of block-level technicians that causes MMG decay within three to five years of commissioning.
- **CLF hub, SHG spoke:** CLFs operate as women-led energy cooperatives that collectively own and manage assets and hold the state's local sales, franchise and after-sales dealerships; SHGs and VOs aggregate demand and run installation and service enterprises, with equipment centrally procured through CREDA-negotiated terms.
- **Panchayat enablement:** PRIs facilitate land access and Gram Sabha approvals, mainstream projects into GPDP planning, generate own-source revenue from DRE enterprises, and authorise installations on panchayat buildings, schools and health centres — the route to the 900+ social-infrastructure sites in this value chain.
- **Regulatory unlocks:** CSERC is to enable net metering for women-led initiatives with surplus credits counted as loan-repayment components; CSPDCL and CREDA are responsible for simplified PPA terms and fast-track single-window clearances — addressing the bankability and exit-risk concerns that deter private capital.

Financing architecture (₹800 Cr, 2026–31)

Instrument	Amount	Relevance to solar mini & micro-grids
Capital subsidies / grants	₹360 Cr	Tiered capex buy-down against the ₹80,000–1,20,000/kW system cost, which rises with storage autonomy and remote-terrain distribution
VGF / PAYG / EaaS risk cushion	₹60 Cr	Explicitly designed to bridge early-stage viability gaps for community assets and energy-as-a-service models — the instrument that answers thin regulated margins
State credit guarantee fund	₹60 Cr	Up to ~75% first-loss cover on qualified women-led loans, countering lender reluctance to accept project cash flows as security
Revolving funds at CLF hub–spoke	₹90 Cr	Community lending for household connections and productive-use assets, capped at 50% of the CLF's existing annual revolving fund
Interest subvention	₹30 Cr	Soft loans and moratoria with SLBC, banks and NBFCs; season-linked repayment for agricultural anchor loads
Programme management & ecosystem	₹200 Cr	Includes ₹35 Cr for the Oorja/Solar Sakhi cadre, O&M contracting and placement; ₹35 Cr for demonstrations including model solar villages and PURE clusters

Additional levers: ₹10 Cr seed fund for women-led DRE enterprises; 20% reserve and price-preference window for women-led suppliers in state procurement; five-year state tax holiday; MGNREGA (now VBGRAM-G) (now VBGRAM-G) convergence for civil works; DMF, Article 275(1) and SCA-LWE allocations for mining-affected and LWE geographies. End-of-life battery and panel handling falls under the E-Waste (Management) Rules, 2022, with CSPDCL to establish modalities and SHGs positioned in reduce–recycle–reuse operations — closing the circularity gap from the outset of procurement.

4 Value-Chain Scope, Architecture & Market Ecosystem

Scope note — this value chain is solar only. It covers solar PV generation with battery storage, power electronics, remote monitoring and last-mile distribution. Biomass-to-power, rice-husk feedstock circularity and biomass gasification are **excluded** — they constitute a separate bioenergy value chain with different feedstock logistics, capital structure and institutional owners, and are assessed elsewhere in the GETM series. All capacity, investment, employment and carbon figures in this report are solar-only.

The solar MMG value chain is a modular, technology-intensive ecosystem combining hardware, software and local commercial operations — evolving from basic electrification toward Distributed Energy Resources and, by 2035, aggregated Virtual Power Plants providing grid-balancing and ancillary services.

Mini & Micro Grid Value-Chain Architecture · Solar-plus-Storage



Modular, technology-intensive chain — evolving from basic electrification → reliable 24×7 supply → Distributed Energy Resources → Virtual Power Plants (2035).

End-to-End Market Ecosystem for the Solar MMG Value Chain

INPUT SUPPLIERS	Solar modules · Li-ion batteries · smart inverters · cabling · smart meters · RMS & digital platforms · EPC equipment vendors
PRIMARY PRODUCERS & AGGREGATORS	CREDA-empanelled operators · private RESCO/ESCO developers · Gram Panchayats · Women SHGs / VOs / CLF energy cooperatives · Village Energy Committees
GENERATION, STORAGE & DISTRIBUTION INFRASTRUCTURE	Solar-plus-storage mini & micro grids · Remote Monitoring Systems · last-mile lines · automated billing
OFF-TAKERS & DEMAND SEGMENTS	Households · telecom towers · rice mills · cold storage · petrol pumps · agri feeders · C&I third-party (wheeling waiver) · 900+ health centres & schools
SUPPORTING ENABLERS	DWEEPTI Yojana (DoPR / Bihan-CGSRLM) · MNRE (PM-KUSUM, PM Surya Ghar) · CSERC (tariff, net-metering) · CSPDCL · NISE / Suryamitra & Oorja Sakhi cadre · IREDA · SIDBI

5 Demand–Supply Assessment & Structural Gaps

- **Supply position:** ~390 MW of off-grid solar, unevenly distributed — acute deprivation persists in Abujhmad and the LWE belt, and rural feeders face unscheduled load-shedding and voltage fluctuation. CREDA is exploring MMG clusters in forest geographies (Bamavapara, parts of Raigarh and Jashpur) where elephant-corridor damage is less constraining. System cost runs ₹80,000–1,20,000/kW depending on storage autonomy, and distribution absorbs 20–30% of capital in remote hamlets — well above national averages.
- **Demand position:** reliability, not access, is the binding constraint across much of the state. Institutional buildings (900+ health centres and schools) need 24×7 power, and productive uses — telecom towers, rice mills, cold storage, petrol pumps, agri feeders — create anchor demand. Willingness to pay is confirmed at ₹150–300/month in Bargaon and ₹50–100/month in Mandari; over 1 lakh solar pumps form a large latent agricultural load. CREDA is advancing open access and RESCO-mode supply, and the wheeling-charge waiver enables C&I third-party sales.
- **Bifurcated demand:** in already grid-served villages the case for standalone solar collapses against subsidised grid power. The real opportunity is threefold: productive-use anchor loads, tribal habitations the grid cannot reliably reach, and institutional reliability.
- **Rationed supply:** field evidence from Jashpur and LCAT across 24 villages shows solar-pump demand far exceeding CREDA target allocation — the binding constraint is target allocation and finance, not community appetite or technology.

6 Community & Stakeholder Insights

Field evidence draws on FGDs in Bargaon (Rajnandgaon) and Mandari (Kanker), March 2026, a CREDA in-depth interview, and Jashpur/LCAT cross-village evidence. Both FGD sites register an emerging-readiness profile — high community acceptance and livelihood potential, but weak institutional preparedness and financial accessibility, precisely the two dimensions DWEEPTI is built to strengthen.

Stakeholder group	Ground insights & core needs	Recommended action (DWEEPTI-aligned)
Primary producers farmers /	Strong solar-pump demand but CREDA-rationed; upfront cost is decisive — electric pump ~₹35,000 against solar pump ~₹3 lakh; irrigation available only 6–8 months with a 1–2 month summer shortage.	Expand Saur Sujala / PM-KUSUM targets; pair with DWEEPTI interest subvention and CLF revolving funds on season-linked repayment to close the upfront-cost gap.
Women SHGs, VOs & CLFs	Volunteered for billing and collection in both villages; group loans via SHGs explicitly welcomed; loan access rated 'easy' in Mandari.	Certify SHG-led revenue desks and constitute Village Energy Committees before any project is commissioned; route CLFs into asset ownership and O&M contracting under the 25% panchayat allocation.
Panchayats PRIs /	Ownership preference is Panchayat-led (Bargaon) or collective (Mandari); institutional preparedness scored weakest (1–2/5); PRI role poorly defined.	Define PRI roles in MMG governance; mainstream projects into GPDP with allocated lines for installation, maintenance and expansion; establish a single-window facilitation and grievance desk.
Local vendors youth /	No local solar technicians — repairs routed from Kanker and Bhanu; youth interest in installation, maintenance and entrepreneurship reported across both sites.	Front-load Suryamitra training in Bastar, Surguja, Kanker and Rajnandgaon; certify women candidates into the Oorja/Solar Sakhi cadre for preferential O&M contracts.
Institutional buyers	Reliability, not access, is the binding constraint for critical social infrastructure.	Extend the state-led CAPEX model to solarise 900+ health centres, schools and streetlights with guaranteed five-year O&M held by certified women-led RESCOs.
Private developers RESCOs /	Grid-arrival risk and thin regulated margins deter capital; bankability needs base load.	Provide grid-arrival protection and DER conversion; mandate Anchor Business Community models; retain the wheeling-charge waiver; use the DWEEPTI credit guarantee and VGF cushion to de-risk entry.

7 Success Stories & Proven Models

CASE STUDY 1 • Community-Managed Solar Microgrids, Simdega, Jharkhand — Transform Rural India Foundation

Context. Simdega, 180 km south-west of Ranchi, covers 3,761 sq km across ten blocks; 70.78% of its population are Scheduled Tribes (2011 Census). Villages in Kurdeg, Kersai and Bolba blocks had long relied on kerosene lamps — hazardous and expensive — with frequent outages disrupting daily life and holding back social and economic progress.

Intervention. Transform Rural India Foundation (TRI) partnered with Gram Oorja Pvt. Ltd. on "The Green Switch – Jharkhand: The Power to Transform Lives", delivering decentralised solar off-grid systems with battery backup under a community-ownership model. Cluster Level Federations and solar committees organised and mobilised villages, selecting sites without grid access and gathering demographic and energy-usage data so that designs matched village-specific need. Technical partnerships handled scalable system design and installation. Village Energy Committees (VECs), formed by women's self-help groups, took charge of operational and financial management — including tariff collection and regular audits. The Gram Panchayat Development Plan (GPDP) incorporated the microgrids, allocating resources for installation, maintenance and expansion with local government funding and incentives, while regulatory support streamlined approvals and permits.

Viability through productive load. Integrating solar pumps and small enterprises was the critical element that made the microgrids economically viable and created local entrepreneurship: community entrepreneurs earned an average of ₹40,000 a year. Agrivoltaics and enterprise-driven microgrids were added to build evidence for policy influence.

Results. 25 hamlets and 1,612 households electrified, impacting 6,725 lives, on 377.72 kWp of installed solar capacity. The project saves 108,750 litres of kerosene annually and eliminates 271,850 kg of CO₂ emissions. Solar pumps have supported agricultural activity and wider economic development. Households save an average of ₹246 per month on kerosene while spending about ₹130 per month on electricity — a net gain alongside a step change in service quality.

Relevance for Chhattisgarh: *Simdega is the DWEEPTI architecture already working at scale in a comparable tribal geography — CLF as mobilising hub, women's SHG-based Village Energy Committees as the O&M and revenue institution, GPDP as the financing route, and productive load as the viability anchor. It is directly transferable to Bastar, Surguja and the LWE belt, and it answers the two weakest field scores recorded in Bargaon and Mandari: institutional preparedness and financial accessibility.*

CASE STUDY 2 • TRI-led Community Solar Lift Irrigation (Chhattisgarh). In Kondagaon, Gond and Halba communities historically farmed only during the kharif season, with merely 7.5% of land irrigated year-round. To combat this, a Community Managed Solar Lift Irrigation (CMSLI) system was introduced, utilizing solar pumps to draw surface water. Crucially, operations are driven entirely by Women Water User Groups (WUGs). The impact is transformative: 44 farmers now cultivate 25 acres during the Rabi season, yielding diverse crops like tomatoes and cucumbers. Additionally, four locals became agri-entrepreneurs. This women-led governance model guarantees system maintenance, financial discipline, and accountability, while government convergence effectively multiplies impact without duplicating efforts.

CASE STUDY 3 • CREDA Solar Pumps & Saur Sujala Yojana (Chhattisgarh). Through CREDA and the Saur Sujala Yojana the state has deployed tens of thousands of subsidised solar

irrigation pumps — among the largest such programmes in India — alongside solar street lighting and standalone solar in un-electrified hamlets. *Relevance: the direct vehicle for the unmet, CREDA-rationed solar-pump demand recorded across the assessed villages; expanding targets and reach is the concrete ask emerging from the field.*

8 Triple-Bottom-Line & Feasibility

- **Economic:** recurring O&M revenue (~₹78 Cr/yr rising to ₹130+ Cr/yr), RESCO energy sales at ₹10–20/kWh via diesel displacement, carbon-credit monetisation and VPP ancillary fees from 2035. Anchor loads — telecom, rice mills, cold storage, health centres — provide the base demand that converts reliable kWh into rural enterprise revenue. Payback is governed by anchor-load structure, capacity factor and tariff mix; the Simdega evidence indicates that productive load, not household connections alone, is what carries the economics.
- **Social:** SHG-led billing and collection and CLF-held asset ownership channel income to women's collectives; tribal electrification, Suryamitra and Oorja Sakhi skilling, and induced enterprise in milling and cold storage stabilise rural livelihoods and reduce migration pressure. DWEEPTI's reservation of 25% of panchayats for VO/CLF RESCOs makes women the primary beneficiaries of the permanent O&M employment pool.
- **Environmental:** solar MMGs displace kerosene and diesel at an effective cost above ₹60/kWh and support the 66%-RE-by-2047 ambition from ~86% coal dependence, with tradable carbon credits. End-of-life battery and panel recycling is brought inside procurement standards through the E-Waste (Management) Rules, 2022.
- **Technical:** solar-plus-storage with remote monitoring is field-demonstrated in Chhattisgarh and modular enough for incremental scale-up. The roadmap runs interconnected MMGs → Distributed Energy Resources → Virtual Power Plants by 2035; mandated minimum storage thresholds and universal RMS adoption are the key technical enablers.

9 Bottlenecks, Risks & Mitigation

Risk category	Identified risk	Severity	Mitigation strategy
Market / price	Grid arrival renders a standalone MMG commercially obsolete (sunk cost); the ₹3.39/kWh regulated feed-in tariff offers thin export margins.	High	Notify grid-arrival protection, DER conversion or stranded-asset compensation; mandate Anchor Business Community loads capturing ₹10–20/kWh in productive use.
Production / climate	Structural day–night PV gap (~8,000 MW to ~5,000 MW) and intermittency; low residential load density in tribal hamlets.	Med	Mandate minimum storage thresholds; pair with pumped hydro; use ABC models and productive load to firm demand.
Operational / supply chain	Absence of block-level technicians causes MMG decay within 3–5 years of commissioning; forest and LWE logistics and security costs.	High	Front-load Suryamitra and Oorja Sakhi deployment ahead of commissioning; contract O&M to certified VO/CLF RESCOs under the 25% allocation; state-wide RMS; secured logistics planning for LWE areas.

Financial bankability /	Thin margins under regulated tariffs; limited long-term debt; lender reluctance to accept project cash flows as collateral; ~₹35,000 electric against ~₹3 lakh solar pump differential deters farmers.	High	DWEEPTI credit guarantee (~75% first-loss), VGF/PAYG cushion, CLF revolving funds and interest subvention; specialised debt recognising project cash flows; season-linked repayment; IREDA/SIDBI lines.
Policy governance /	Subsidy mistrust and slow disbursement erode community trust; uncertainty on virtual and group net-metering and grid interactivity deters investors.	High	Notify the Chhattisgarh Mini-Grid Policy with a binding 500 MW-by-2030 target, defined exit options and streamlined net-metering; single-window, time-bound subsidy delivery through the DWEEPTI District-Level Implementation Committee.

10 Stakeholder Matrix for Scale — Recommendations & Actions

Stakeholder	Role in scale-up	Recommended action / point for action
Energy Department (State)	Policy notification, target-setting, grid-arrival protection	Notify the Mini-Grid Policy with the 500 MW target, grid-arrival protection and defined exit options; align with Anjor/Vision-2047
Dept. of Panchayati Raj & Rural Development (DWEEPTI nodal)	Scheme anchor; SLSC oversight; PRI enablement and GPDP integration	Notify scheme guidelines with sizing protocols, KPI framework and phase-wise targets; institutionalise women-led O&M contracting at panchayat level
Bihan / CGSRLM	Mobilisation, CLF and VEC formation, RESCO development	Constitute Village Energy Committees on the Simdega model before commissioning; build CLF vendor and O&M capability across Bastar and Surguja
CREDA (State Nodal)	RESCO tendering, state-wide RMS, empanelment, asset monitoring	Reposition from asset-owner to ecosystem-enabler; expand rationed Saur Sujala/PM-KUSUM targets; operationalise the 20% women-led vendor preference window
CSERC & CSPDCL (Regulator and DISCOM)	Feed-in tariff, net-metering, grid codes, PPAs, RPO compliance	Finalise virtual and group net-metering with surplus credits as loan repayment; issue minimum O&M benchmarks and allot 25% of panchayats to VO/CLF RESCOs; simplify PPA terms and retain the wheeling-charge waiver
Tribal Welfare / Health / Education	Social-infrastructure solarisation and budget convergence	Solarise 900+ health centres, schools and streetlights with guaranteed five-year O&M held by certified women-led RESCOs

District Administration (DLIC) & PRIs	Site identification and appraisal; land access, Gram Sabha approval, GPDP planning	Prioritise shadow and LWE zones and compress approval timelines through Collector-chaired protocols; allocate GPDP lines for installation, maintenance and expansion; authorise installations on panchayat buildings, schools and health centres
Private developers / RESCOs	Capital, technology, off-take agreements, EPC	Deploy RESCO/ESCO models with ABC anchor loads; sub-let O&M to certified SHG/VO RESCOs; meet the 10–12% rising to 33.3% channel-partner floor
MNRE (Central)	PM-KUSUM Component A VGF and PM Surya Ghar support	Sustain VGF for 0.5–2 MW decentralised solar plants; simplify portal access for low-digital-literacy rural applicants
NISE / SCGJ & IREDA / SIDBI / SLBC	Suryamitra training and tribal-district O&M workforce; concessional and specialised debt	Deliver training ahead of commissioning and certify women technicians into the Oorja/Solar Sakhi cadre; offer project-cash-flow-secured lending against the DWEEPTI guarantee and accord priority-sector treatment to DRE

Input / Output Flow

Value Chain Flow - Mini & Micro Grids



Source: CREDA, CSERC, MNRE, NISE

E03 Small Hydropower (SHP)

ET • ENERGY TRANSITION

Net-new, decentralised renewable generation from projects up to 25 MW — micro (≤ 100 kW), mini (101 kW–2 MW), and small (2–25 MW) — typically run-of-river and well-suited to forest-belt and hilly geographies.

1 Executive Dashboard

EXECUTIVE DASHBOARD — SMALL HYDROPOWER AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline vs 2030 target)

Direct FTE Employment. 170–340 long-term FTEs on a 100–200 MW build-out (CEEW coefficient ~1.7 FTE/MW), plus 850–2,400 construction-phase jobs over 2–4-year build cycles — concentrated in civil-works O&M, electromechanical maintenance, water-resource monitoring and grid-tie operations across coal-transition districts.

Market & Investment Opportunity. ₹650–1,600 Cr state pipeline at MNRE benchmark ₹6.5–8.0 Cr/MW for 100–200 MW commissioned by 2030 — from a ~17 MW operational base (7 MW Sikaser on the Pairi + 10 MW Gangrel on the Mahanadi). Central Financial Assistance runs ₹25 lakh/MW (general) to ₹50 lakh/MW (special/tribal areas).

Revenue & Demand Certainty. Levelised cost ₹3.5–5.0/kWh grid-connected (₹5.0–7.0/kWh off-grid); demand underpinned by the Hydro Purchase Obligation (large hydro in the RPO regime since 2019) and forest-area grid-integration needs SHP naturally fills.

Strategic Outcome. SHP is the only CG RE value chain geographically targeted at the same forest-belt and tribal districts (Korba, Surguja, Jashpur, Bastar) where the Just Transition workforce question is most acute — converting Mahanadi-basin potential from theoretical inventory to deployable capacity.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Small Hydropower (≤25 MW) · Chhattisgarh 2026–36

SHP CAPACITY	INVESTMENT	DIRECT FTE JOBS	BASIN POTENTIAL
17 → 100–200 MW	₹650–1,600 Cr	170–340	~627 MW
commissioned by 2030 across Mahanadi tributaries	at MNRE benchmark ₹6.5–8.0 Cr/MW	long-term (1.7 FTE/MW) + 850–2,400 construction-phase	Mahanadi basin hydro potential @ 60% load factor

Metric	2024–26 Baseline	2030–36 Target
PSH capacity (Chhattisgarh)	0 MW commissioned; 2,400 MW (Sterlite Grid + Gandhwani) with EC; 7 sites at ~10,000 MW	3,000–5,000 MW commissioned by 2032; Hasdeo Bango + Sikaser anchors developed
PSH capacity (India)	4.75 GW commissioned (Dec 2024); ~44.5 GW under development	CEA target 18,896 MW by 2030; ~79 GW pipeline by 2032
Capital outlay	₹5.40 Cr/MW CEA benchmark; budgetary support ₹1–1.5 Cr/MW	₹16,200–27,000 Cr CG pipeline at 3,000–5,000 MW

Metric	2024–26 Baseline	2030–36 Target
Storage output	~3,000 MW day-night PV gap unfilled	6–10 hr daily peak-shifting; structural closure of the gap with 24×7 dispatchable RE
Job potential (CG)	Construction jobs from 2.4 GW pipeline (~6,000–9,000 peak); ~400–600 O&M FTE	7,500–18,000 construction-phase + 500–1,250 long-term O&M FTE on 3,000–5,000 MW

2 Contextual Overview

National Context

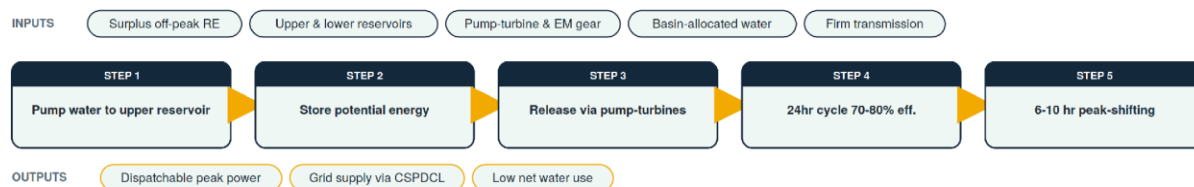
- **Large potential, slow deployment:** MNRE assesses 21,133 MW of SHP potential across 7,133 sites, of which only 4,647 MW (~22%) is commissioned — the pipeline slowed mainly by forest-clearance delays and hydrological uncertainty (61 hydropower projects were forest-clearance-stalled as of 2024).
- **CG named a priority state:** MNRE explicitly names Chhattisgarh a priority focus state for SHP alongside Maharashtra, Karnataka and Kerala; the HPO regime (large hydro in RPO since 2019) provides a demand floor.

Chhattisgarh Context

- **Real endowment:** the Mahanadi basin holds ~627 MW total hydropower potential at 60% load factor across the mainstem and tributaries (Pairi, Hasdeo, Mand, Sheonath, Ib); the sub-25 MW SHP fraction is materially deployable but not yet systematically mapped.
- **Proven operational model:** the 7 MW Sikaser and 10 MW Gangrel/R.S. Sagar SHPs are working state-tier proof-points; CREDA has been the state RE nodal agency since 2001 with SHP in its mandate.
- **CREDA priority (IDI):** small hydro is one of four priority near-term RE subsectors (with utility solar, FSPV, biomass-to-power), with the Mahanadi as geographic anchor and SHP suited to closing forest-area grid gaps in Bamavapara, Raigarh and Jashpur.

Input / Output Flow

Value Chain Flow · Pumped Storage Hydropower



Source: CEA, CSPGCL, CSPDCL, VAPCOS

3 Demand & Supply Assessment

Demand → Gap → Opportunity → Action · Pumped Storage Hydropower



Source: CEA, CSPGCL, CSPDCL, VAPCOS

Supply Analysis

- **Installed base:** ~17 MW operational (Sikaser + Gangrel); the 120 MW Hasdeo Bango (large hydro) is operationally relevant. Equipment supply is well-developed domestically (BHEL, Jyoti, Flovel, WAPCOS; ANDRITZ, Voith).
- **Cost & build inputs:** ₹6.5–8.0 Cr/MW capex; 2–4-year build (far shorter than PSH); 25–40-year asset life; 70:30 debt-equity; 9.0–10.0% cost of debt via PFC/REC/IREDA (18-year tenor).
- **Resource shape:** run-of-river CUF 30–45%, monsoon-concentrated — the binding supply variable that portfolio bundling must smooth.

Demand Dynamics

- **Regulatory floor:** HPO + rising RPO through 2030 create a binding non-solar procurement obligation SHP fulfils at competitive tariffs.
- **Geographic demand:** forest-area grid integration (Bamavapara, Raigarh, Jashpur) creates specific demand for decentralised, locally-generated RE; portfolio bundling with solar and biomass yields a higher-value round-the-clock dispatch product.

Supply–Demand Gaps

- **Four structural gaps:** (1) no sub-25 MW SHP site census in the Mahanadi basin; (2) no SHP-specific tariff/bidding/PPA framework (the 2022 State Hydropower Policy is PSH-focused); (3) forest-clearance and hydrological uncertainty in candidate geographies; (4) coexistence with irrigation water and downstream fisheries.
- **What is missing:** the site census, the policy addendum, and the bundled-portfolio bidding mechanism — the technical model, institution (CREDA) and central support (CFA, IREDA, HPO) already exist.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Small Hydropower

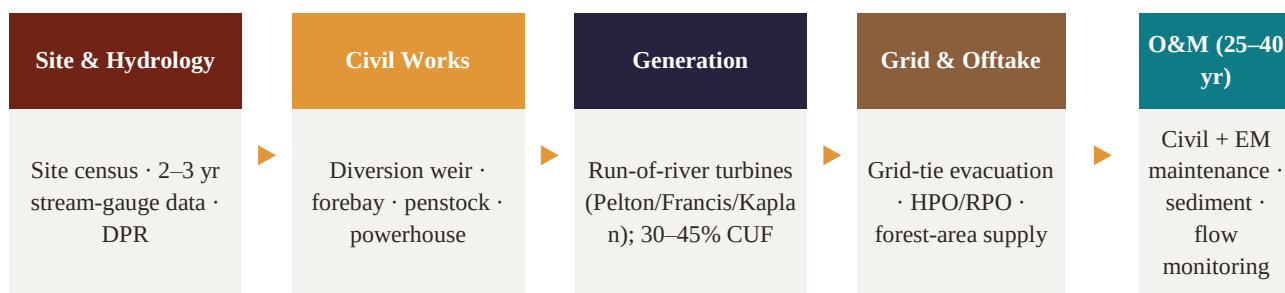


Source: MNRE, CREDA, CSPGCL, VAPCOS, PFC/REC/IREDA

4 Market Ecosystem for the Value Chain

The SHP value chain spans site identification and hydrological assessment, run-of-river civil works (weir, forebay, penstock, powerhouse), turbine-generator sets, grid-tie evacuation, and 25–40-year O&M. Unlike large hydro it rarely involves major dams or submergence. Upstream is domestic electromechanical manufacturing; midstream is DPR, clearances and EPC; downstream is O&M and grid dispatch.

Small Hydropower Value-Chain Architecture



Market Ecosystem for the Small Hydropower Value Chain

Inputs & Technology	Turbines (Pelton/Francis/Kaplan/cross-flow) · generators · governors · controls — BHEL, Jyoti, Flovel, ANDRITZ, Voith
Producers / Developers	CSPGCL (state genco) · NHPC/NEEPCO/SJVNL · private IPPs (emerging in central-Indian basins)
Development & Grid Infra	DPR · hydrology · forest & environmental clearance · EPC · grid-tie evacuation · basin siting
Off-takers	CSPDCL (offtaker) · HPO/RPO compliance · forest-area grid · industrial direct-PPA · SHP+solar+biomass bundles
Enablers	MNRE CFA (₹25–50 lakh/MW) · IREDA/PFC/REC (18-yr) · CREDA · CSERC · Forest/Water/Fisheries Depts · VAPCOS

5 Community & Stakeholder Insights

Data note. Like PSH, SHP is a state-utility/PSU/private-developer infrastructure play rather than a community-electrification programme, so village-FGD signal is indirect. Three field channels shape deployment design: the CREDA IDI (Nikhil Garg, Executive Engineer), the Berchegondi forest-governance FGD, and NRM Water Security + Inland Fisheries FGDs establishing the coexistence envelope.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CREDA (state nodal — IDI anchor)	Places SHP among four priority RE subsectors, Mahanadi as anchor; flags forest-area grid gaps in	Commission a joint CSPGCL–CREDA–VAPCOS SHP site census across the basin; notify

	Bamavapara, Raigarh, Jashpur; SHP site census layer is missing.	an SHP-specific addendum to the 2022 Hydropower Policy.
Forest-belt communities (Berchegondi Samiti) Van	Active Van Samiti since 2006, 92 IFR titles, 8 SHG/CLFs — demonstrates JFM-based community institutional capacity in candidate forest-belt SHP geographies.	Use the Van Samiti template to mediate forest-clearance and SHG-led benefit-sharing covenants; embed these in PPAs upfront.
Irrigation-water users (NRM Water Security FGDs)	Sonesarar/Tumdibod document 10 months/yr water availability with 1–2-month summer shortage and declining groundwater — the run-of-river coexistence constraint.	Guarantee ecological flows in PPAs; coordinate abstraction with the Water Resources Department; diversify across basin sites.
Downstream fishers (Inland Fisheries FGDs)	Bargaon-Mathaldabri (24 fisher HH) and Dashpur (30 fisher HH) establish fishing-livelihood exposure at run-of-river sites.	Fisheries-Department-led EIA and fishing-rights mediation built into siting and PPAs.
CSPGCL / private IPPs	CSPGCL holds public-tier development capacity (PSH FR/DPR precedent with VAPCOS); private IPPs emerging in lower-clearance central basins.	Replicate the PSH DPR machinery for SHP; open an SHP IPP-route bidding track with CFA pass-through.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Returns & support:** LCOE ₹3.5–5.0/kWh (grid) with CFA (₹25–50 lakh/MW), 18-year concessional debt, 40-year project life and 2% escalating tariff under the 2018-19 Hydropower Policy improve viability.
- **Revenue-visibility lever:** the source does not state a project IRR; recognising SHP+solar+biomass portfolio bundling as a single dispatch product is the recommended way to lift developer revenue visibility and mitigate seasonality — an analyst-flagged design choice, not a quantified IRR.

2. Social Benefits

- **Just Transition convergence:** 170–340 long-term + 850–2,400 construction FTEs land in coal-transition districts (Korba, Surguja, Raigarh, Jashpur), delivered through ITIs/polytechnics for civil and electromechanical roles.
- **Community governance:** JFM institutions (Berchegondi model) enable inclusive benefit-sharing and forest-clearance mediation.

3. Environmental & Climate Resilience

- **Low-footprint generation:** run-of-river SHP avoids major submergence; net-new decentralised RE for forest geographies where utility solar cannot reach.

- **Coexistence caution:** ecological-flow guarantees and irrigation/fisheries coexistence protocols must be built in upfront to protect water and livelihood security.

4. Technical Feasibility

- **Proven & domestic:** technology is field-demonstrated in-state (Sikaser, Gangrel) with a mature domestic equipment base; 2–4-year builds de-risk delivery.
- **Binding enabler:** DPR-stage hydrological assessment and pre-positioned forest-clearance bundling are the decisive prerequisites for scaling.

7 Success Stories & Proven Models

CASE STUDY 1 · Sikaser & Gangrel SHPs (Chhattisgarh) — In-State Operational Proof

The 7 MW Sikaser SHP on the Pairi River and the 10 MW Gangrel/R.S. Sagar SHP on the Mahanadi at Dhamtari are working state-tier run-of-river proof-points, establishing that the technical and operational model functions in Chhattisgarh's basin conditions under CREDA (state nodal agency since 2001).

Relevance: *the operational template for scaling from 17 MW to 100–200 MW — what is missing is the basin-wide site census and an SHP-specific policy addendum, not proof of concept.*

CASE STUDY 2 · The CSPGCL–VAPCOS PSH Census — A Ready Methodological Template

CSPGCL and VAPCOS already conducted a systematic pumped-storage site census (feasibility reports and DPRs) for the 2022 State Hydropower Policy — demonstrating the state has the institutional machinery to map, assess and develop hydropower sites at scale.

Relevance: *the same machinery can be applied to the missing sub-25 MW SHP layer across the Pairi, Hasdeo, Mand, Sheonath and Ib tributaries — the single most important near-term intervention.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** forest-clearance delays and hydrological uncertainty are the binding national and CG constraints; grid-tie in forest geographies adds cost.
- **Solution:** DPR-stage hydrological assessment with pre-positioned Stage-I/II forest-clearance bundling; prioritise lower-clearance-overhead basin sites.

Financial Barriers

- **Barrier:** seasonality (30–45% CUF, monsoon-concentrated) compresses revenue visibility for SHP-only projects.
- **Solution:** stack CFA (₹25–50 lakh/MW) + IREDA/PFC/REC concessional debt (18-yr) and bundle SHP with solar and biomass as a single dispatch product to smooth revenue.

Knowledge & Technical Skill Gaps

- **Barrier:** missing sub-25 MW site census and SHP-specific bidding/tariff/PPA frameworks; local civil/EM skilling gaps.
- **Solution:** commission the CSPGCL–CREDA–VAPCOS census; notify an SHP addendum to the 2022 policy; deliver ITI/polytechnic skilling in coal-transition districts.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Seasonality (30–45% CUF, monsoon-concentrated) and SHP-only dispatch shape compress revenue visibility.	Med	Recognise SHP+solar+biomass portfolio bundling as a single dispatch product for RPO compliance; stack CFA and concessional debt.	
Production / Climate	Hydrological uncertainty and rainfall variability — the 2024 national hydro output fell 16.3% (largest in 38 years, El Niño-influenced).	High	Portfolio-level diversification across multiple basin sites; rigorous DPR-stage hydrology; integrate with solar/biomass for RTC dispatch.	
Operational / Supply Chain	Forest-clearance delays (national 22% deployment) apply to CG forest-belt candidate geographies; no SHP site census.	High	Pre-position forest-clearance bundling; commission the CSPGCL–CREDA–VAPCOS sub-25 MW site census as the first intervention.	
Policy / Governance	No SHP-specific tariff/bidding/PPA framework; run-of-river coexistence with irrigation and fisheries unaddressed.	High	Notify an SHP addendum to the 2022 Hydropower Policy with ecological-flow guarantees, fishing-rights mediation and SHG benefit-sharing covenants.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Baseline vs 2030–36 Target (bar graph → editable data table)

Indicator	Baseline 2024–25	Target 2030
SHP Capacity (MW)	17	150
Direct FTE Employment (jobs)	29	255
Investment Pipeline (₹ Cr)	123	1,125

Target capacity = midpoint of 100–200 MW; FTE at 1.7 FTE/MW; investment at ~₹7.25 Cr/MW midpoint. Source: value-chain document (Table 1.1).

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Commission the sub-25 MW SHP site census (CSPGCL–CREDA–VAPCOS); notify an SHP-specific addendum to the 2022 Hydropower Policy (bidding, tariff, CFA pass-through, ecological flows, forest-clearance bundling); sequence SHP into Just Transition coal-district employment design with ITI/polytechnic skilling.

Private Sector & Investors

- Enter via IPP-route SHP in lower-clearance central-Indian basins; bring EM equipment, EPC and O&M; structure 70:30 debt-equity with IREDA/PFC/REC; adopt SHP+solar+biomass bundled offtake to improve revenue visibility.

Development Agencies & NGOs

- Deploy JFM/Van Samiti governance (Berchegondi model) for forest-clearance and benefit-sharing mediation; facilitate ecological-flow and fisheries coexistence protocols; support community trust funds and vocational skilling.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Small Hydropower Value Chain
MNRE (Central)		Small Hydro Programme policy, technical advisory, CFA disbursement (₹25–50 lakh/MW), priority-state designation.
Ministry of Power / CERC		HPO regime administration and tariff principles.
PFC / REC / IREDA		Concessional lending at RE-parity (70:30 D:E, 9.0–10.0%, 18-year tenor).
MoEFCC / Forest Department		Environmental and Stage-I/II forest clearance; cluster-level bundling.
CREDA (State Nodal Agency)		State RE nodal since 2001; SHP facilitation, site census coordination, CFA disbursement.
CSPGCL (State Genco)		Public-tier SHP development; replicate the PSH FR/DPR machinery for the SHP layer.
CSPDCL / CSERC		State offtaker; SHP-specific tariff, bidding and PPA frameworks (addendum to be notified).
Water Resources / Irrigation Department		Basin-water allocation and ecological-flow guarantees at run-of-river sites.
Fisheries Department		Downstream fishing-rights mediation and EIA at run-of-river sites.
ITIs / Polytechnics		Civil-works and electromechanical skilling for coal-transition-district workforce.

Notes

- **Capacity/FTE basis:** the 100–200 MW target is bounded by the undeveloped sub-25 MW fraction of the Mahanadi's ~627 MW assessed potential and realistic 2–4-year build timelines; FTE uses the CEEW ~1.7 FTE/MW coefficient — ranges, not point estimates.
- **Basin-potential caveat:** the ~627 MW figure is basin-wide hydropower potential; the sub-25 MW SHP fraction is not separately disaggregated in public data — hence the census recommendation.
- **Fast-moving inputs:** capex benchmarks, CFA quanta, debt terms and hydrological/rainfall conditions change and may post-date this analysis — verify against MNRE/IREDA/India-WRIS primary sources before publication.

Analyst additions: risk severities, the four diagrams and the portfolio-bundling revenue-visibility note are analytical framing; all quantitative headline metrics o

[1]**Methodology.** Employment: 170–340 long-term FTEs = 100–200 MW × ~1.7 FTE/MW (CEEW SHP studies); construction 850–2,400 FTE at 5–7× the long-term rate. Investment: ₹650–1,600 Cr = 100–200 MW × ₹6.5–8.0 Cr/MW (MNRE benchmark); installed-base capital ~₹123 Cr on 17 MW. CFA ₹25 lakh/MW (general) / ₹50 lakh/MW (special/tribal). LCOE ₹3.5–5.0/kWh grid, ₹5.0–7.0/kWh off-grid; CUF 30–45%. Basin: ~627 MW Mahanadi potential at 60% load factor (sub-25 MW fraction not disaggregated — hence the site-census recommendation). All figures originate in the source diagnostic and its endnotes (MNRE, IREDA, CEEW, ICED-NITI, India-WRIS, CGPSC). Fast-moving inputs should be re-verified before external citation.

E04 Utility-Scale Solar

ET · ENERGY TRANSITION

Large-scale ground-mounted solar power projects (typically exceeding 1 MW), including solar-plus-storage and Commercial & Industrial (C&I) Open Access, that sell electricity to state utilities or large industrial consumers under long-term contracts.

Executive Dashboard

EXECUTIVE DASHBOARD — UTILITY-SCALE SOLAR AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline vs RPO-gap target)

Direct FTE Employment. +1,827 long-term O&M FTEs from the 2,100 MW addition (blended 0.87 FTE/MW), on a ~1,217 FTE installed base — plus 6,300–10,500 temporary construction jobs across EPC, civil works and module installation. The workforce skews skilled: O&M technicians, drone-inspectors, BESS specialists and grid engineers.

Market & Investment Opportunity. ₹8,400 Cr (~USD 1 Bn) bankable pipeline — the 2,100 MW RPO gap at ₹4 Cr/MW. This is a floor, not a ceiling: the C&I Open Access market has already reached 380.7 MW, and solar-plus-storage is a higher-value growth tier.

Revenue Potential. ~₹41 Cr gross annual revenue per 100 MW for standard solar-only, secured by 25-year PPAs with CSPDCL at 10–12% project IRR (8–9-year payback). CSERC has approved a premium ₹4.01/kWh for SECI's 100 MW Rajnandgaon solar-plus-storage — dispatchable peak power is bankable.

Carbon & Compliance Outcome. ~102 MT CO₂ avoided over 25 years from closing the gap (4.87 MT per 100 MW). Utility-scale solar is the one segment where compliance, capital and carbon are pre-aligned — the execution gap is institutional, not commercial.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Utility-Scale Solar · Chhattisgarh RPO-Gap Investment Pipeline

RPO CAPACITY GAP	INVESTMENT PIPELINE	DIRECT FTE JOBS	CARBON AVOIDED
+2,100 MW	₹8,400 Cr	+1,827	~102 MT
to close the 12.50% Solar RPO shortfall (3,306 MU procurement gap)	~USD 1 Bn at ₹4 Cr/MW — a bankable floor, not a ceiling	long-term O&M FTEs (0.87 FTE/MW) + 6,300–10,500 construction jobs	CO ₂ avoided over 25-year life from closing the 2,100 MW gap

2 Contextual Overview

National Context

- **National backbone:** utility-scale solar is over 76% of India's 129.92 GW installed solar (late 2025); India ranks third globally in solar generation, with utility-scale as the spine of the 500 GW non-fossil-by-2030 target.
- **Binding demand signal:** Chhattisgarh's 12.50% Solar RPO applied to FY2025-26 demand generates a 3,306 MU procurement gap ≈ 2,100 MW shortfall — a legally enforceable liability that compounds annually, not a deferrable target.

Chhattisgarh Context

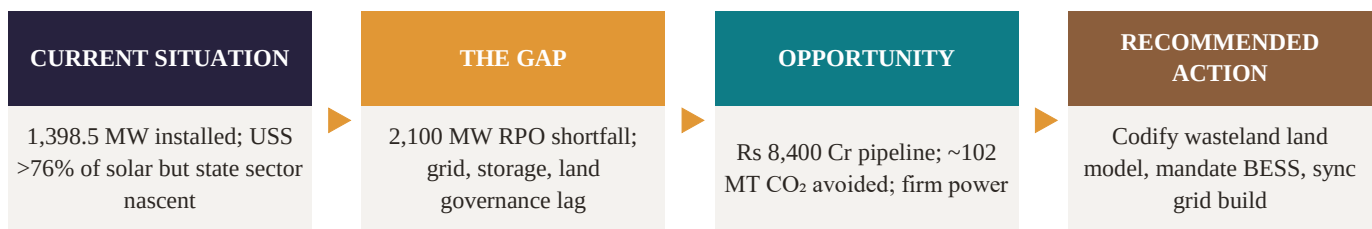
- **The fossil-fiscal paradox:** CG produces ~21% of India's coal and hosts ~7% of national thermal capacity; 22% of state revenue is energy-derived, 78% of it fossil —

so fossil subsidies run $\sim 4\times$ clean-energy support, creating structural disincentive despite the non-negotiable RPO.

- **Proven higher-value model:** the 100 MW SECI Rajnandgaon solar-plus-storage plant (India's largest at commissioning), World Bank/CTF-financed, secured ₹4.01/kWh for dispatchable power and repurposed 451 acres of wasteland across 9 villages via tripartite agreements.
- **CREDA direction (IDI):** lift state RE share from $\sim 16\%$ to 40–45% over 5–10 years with USS as primary vehicle; 100–150 MW of active utility-scale + storage already in the pipeline; a structural day-night PV gap ($\sim 8,000$ MW $\rightarrow \sim 5,000$ MW) makes storage a bid-design default.

Demand & Gap Assessment

Demand $\rightarrow$ Gap $\rightarrow$ Opportunity $\rightarrow$ Action · Utility-Scale Solar



Source: SECI, World Bank/CTF, CREDA, CSPDCL, CSERC

3 Demand & Supply Assessment

Supply Analysis

- **Installed base:** 1,398.5 MW cumulative; 380.7 MW under C&I Open Access (Sept 2023); 100 MW Rajnandgaon solar-plus-storage commissioned. Chhattisgarh's USS engagement remains limited relative to national momentum.
- **Cost & IRR inputs:** ₹4 Cr/MW solar-only (10–12% IRR, 8–9-yr payback); BESS roughly doubles project cost but the ₹4.01/kWh dispatchable tariff de-risks it; irradiance and wasteland availability underpin viability.
- **Land model:** the Rajnandgaon wasteland-tripartite template (non-agricultural land, PRI-validated) is the structurally safe supply pathway versus the Pavagada agricultural-lease model.

Demand Dynamics

- **Regulatory pull:** the 2,100 MW RPO gap is a persistent, legally enforceable demand signal; the Solar Energy Policy 2017–27 dynamically links targets to RPO.
- **Private pull:** 380.7 MW of C&I Open Access under tariff/wheeling exemptions signals private appetite independent of utility procurement; RESCO-mode housing-society solar at ₹10/unit is an adjacent near-term market (CREDA IDI).

Supply–Demand Gaps

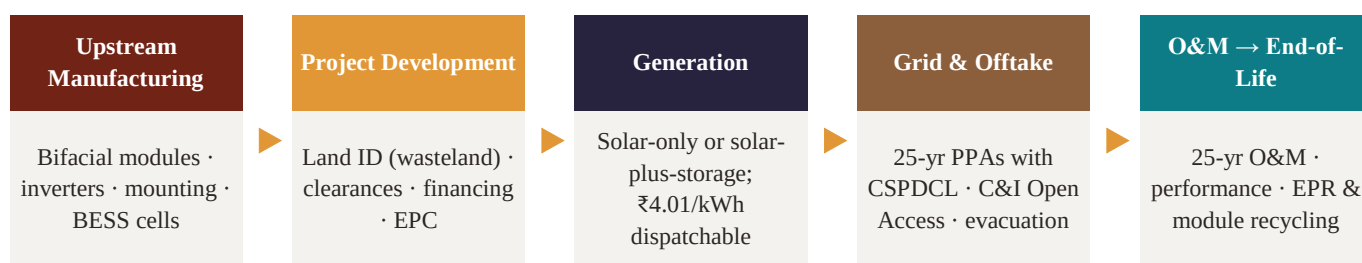
- **Grid-evacuation deficit:** transmission and substation infrastructure has not kept pace with the RE pipeline; the day-night PV gap makes storage and pumped hydro mandatory companions, not add-ons.

- **Institutional, not financial:** the field GRI scoring rates financial accessibility as non-binding (central/SECI finance is available) — the binding constraints are grid, land-use governance and fossil-revenue political economy.
- **Benefit-sharing gap:** villages adjacent to the 100 MW SECI plant (Bargaon) report no awareness and no benefit-sharing — land governance is addressed by the Rajnandgaon model but revenue-sharing is not.

4 Market Ecosystem for the Value Chain

The utility-scale solar value chain is a capital-intensive, infrastructure-driven ecosystem (B2G/B2B) across three segments: upstream module/inverter/BESS manufacturing, midstream project development (land, clearances, financing, EPC), and downstream O&M, grid integration and end-of-life management over a 25-year life. It is anchored by 25-year PPAs and enforced by the Solar RPO.

Utility-Scale Solar Value-Chain Architecture



Market Ecosystem for the Utility-Scale Solar Value Chain

Inputs & Technology	Bifacial modules · inverters · mounting structures · BESS cells · drone inspection · grid-evacuation equipment
Producers / Developers	SECI (aggregator) · Tata Power · Vikram Solar · Jakson Green · RESCO/C&I OA developers
Development & Grid Infra	Land (Rajnandgaon wasteland model) · EPC · substations · transmission corridors · storage pairing
Off-takers	CSPDCL (25-yr PPA offtaker) · C&I Open Access (380.7 MW) · industrial captive · grid peak power
Enablers	MNRE (500 GW) · CREDA · CSERC (12.5% RPO, ₹4.01/kWh) · World Bank/CTF · PRIs · SHG trust funds

5 Community & Stakeholder Insights

Data note. Utility-scale solar is least visible at village level but most enforceable at state level. Field evidence draws on the CREDA IDI (principal anchor) and FGDs in Bargaon (Rajnandgaon, 300 HH — adjacent to the 100 MW SECI plant) and Mandari (Kanker, 98 HH), March 2026.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CREDA (state nodal — IDI anchor)	Objective to lift RE share 16%→40–45% in 5–10 yrs with USS as primary vehicle; 100–150 MW pipeline active; binding constraint is grid + land governance, not deal flow.	Consolidate rooftop/mini-grid/USS under a unified DRE policy; make USS the first tranche of a multi-decade RPO procurement programme.
Communities adjacent to USS (Bargaon FGD)	No awareness of the neighbouring 100 MW plant, no benefit-sharing, no local-employment engagement; household voltage fluctuation and under-sized transformers reported.	Embed SHG-governed community trust funds financed by a per-MWh USS cess in every tender — not discretionary CSR; targeted transformer upgrades.
Tribal-belt communities (Mandari FGD)	High floating-solar acceptability (pond with no fishing-contract opposition, substation land nearby); WTP ₹50–100/month; collective-ownership preference; low PM-KUSUM/PM Surya Ghar awareness and subsidy mistrust; bank loans rated easy.	Pilot floating-solar tenders in Kanker; single-window, time-bound subsidy delivery to rebuild trust; support collective-ownership models.
PRIs / Local administration	PRI capacity for tripartite land deals is weak (institutional preparedness scored 1–2/5); no Rajnandgaon-style template beyond the original 9 villages.	Empower PRIs as the statutory land-validation authority; codify the Rajnandgaon wasteland-tripartite model as default for USS >50 MW.
SECI / World Bank / CTF (aggregators & financiers)	De-risked the Rajnandgaon pilot via aggregation + concessional finance; ₹4.01/kWh dispatchable tariff proves solar-plus-storage bankability.	Sustain aggregation and concessional finance; front-load storage and transmission-corridor approvals in every new tender.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Revenue & returns:** ~₹41 Cr/100 MW gross annual revenue; 10–12% project IRR; 8–9-year payback under 25-year PPAs — stable, low-risk infrastructure returns attractive to institutional investors.
- **Higher-value tier:** solar-plus-storage roughly doubles capex but the ₹4.01/kWh dispatchable tariff recognises its system value, improving bankability of hybrid projects.

2. Social Benefits

- **Employment:** +1,827 long-term FTEs + 6,300–10,500 construction jobs; Suryamitra and ITI-tied skill pipelines are the binding upstream constraint, not raw labour supply.

- **Just Transition:** redirecting a defined share of fossil-fuel subsidy toward re-skilling, coal-belt transition and SHG/CBO-governed community trust funds converts a fiscal liability into inclusive livelihoods.

3. Environmental & Climate Resilience

- **Emissions:** ~102 MT CO₂ avoided over 25 years — one of the largest GHG-reduction pathways in state history — while diversifying away from coal-dependent revenue.
- **Circularity window:** India faces ~11 MT of solar-module waste by 2047; CG can embed EPR, recycling-fee deposits and module traceability into every tender now, ahead of the liability.

4. Technical Feasibility

- **Proven & scalable:** solar and solar-plus-storage are field-demonstrated in-state (Rajnandgaon); the model scales through repeated tenders.
- **Binding enabler:** synchronised transmission-corridor approvals and mandated minimum BESS sizing on large bids are the decisive technical prerequisites.

7 Success Stories & Proven Models

CASE STUDY 1 · SECI Rajnandgaon 100 MW Solar-plus-Storage (Chhattisgarh) — Dispatchable Peak Power Proven

India's largest solar-plus-storage plant at commissioning, financed with World Bank/Clean Technology Fund concessional capital (~₹945 Cr) and structured by SECI, secured a CSERC-approved ₹4.01/kWh tariff for dispatchable peak power — proving hybrid solar is commercially viable and reframing solar as a grid-stability solution rather than an intermittency source.

Relevance: *the bankability template for mandating minimum BESS on large USS bids and closing the day-night PV gap — directly replicable across the 2,100 MW pipeline.*

CASE STUDY 2 · The Rajnandgaon Wasteland-Tripartite Land Model — Conflict-Free Siting

The plant repurposed 451 acres of non-agricultural wasteland across nine villages through tripartite agreements (developer, state, community), avoiding the dispossession and food-security trade-offs of the Karnataka Pavagada agricultural-lease model.

Relevance: *codified as the statutory default for USS tenders >50 MW — with PRIs as land-validation authority and agricultural plots excluded by statute — it forecloses Pavagada-style conflict. (The remaining gap: revenue-sharing, which SHG-governed trust funds should close.)*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** outdated transmission/substation infrastructure cannot absorb large intermittent RE; the day-night PV gap (~8,000→5,000 MW) strands solar-only capacity.

- **Solution:** synchronise transmission-corridor approvals with generation tenders; mandate minimum BESS sizing on bids above 100 MW; pair with pumped hydro.

Financial Barriers

- **Barrier:** fossil-fiscal dependence (78% of energy revenue) disincentivises RE; historical absence of Green Energy Corridor investment.
- **Solution:** the RPO gap plus 25-year PPAs and SECI/World Bank/CTF concessional finance make capital available — extend C&I Open Access exemptions (7–10-yr window) beyond the 500 MW ceiling to unlock the next tranche.

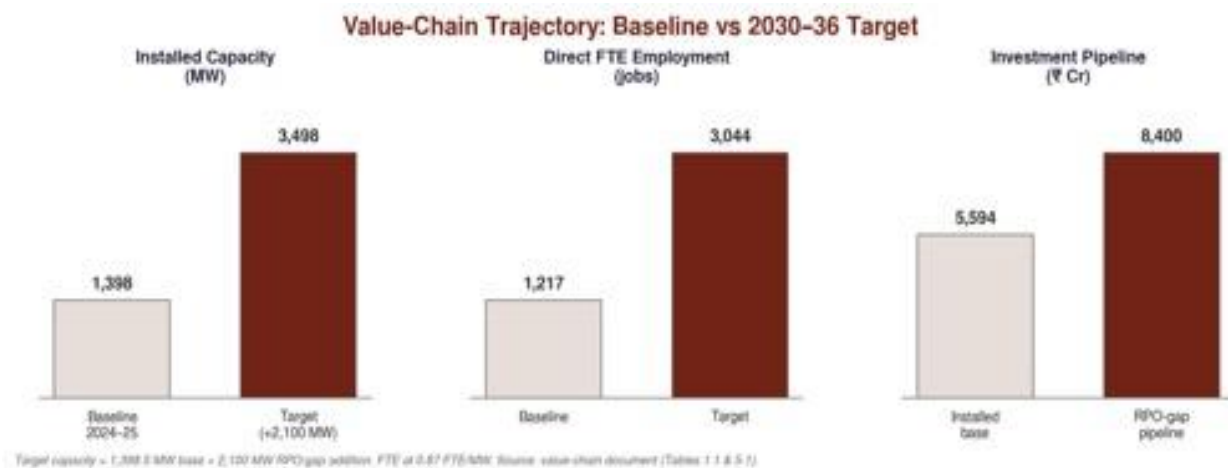
Knowledge & Technical Skill Gaps

- **Barrier:** weak PRI capacity for tripartite land deals; low community awareness and subsidy mistrust; skilled-O&M pipeline gaps.
- **Solution:** empower and train PRIs as land-validation authority; front-load Suryamitra/ITI skilling; single-window, time-bound subsidy delivery to rebuild trust.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Fossil-revenue political economy disincentivises RE despite the binding RPO; C&I demand capped by the 500 MW exemption ceiling.	Med	Frame the 2,100 MW gap as a legal liability; extend C&I OA exemptions (7–10 yrs) beyond 500 MW; redirect fossil subsidy via a Just Transition framework.	
Production / Climate	Structural day-night PV gap (~8,000→5,000 MW) and intermittency; grid cannot firm supply without storage.	High	Mandate minimum BESS on large bids; pair with pumped hydro; use the ₹4.01/kWh dispatchable tariff as the bid-design signal.	
Operational / Supply Chain	Grid-evacuation and transmission-corridor capacity lag the generation pipeline; ~11 MT national solar-waste burden by 2047.	High	Bundle transmission approvals with tenders; embed EPR and module-recycling deposits at procurement to make CG a circular-economy leader.	
Policy / Governance	Land-conflict risk (Pavagada precedent) and absent village-level benefit-sharing even next to the SECI plant.	High	Codify the Rajnandgaon wasteland-tripartite model as default (PRIs as validators); embed SHG-governed per-MWh community trust funds in every tender.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.



10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Codify the Rajnandgaon wasteland model as the >50 MW default; consolidate a unified DRE policy; front-load grid + storage in tenders; extend C&I OA exemptions; establish a formal Just Transition framework redirecting fossil subsidy to re-skilling and community trust funds; embed EPR at procurement.

Private Sector & Investors

- Deploy solar-only and solar-plus-storage under 25-year PPAs and C&I Open Access (RESCO/captive); bring EPC, module/BESS supply and O&M; access SECI aggregation and World Bank/CTF concessional finance; adopt wasteland siting.

Development Agencies & NGOs

- Strengthen PRI land-validation capacity; seed and govern SHG/CBO community trust funds and benefit-sharing; deliver Suryamitra/ITI skilling; support single-window subsidy delivery and awareness to rebuild trust.

11 Key Departments & Institutional Alignment

Nodal Institution	Department / Primary Responsibility in the Utility-Scale Solar Value Chain
MNRE (Central)	National RE strategy, 500 GW non-fossil roadmap, physical-progress monitoring, state target alignment.
SECI	Central project aggregation, PPA structuring, international finance mobilisation, technical assistance.
CREDA (State Nodal Agency)	Policy implementation, single-window clearance, USS tender design, 2,100 MW RPO-gap closure, grid coordination.
CSERC (Regulator)	12.50% Solar RPO enforcement, tariff approval (₹4.01/kWh dispatchable), PPA clearance, end-of-life recycling mandates.
CSPDCL (State DISCOM)	Primary offtaker, 25-year PPA execution, transmission/evacuation upgrades, tripartite land-use agreements.

CSIDC	Industrial-policy facilitation, C&I Open Access support, local manufacturing/services ecosystem.
Energy Department, GoCG	Institutional oversight, large-project approval, state signatory in tripartite land-use agreements.
Local Administration & PRIs	Wasteland identification/validation, land-use conversion, grievance redressal, social-conflict mediation.
World Bank / CTF	Concessional blended finance and de-risking for solar-plus-storage (Rajnandgaon template).
SHGs / CBOs	Govern benefit-sharing and community trust funds under the Just Transition framework.

Data Integrity & Currency Notes

- **Capacity/FTE basis:** the 2,100 MW gap derives from the 12.50% RPO applied to FY2025-26 demand (3,306 MU); +1,827 FTE uses a blended 0.87 FTE/MW; ₹8,400 Cr uses ₹4 Cr/MW — a conservative solar-only floor.
- **Field-scoring caveat:** the GRI readiness index was scored for distributed-solar adoption and is used here as a proxy for community land/benefit-sharing readiness in USS-adjacent geographies, not a direct USS score.
- **Fast-moving inputs:** tariffs, IRR bands, C&I OA capacity and the 500 MW exemption ceiling change frequently and may post-date this analysis — verify against CSERC/CREDA primary sources before publication.

Analyst additions: risk severities and the four diagrams are analytical framing; all quantitative headline metrics originate in the source document (endnotes referen

[1]**Methodology.** Employment: +1,827 long-term FTEs = 2,100 MW × 0.87 blended FTE/MW; installed base ~1,217 FTE on 1,398.5 MW; construction 6,300–10,500 temporary jobs. Investment: ₹8,400 Cr = 2,100 MW × ₹4 Cr/MW (conservative solar-only floor); installed-base capital ~₹5,594 Cr. Capacity gap: 12.50% Solar RPO on FY2025-26 demand → 3,306 MU procurement gap ≈ 2,100 MW. Revenue: ~₹41 Cr/100 MW/yr solar-only; project IRR 10–12%; ₹4.01/kWh CSERC-approved dispatchable (Rajnandgaon solar-plus-storage). Carbon: 4.87 MT CO₂/100 MW over 25 yrs → ~102 MT for 2,100 MW. All figures originate in the source diagnostic and its cited endnotes (CSERC orders, CREDA data, MNRE filings, World Bank/CTF docs, IISD/CEEW). Fast-moving inputs (tariffs, IRR, C&I OA) should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Utility-Scale Solar

INPUTS



OUTPUTS

Firm power via PPA	CO ₂ avoided	Skilled employment	Recoverable module material
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Source: SECI, World Bank/CTF, CREDA, CSPDCL, CSERC

E05 Pumped Storage Hydropower (PSH)

ET · ENERGY TRANSITION

The world's most mature grid-scale storage technology, shifting surplus daytime renewable generation to peak evening and night hours by pumping water between a lower and an upper reservoir.

1 Executive Dashboard

EXECUTIVE DASHBOARD — PUMPED STORAGE HYDROPOWER AT A GLANCE (Chhattisgarh · GETM 2026–2036 · committed vs 2030–32 target)

Direct Employment. A 1,200 MW PSH project supports ~3,000–4,500 construction-phase jobs at peak and 200–300 long-term O&M positions over a 50-year asset life. For the 3,000–5,000 MW pipeline that implies ~7,500–18,000 cumulative construction-phase jobs and 500–1,250 long-term O&M roles concentrated at project sites (civil, electromechanical, water-resource monitoring, grid-tie).

Market & Investment Opportunity. ₹16,200–27,000 Cr for a realistic 3,000–5,000 MW 2030–32 pipeline at the CEA benchmark ₹5.40 Cr/MW — bounded below by the 2.4 GW already holding environmental clearance (Sterlite Grid + Gandhwani Energy) and above by the seven CSPGCL-identified sites totalling ~10,000 MW.

Storage & System Value. PSH is the single largest grid-scale storage technology in commercial deployment globally and the only one that addresses Chhattisgarh's ~3,000 MW day-night PV gap at utility scale — providing 6–10 hours of daily peak-shifting and converting daytime solar surplus into 24×7 dispatchable renewable power.

Strategic Outcome. PSH is the storage backbone of the RE portfolio: it answers the question every other CG RE value chain poses but cannot resolve internally — what powers the night

when solar stops and biomass scales slowly. Without PSH the solar build-out terminates at a daytime ceiling.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Pumped Storage Hydropower (PSH) · Chhattisgarh 2026–36

PSH CAPACITY	INVESTMENT	STORAGE OUTPUT	EMPLOYMENT
0 → 3,000–5,000 MW	₹16,200–27,000 Cr	closes ~3,000 MW	7,500–18,000
commissioned by 2032; 7 sites identified at ~10,000 MW	at CEA benchmark ₹5.40 Cr/MW + budgetary support	day-night PV gap; 6–10 hr daily peak-shifting	construction-phase + 500–1,250 long-term O&M jobs

2 Contextual Overview

National Context

- **Rapid national scale-up:** 4.75 GW commissioned (Dec 2024) with 44.5 GW under development; CEA’s optimal-mix model places the 2030 requirement at 18,896 MW (a ~₹1.02 lakh Cr pipeline at ₹5.40 Cr/MW); private players (Greenko, Adani Green, JSW) are positioned for nearly two-thirds of the planned ~51 GW by 2032.
- **Policy templates:** Madhya Pradesh’s Pumped Hydro Storage Policy 2025 and Andhra Pradesh’s Integrated Clean Energy Policy 2024 provide tariff/bidding templates; CEA DPR Guidelines (v2.0 June 2023, v4.0 Nov 2025) tighten technical scrutiny.

Chhattisgarh Context

- **Policy-anchored and moving:** the CG State Hydropower (Pump Storage Based) Establishment Policy 2022 (cabinet-notified, one of India’s earliest) designates CSPGCL nodal and identifies seven sites at ~10,000 MW (Hasdeo Bango 1,200, Sikaser 1,200, Dangri 1,400, Rauni 2,100, Kotpalli 1,800 MW); VAPCOS is on the FRs/DPRs.
- **Private pipeline advanced:** two 1,200 MW projects (Sterlite Grid, Gandhwani Energy) received Centre-level environmental clearance in January 2024 (2,507 ha allocated, ~3–4-year build); Sarda Energy adds momentum.
- **CREDA priority (IDI):** a 1,200 MW Rajnandgaon storage unit and the Mahanadi basin are the 5–10-year operational priorities, with PSH framed as a structural — not optional — complement to utility-scale solar.

3 Demand & Supply Assessment

Supply Analysis

- **Installed base:** 0 MW commissioned in CG; institutional readiness has not yet converted into operational capacity. Public tier anchored by CSPGCL; private tier by

Sterlite/Gandhwani/Sarda and national developers (Greenko, Adani, JSW, NHPC, NTPC).

- **Cost & build inputs:** ₹5.40 Cr/MW CEA benchmark; 5–7-year build (clearance to commissioning); 50-year asset life; central budgetary support ₹1.5 Cr/MW (≤ 200 MW) / ₹1 Cr/MW (> 200 MW) for enabling infrastructure.
- **Configuration choice:** closed-loop / off-river configurations reduce reservoir-water and fisheries conflict but cost more — a design trade-off at anchor sites.

Demand Dynamics

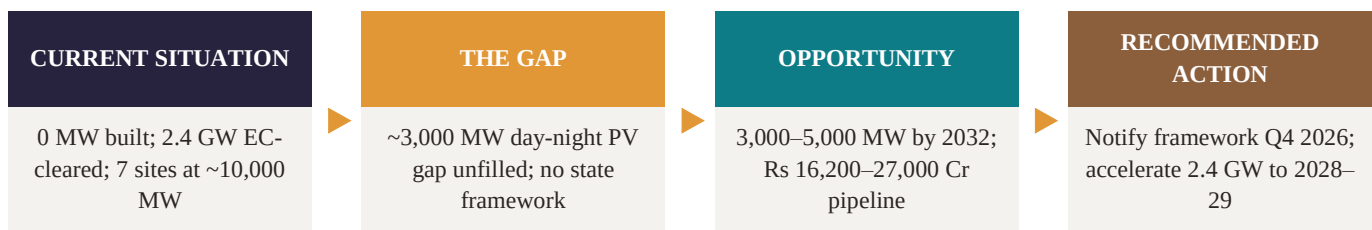
- **System need:** PSH fills the ~3,000 MW day-night PV gap with 6–10 hr peak-shifting — the demand is structural to the solar and biomass build-out.
- **Emerging demand instruments:** Time-of-Day tariffs and Energy Storage Obligations must be translated into PPA-grade demand signals; the ISTS-charge waiver (for PSH meeting the 70%-RE pumping condition) is a transitional concession to extend for the CG pipeline.

Supply–Demand Gaps

- **Three structural gaps:** (1) no PSH commissioned yet; (2) state PSH-specific tariff/bidding/PPA frameworks not fully notified, weakening developer revenue visibility; (3) reservoir-water governance at Hasdeo Bango and Mahanadi sites (irrigation + $> 15,000$ MW thermal water demand + downstream fisheries) not yet codified.
- **Execution-risk shadow:** Indian PSH history is dominated by cost/schedule overruns (Tehri ~13 yrs late; Ghatghar +431%) — sequencing and DPR rigour are decisive.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Pumped Storage Hydropower

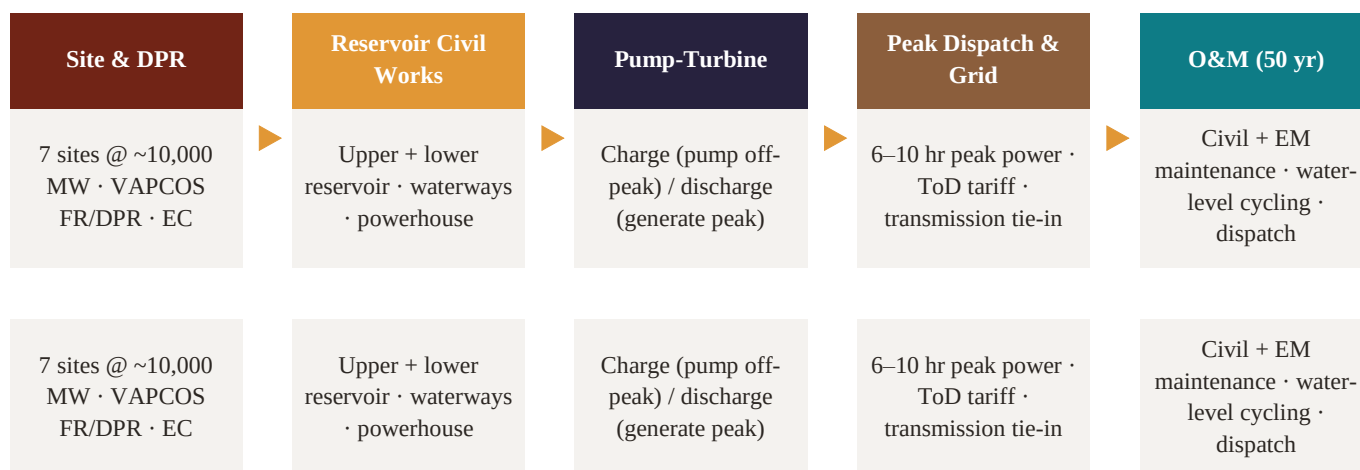


Source: CEA, CSPGCL, CSPDCL, VAPCOS

4 Market Ecosystem for the Value Chain

PSH stores energy by pumping water to an upper reservoir off-peak and generating on demand through reversible pump-turbines during peak hours. The chain spans site FR/DPR and clearance, upper/lower reservoir and waterway civil works, electromechanical pump-turbine and motor-generator sets, transmission tie-in, and 50-year O&M. It is capital-intensive and coordinated across state-utility, PSU and private developers.

Pumped Storage Hydropower Value-Chain Architecture



Market Ecosystem for the Pumped Storage Hydropower Value Chain

Inputs & Technology	Reversible pump-turbines · motor-generators · penstocks · transformers · SCADA · closed-loop / off-river configurations
Producers / Developers	CSPGCL (nodal) · Sterlite Grid · Gandhwani Energy · Sarda Energy · Greenko / Adani Green / JSW / NHPC / NTPC
Development & Grid Infra	VAPCOS FR/DPR · environmental clearance · land · transmission tie-ins · Green Energy Corridor evacuation
Off-takers	CSPDCL (oftaker) · peak/ToD power · Energy Storage Obligation · RE firming for solar & biomass
Enablers	CG PSH Policy 2022 · CEA DPR guidelines · MoP · CERC (ISTS waiver) · PFC/REC/IREDA · Water Resources & Fisheries Depts

5 Community & Stakeholder Insights

Data note. PSH is a state-utility/PSU/private-developer infrastructure play with no direct village-electrification signal. Field evidence enters indirectly via the CREDA IDI (Nikhil Garg, Executive Engineer), Inland Fisheries FGDs (Bargaon-Mathaldabri 24 HH, Dashpur 30 HH) and NRM Water Security FGDs (Sonesarar, Tumdibod) that set the reservoir-coexistence envelope.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CREDA (state — IDI anchor)	1,200 MW Rajnandgaon unit and Mahanadi are the 5–10-yr priorities; PSH is the structural answer to the ~3,000 MW day-night PV gap.	Sequence PSH tenders with paired transmission upgrades; embed ToD tariffs and Energy Storage Obligations for peak-dispatch value.

CSPGCL (state nodal) + VAPCOS	Seven anchor sites (~10,000 MW) with FRs/DPRs under way; institutional readiness ahead of operational capacity.	Operationalise the Hasdeo Bango + Sikaser 1.2 GW pair as the public second wave; evaluate closed-loop configurations to minimise conflict.
Private developers (Sterlite, Gandhwani, Sarda)	2.4 GW already EC-cleared (2,507 ha, ~3–4-yr build) — the anchor demonstration pipeline.	Structure long-term PPAs and sequence transmission tie-ins ahead of commissioning to avoid the cost-overrun pattern.
Downstream fishers (Inland Fisheries FGDs)	Active fishing livelihoods (24 HH Bargaon-Mathaldabri, 30 HH Dashpur) on candidate reservoir geographies.	Reservoir-impact assessment with fishing-rights mediation (Sembcorp-style threshold adapted for water-level cycling); SHG benefit-sharing.
Irrigation-water users (NRM FGDs)	Sonesarar/Tumdibod document 10 months/yr availability with summer shortage and declining groundwater — coexistence constraint.	Irrigation-water guarantee covenants for downstream villages; Water Resources Department reservoir-allocation coordination.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Bankability drivers:** ₹5.40 Cr/MW benchmark plus budgetary support (₹1–1.5 Cr/MW), RE-parity concessional debt (PFC/REC/IREDA) and the ISTS-charge waiver improve economics — but PSH tariffs are high relative to solar and require ToD/ESO demand signals to be viable.
- **Execution economics:** the decisive lever is controlling cost/schedule overruns via rigorous DPR scrutiny (CEA v4.0), competitive least-cost bidding and milestone-linked disbursement; the source states no project IRR — ROI would be an analyst estimate.

2. Social Benefits

- **Employment:** ~7,500–18,000 construction-phase jobs and 500–1,250 long-term O&M roles concentrated at project sites, with skilled civil and electromechanical opportunities.
- **Livelihood protection:** fishing-rights mediation and irrigation-water guarantees, with SHG-led benefit-sharing on the Rajnandgaon tripartite template, are prerequisites for social licence.

3. Environmental & Climate Resilience

- **Enabling deep RE integration:** PSH firms intermittent solar/biomass into 24×7 dispatchable RE — the environmental value is system-level decarbonisation of the night.

- **Reservoir-water caution:** water-level cycling must coexist with irrigation, industrial and fisheries demand; closed-loop/off-river configurations reduce impact at higher cost.

4. Technical Feasibility

- **Globally proven:** PSH is the most mature and largest-deployed grid-scale storage; the technology risk is execution (geotechnical, clearances, land), not concept.
- **Binding enabler:** transmission sequencing ahead of generation and firm dispatch (curtailment-free operation) are the decisive technical prerequisites.

7 Success Stories & Proven Models

CASE STUDY 1 · Sterlite Grid + Gandhwani Energy 2.4 GW (Chhattisgarh) — EC-Cleared Anchor Pipeline

Two private 1,200 MW PSH projects received Centre-level environmental clearance in January 2024 (2,507 ha allocated, ~3–4-year build horizon), confirming the CG pipeline is operationally moving and providing an anchor demonstration ahead of the public second wave.

Relevance: *the near-term proof pipeline — CSPGCL should structure long-term PPAs and sequence transmission tie-ins ahead of commissioning to avoid the cost-overrun pattern that defines Indian PSH history.*

CASE STUDY 2 · Tehri & Ghatghar PSPs (India) — The Cost-Overrun Cautionary Lesson

Indian PSH execution history is dominated by overruns: the Tehri PSP ran ~13 years late, and the Ghatghar PSP overran from ₹288.83 Cr to ₹1,535.26 Cr (+431%) — reflecting underestimated geotechnical complexity, clearance delays and land-acquisition friction.

Relevance: *CG's bidding framework must incorporate rigorous DPR scrutiny (CEA v4.0), competitive least-cost bidding and milestone-linked disbursement to control these risks from the outset.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** PSH economics collapse without firm dispatch and curtailment-free operation; transmission has historically lagged generation.
- **Solution:** pair every tendered MW with a transmission and Mahanadi-corridor evacuation upgrade, jointly financed by CSPDCL and Green Energy Corridor allocations.

Financial Barriers

- **Barrier:** high capex and cost-overrun history; weak developer revenue visibility without a PSH-specific tariff regime.

- **Solution:** notify a CG PSH tariff/bidding framework with ToD tariffs and Energy Storage Obligations; stack budgetary support, RE-parity debt and the ISTS waiver; use milestone-linked disbursement.

Knowledge & Technical Skill Gaps

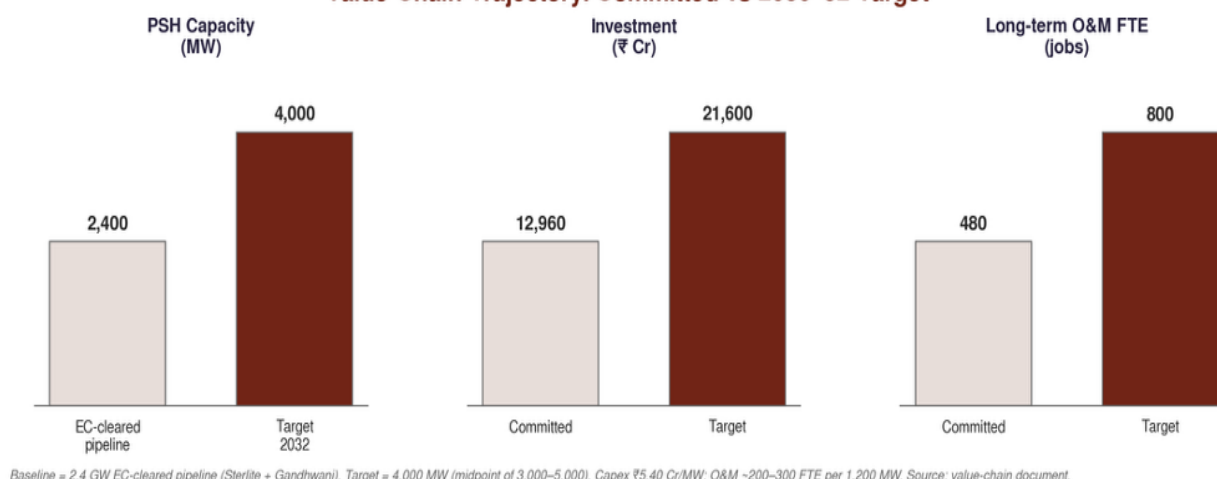
- **Barrier:** reservoir-water governance and community-coexistence protocols are uncoded; geotechnical DPR rigour is decisive.
- **Solution:** codify irrigation/fisheries coexistence protocols; apply CEA v4.0 DPR scrutiny; build EM/civil O&M skilling at project sites.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	PSH tariffs are high relative to solar; without competitive bidding, ESO and ToD tariffs, PSH economics struggle.	Med	Translate ToD tariffs and Energy Storage Obligations into PPA-grade demand signals; use least-cost competitive bidding.	
Production / Execution	Cost/schedule overruns dominate Indian PSH history (Tehri ~13 yrs late; Ghatghar +431%).	High	Apply CEA v4.0 DPR scrutiny, competitive least-cost bidding, milestone-linked disbursement; sequence transmission ahead of generation.	
Operational / Reservoir	Reservoir-water cycling conflicts with irrigation, >15,000 MW thermal water demand and downstream fisheries.	High	Adopt closed-loop/off-river configurations where feasible; codify irrigation guarantees and fishing-rights mediation upfront.	
Policy / Governance	No PSH commissioned yet; state-specific tariff/bidding/PPA frameworks not fully notified.	Med	Notify a CG PSH tariff and bidding framework (MP 2025 / AP 2024 templates); extend the ISTS waiver for the CG pipeline.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Committed vs 2030-32 Target



10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Accelerate the 2.4 GW EC-cleared anchor pipeline with long-term PPAs; operationalise the Hasdeo Bango + Sikaser 1.2 GW public pair; sequence transmission ahead of generation; notify a PSH-specific tariff/bidding framework with ToD tariffs and ESOs; codify reservoir-coexistence protocols.

Private Sector & Investors

- Develop EC-cleared and CSPGCL-identified sites (Sterlite, Gandhwani, Sarda, and national developers); bring pump-turbine EM supply, EPC and O&M; structure milestone-linked financing with PFC/REC/IREDA and the ISTS waiver; evaluate closed-loop configurations.

Development Agencies & NGOs

- Facilitate fishing-rights and irrigation-water coexistence protocols and SHG-led benefit-sharing (Rajnandgaon template); support community-interface mediation and reservoir-impact assessment.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Pumped Storage Hydropower Value Chain
Ministry of Power (Central)		PSH Guidelines 2023; national policy framework.
Central Electricity Authority (CEA)		PSH DPR guidelines and technical scrutiny; optimal-mix modelling; capex benchmarking; site clearance recommendations.
CERC		Tariff principles; ISTS-charge waiver for qualifying PSH.
MoEFCC		Environmental clearances (Sterlite + Gandhwani cleared Jan 2024).
PFC / REC / IREDA		RE-parity concessional financing on loan tenor and interest.

Energy Department, GoCG	Cabinet-level oversight; CG PSH Establishment Policy 2022; cross-departmental coordination.
CSPGCL (State Nodal Agency)	Public-tier PSH development; FR/DPR via VAPCOS; site allocation; EPC management.
CSPDCL / CSERC	Primary offtaker; long-term PPAs, transmission planning; tariff and PPA approvals.
Water Resources / Irrigation Department	Reservoir-allocation authority; coexistence with irrigation and industrial water demand.
Forest & Fisheries Departments; PRIs	Forest/wildlife clearances; downstream fishing-rights mediation; land-acquisition support and community interface.

— Data Integrity & Currency Notes

- **Capacity/investment basis:** the 3,000–5,000 MW target is bounded below by 2.4 GW already EC-cleared and above by the seven CSPGCL sites at ~10,000 MW; ₹16,200–27,000 Cr uses the CEA ₹5.40 Cr/MW benchmark — a range reflecting execution and sequencing risk.
- **Employment coefficients:** 3,000–4,500 construction and 200–300 O&M per 1,200 MW are typical benchmarks scaled to the pipeline; the ~480→800 O&M figures in the trajectory chart apply ~0.2 FTE/MW to committed vs target capacity — directional, not a precise headcount.
- **Fast-moving inputs:** the ISTS-waiver cut-off, CEA benchmarks, national PSH capacity and policy templates change frequently and may post-date this analysis — verify against CEA/CERC/MoP primary sources before publication.
- **Analyst additions:** risk severities, the four diagrams and the ROI data-gap note are analytical framing; all quantitative headline metrics originate in the source document (references [1]–[14]).

[1]**Methodology.** Capacity/investment: 3,000–5,000 MW target bounded by 2.4 GW EC-cleared (Sterlite + Gandhwani) below and seven CSPGCL sites (~10,000 MW) above; ₹16,200–27,000 Cr = capacity × CEA benchmark ₹5.40 Cr/MW; budgetary support ₹1.5 Cr/MW (≤ 200 MW) / ₹1 Cr/MW (> 200 MW). Employment: ~3,000–4,500 construction + 200–300 O&M per 1,200 MW → ~7,500–18,000 construction + 500–1,250 O&M across the pipeline; the trajectory chart applies ~0.2 O&M FTE/MW to committed (2,400 MW) vs target (4,000 MW). Storage: fills the ~3,000 MW day-night PV gap with 6–10 hr peak-shifting; national PSH 4.75 GW (Dec 2024) → CEA 18,896 MW by 2030. All figures originate in the source diagnostic and its endnotes (CEA, MoP, ICRA/IEEFA/Prayas, CG PSH Policy 2022, VAPCOS). Fast-moving inputs should be re-verified before external citation.

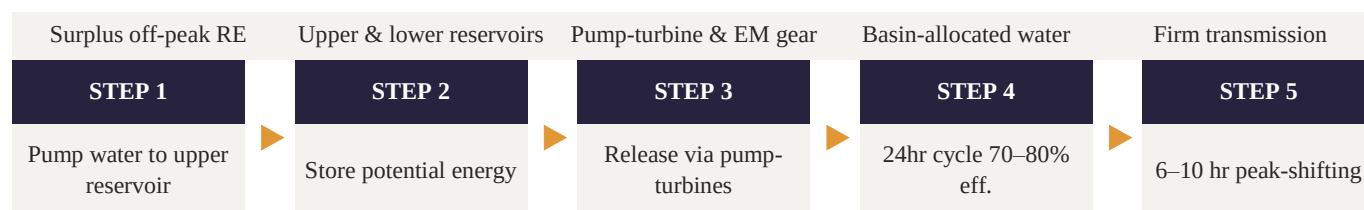
Input / Output Flow

Enablers

CG PSH Policy 2022 · CEA DPR guidelines · MoP · CERC (ISTS waiver) · PFC/REC/IREDA · Water Resources & Fisheries Depts

Value Chain Flow · Pumped Storage Hydropower

INPUTS



OUTPUTS

Dispatchable peak power	Grid supply via CSPDCL	Low net water use
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E06 RE MANUFACTURING (BIO-ENERGY)

ET · ENERGY TRANSITION

The bioenergy manufacturing value chain — biomass-to-power, biomass pellets, Compressed Biogas (CBG), and 2G ethanol — that converts Chhattisgarh's surplus agricultural residue into electricity, transport fuels, and industrial fuels through decentralised aggregation and conversion.

Source: CEA, CSPGCL, CSPDCL, VAPCOS

1 Vision & Targets

Convert Chhattisgarh's 10.9 MMT of surplus paddy straw from a burned liability into a rural bio-economy — biofuels, CBG, pellets and co-firing feedstock — built on farm-gate collection, women-led aggregation and village-level pre-processing. This is not an electricity programme: its binding constraint is rural logistics, its primary products are liquid and gaseous fuels, and its employment lands across the paddy belt rather than at plant gates. DWEEPTI supplies the community institutions, manufacturing incentives and panchayat machinery to build the missing rural middle.

Executive Dashboard · RE Manufacturing (Bio-energy) · Chhattisgarh 2026–36

DIRECT FTE JOBS	RECURRING MARKET	FEEDSTOCK	LABOUR INTENSITY
8,988+	₹700+ Cr/yr	10.9 MMT	16.24 FTE/MW
illustrative potential — most labour-intensive RE value chain	₹570 Cr ethanol + ₹138 Cr CBG + ₹2,122 Cr power capex	surplus paddy straw/yr — an environmental liability to monetise	biomass-to-power vs 0.87 (solar), 3.36 (FSPV) — 4–18×

Metric	Baseline / current position	2030–36 opportunity
Surplus feedstock	10.9 MMT paddy straw/yr, much of it burned	Monetised through an organised trading platform and depot network
Direct employment FTE	2–3 operational biomass plants state-wide	8,988+ illustrative direct FTEs at 16.24 FTE/MW — the most labour-intensive RE chain
Recurring market	9.51 crore-litre ethanol blending deficit	₹700+ Cr/yr (₹570 Cr ethanol + ₹138 Cr CBG)
Capex market	—	₹2,122 Cr power capex (353.7 MW at ~₹6 Cr/MW); ₹250–350 Cr per 2G plant; ~₹100 Cr per CBG plant
Committed public capital	₹700 Cr (BPCL + GAIL CBG, Raipur/Bhilai)	Proposed 500 KLPD IOC ethanol plant (₹1,500–2,000 Cr); PM JI-VAN VGF up to ₹150 Cr/project
Rural enterprise base	130+ FPOs; ~2.7 lakh SHGs and 580 CLFs under Bihan	Depot, baling, pre-processing and briquette/pellet enterprises under DWEEPTI's manufacturing provisions
Women-led delivery (DWEEPTI)	Bioenergy sits inside DWEEPTI's technology basket	10–12% SHG channel partners in first two years, rising to 33.3% by 2031; 20% procurement preference window

Source: RE Manufacturing value-chain diagnostic; CBDA, MNRE, MoPNG and OMC announcements; DWEEPTI Yojana (2026–2031).

At a glance

- **Direct FTE employment.** 8,988+ illustrative direct FTEs — structurally the most labour-intensive RE value chain at 16.24 FTE/MW for biomass-to-power against 3.36 for floating solar and 0.87 for utility solar. The 353.7 MW biomass-power potential alone implies ~5,744 jobs (3,300 permanent O&M); each 2G ethanol plant ~1,200 jobs; each MMT of pellets ~938 jobs — distributed across the paddy belt, not concentrated at plant sites.
- **Market & compliance pull.** ₹700+ Cr/yr of recurring biofuel demand plus a ₹2,122 Cr one-time capex market. National mandates — E20 by 2025-26, 5% CBG by 2028-29, 5–7% biomass co-firing under SAMARTH — convert the residue paradox into a binding compliance market with OMCs as anchor off-takers.
- **Strategic outcome.** A rural bio-economy rather than a power programme. The technology is proven (Hira Group, Rajnandgaon); what is missing is the trading platform, aggregation depots, rural demand aggregation and workforce — all of which are institutional, not technical, and all of which DWEEPTI's community architecture is built to supply.

2 Contextual Overview

National context

- **Mandate-driven markets:** E20 ethanol blending by 2025-26, 5% CBG blending by 2028-29 and 5–7% biomass co-firing in coal plants under the SAMARTH Mission create legally mandated, recurring biomass demand.
- **Support architecture:** National Policy on Biofuels (2018/2022), PM JI-VAN Yojana VGF (up to ₹150 Cr per 2G plant), and MNRE Central Financial Assistance (₹40 lakh/MW non-bagasse cogeneration; ₹21 lakh/MTPH non-torrefied and ₹42 lakh/MTPH torrefied pellets).

Chhattisgarh context

- **The structural paradox:** the state hosts ~7% of India's coal-thermal capacity yet runs a 9.51 crore-litre ethanol deficit and burns much of its 10.9 MMT surplus paddy straw because there is no organised market to monetise it.
- **Proven feasibility:** Hira Group operates a biomass power plant in Rajnandgaon (one of 2–3 biomass plants state-wide); the CNG/CBG ecosystem is largely absent due to supply gaps, so new CBG capacity is uncontested.
- **Offtake direction:** CREDA reports biomass-to-energy as rolling but constrained by forest-area grid issues, and CSPDCL is a reluctant biomass-PPA offtaker in a power-surplus state — pushing strategy toward biofuels, CBG and co-firing that do not need DISCOM offtake.
- **Institutional readiness:** Bihan (CGSRLM) contributes ~2.7 lakh SHGs and 580 CLFs alongside 130+ FPOs — the aggregation backbone this value chain requires, and the delivery chassis DWEEPTI now formalises.

3 DWEEPTI Yojana — The Overarching Institutional Instrument

The DWEEPTI Yojana (Decentralised Women Empowerment on Energy & Policy for Transformative Inclusion), 2026–2031, has been approved and taken up by the Government of Chhattisgarh and is the overarching scheme through which this value chain will be delivered. It is anchored in the Department of Panchayati Raj & Rural Development, implemented through Bihan (CGSRLM) within the Panchayati Raj framework, with CREDA and CSPDCL as technical support agencies. Biomass and bioenergy sit expressly inside its technology basket, and the MNRE definition of DRE livelihood applications that DWEEPTI adopts names small-scale biomass briquette and pellet-making machines among eligible products — placing decentralised bio-energy manufacturing directly within scheme scope.

Manufacturing provisions for women

- **Cluster manufacturing through RIPA–CLF integration:** the policy provides for Rural Industrial Parks managed by Cluster Level Federations, with DRE-powered Common Facility Centres housing shared processing machines and training facilities; cluster-scale biomass gasifier plants generating electricity or thermal energy for industrial use from locally available biomass; DRE-powered agro-processing hubs serving village clusters; and CLF-level waste-to-energy converting agricultural waste. This is the ready-made vehicle for decentralised pre-processing capacity.
- **Village and enterprise-tier manufacture:** the eligible product list covers briquette and pellet-making machines, biomass dryers, agro-processing units (flour mills, rice hullers, oil expellers, millet units), micro cold storage, biofertiliser production and a manufacturing-and-repair basket — the layer through which women-led units enter this chain.

- **Channel-partner and franchise mandates:** private suppliers and manufacturers benefiting under the scheme must reach 10–12% SHG channel partners within the first two years and 33.3% by policy close. Local sales, franchise and after-sales dealerships are granted only to CLFs, with equipment centrally procured and supplied against demand raised by SHGs and VOs under the CLF.
- **Procurement and fiscal preference:** a 20% reserve and price-preference window for women-led DRE suppliers in state procurement maintained by CREDA; preferential departmental procurement of DRE products and services from women-led enterprises; a five-year state tax holiday for eligible women collectives; stamp-duty and electricity-duty exemptions; and fast-track single-window clearances.
- **Capital for manufacturing units:** ₹360 Cr of tiered capital subsidies; a ₹10 Cr seed fund for women-led DRE enterprises; ~75% first-loss credit guarantee; ₹90 Cr of CLF revolving funds; and interest subvention. The finance annexure maps PMMY Mudra Tarun loans (₹5–10 lakh) to small biomass units and composite loans of ₹10 lakh–₹1 Cr to medium-scale DRE manufacturing units and RIPA common facility centres.
- **Eligibility test:** minimum 51% women ownership and 51% women representation in decision-making bodies with a woman in a key CXO-level position; or promotion and primary management by SHGs, CLFs, FPOs, women's cooperatives, RIPAs or Panchayats. Priority-sector enterprises including MSMEs are a named service tier.
- **Skilling and market access:** the certified Oorja Sakhi cadre, delivered through Skill Council for Green Jobs-empanelled partners, is the existing state vehicle into which the proposed Biomitra bioenergy curriculum can be inserted. Market linkages include branding support and preference for women-led enterprise output at Bihan and NRLM fairs.
- **MGNREGA (now VBGRAM-G) convergence:** civil and ground works — foundations, trenches and sheds — are permitted for DRE productive assets, which is the direct construction route for aggregation depot sheds, storage platforms and pre-processing yards.

4 Rural Markets & the Role of Communities and Panchayats

This value chain has two distinct demand faces. The mandate market (OMC offtake, SAMARTH co-firing, E20 and CBG blending) is large, contracted and distant. The rural market is smaller per transaction but is what makes farm-gate collection worth doing, keeps value inside the village and gives panchayats a revenue reason to host the infrastructure. Both are needed: the mandate market finances the plants, the rural market finances the middle.

Potential rural market	What is traded	Community / panchayat role
Farm-gate feedstock supply	Paddy straw sold above the marginal cost of collection, against a transparent platform price signal	SHG and VO cadres aggregate supply and identify sellers; Gram Sabha-backed social audit of payments builds the trust the price signal depends on
Baling, collection & transport services	Custom-hiring of balers and rakes; short-window post-harvest collection contracts	FPO and SHG enterprises operate equipment financed by MNRE CFA and CLF revolving funds; panchayat coordinates the harvest-window schedule

Depot & storage operations	Storage rental, weighing, quality grading and depot service fees	Panchayat leases common or government land with Gram Sabha approval and earns own-source revenue from joint enterprises; MGNREGA (now VBGRAM-G) (now VBGRAM-G) funds sheds, foundations and platforms
Village & cluster pre-processing	Briquette and pellet manufacture, torrefaction, densification — MNRE CFA at ₹21/₹42 lakh per MTPH	CLF-run units and RIPA Common Facility Centres hold the machines; SHGs supply labour and raise demand; franchise rights sit with the CLF
Rural thermal fuel market	Briquettes and pellets displacing firewood in agro-processing, bakeries, eateries, brick kilns and institutional kitchens	Panchayat acts as market facilitator for women-led DRE products; community and school kitchens provide anchor local demand and support the 40% traditional-biomass reduction target
Cluster energy for enterprises	Heat and power from cluster biomass gasifiers sold to RIPA enterprises and processing hubs	CLFs manage RIPA assets and bill enterprise users; panchayat integrates targets into GPDP under the Gram Urja Swaraj campaign
By-product markets	Biochar and soil amendment, fermented organic manure from CBG plants, livestock-feed adjacencies documented in the FGDs	SHG enterprises package and sell locally; Agriculture Department and panchayat link output to farmer demand and Bihan/NRLM fairs

What panchayats specifically unlock

- **Land and consent:** facilitating land decisions and leasing suitable common or government land to women entrepreneurs with Gram Sabha approval — the precondition for every depot, storage yard and pre-processing unit in this chain.
- **Planning and budget:** mainstreaming projects into GPDP, BPDP and DPDP with allocated lines for depots and Common Facility Centres; formulating women-led projects under Finance Commission grants through Block and Zila Panchayats; setting local energy targets under Gram Urja Swaraj.
- **Revenue and market facilitation:** establishing DRE enterprises in partnership with women-led CBOs to generate panchayat own-source revenue, and acting as market facilitator for women-led bio-energy products and services.
- **Accountability:** Gram Sabha oversight and social audit of feedstock payments and depot operations — the mechanism most likely to close the trust gap that currently keeps farmers out of residue markets.

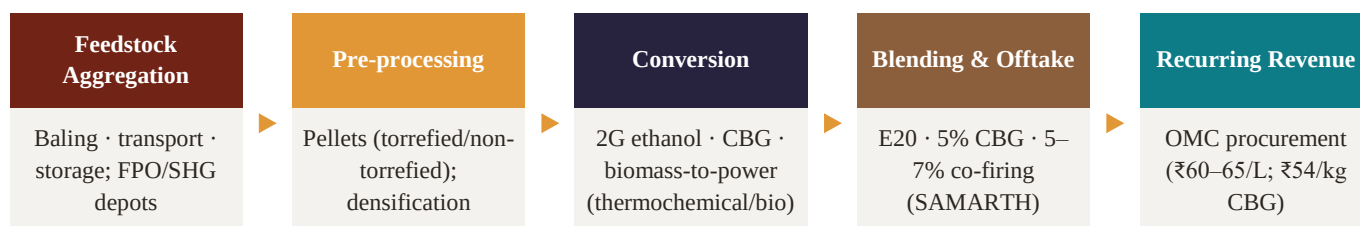
Market Ecosystem for the Bio-energy Value Chain — Rural & Community Anchors

Inputs & Feedstock	10.9 MMT surplus paddy straw · balers & rakes · farm-gate collection · FPO / SHG / VO collection networks · panchayat common land for storage yards
Primary Producers & Manufacturers	Hira Group (biomass power) · 2G ethanol bio-refineries · CBG plants · pellet & briquette manufacturers · CLF-run village pre-processing units
Processing, Logistics & Cluster Infra	Chhattisgarh Biomass Trading Platform · regional aggregation depots & storage hubs · RIPA-CLF Common Facility Centres · cluster biomass gasifiers · decentralised pre-processing
Off-takers & Markets	Mandate markets: OMCs (IOC / BPCL / GAIL) · SAMARTH co-firing · E20 & CBG blending · Rural: briquettes for clean cooking · agro-processing thermal · CBG for local transport · biochar & FOM
Supporting Enablers	DWEEPTI Yojana (DoPR · Bihan-CGSRLM) · CLFs · Gram Panchayats · National Biofuel Policy · PM JI-VAN VGF (≤₹150 Cr) · SAMARTH · MNRE CFA · CBDA · Industrial Policy 2024–29 · MGNREGA convergence

5 Value-Chain Architecture & Market Ecosystem

Crop residue is aggregated, pre-processed into pellets, and converted into 2G ethanol, CBG or biomass power for offtake under the E20, CBG and SAMARTH mandates. Employment and value concentrate in dispersed rural logistics, not at plant sites.

RE Manufacturing (Bio-energy) Value-Chain Architecture

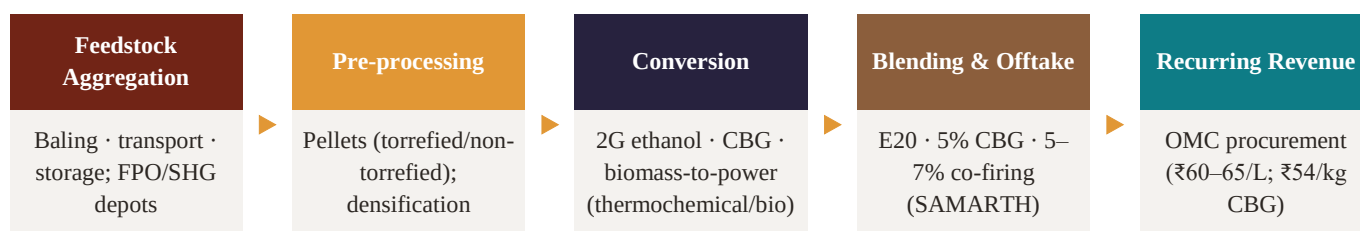


6 Demand–Supply Assessment, Including Community & Rural Dimensions

Supply

- **Feedstock base:** 10.9 MMT/yr of surplus paddy straw; FGDs confirm paddy as the primary crop (70% of cropped area in Sonesarar) and rate availability sufficient — but residue is largely burned for lack of an organised buyer.
- **Rural supply institutions:** 130+ FPOs, ~2.7 lakh SHGs and 580 CLFs form the only realistic aggregation backbone. Collection is a short post-harvest window competing with peak labour demand, and much residue handling falls to women — so payment routing, not just price, decides whether supply materialises: compensation must reach the collecting household or SHG, not only the landholder.
- **Community infrastructure dependency:** depots and storage yards need panchayat common land under Gram Sabha resolution and MGNREGA (now VBGRAM-G) (now VBGRAM-G)-funded civil works. Where these are not sequenced ahead of plant commissioning, feedstock cost stays sub-economic regardless of conversion technology.
- **Cost & capex inputs:** 2G ethanol ₹250–350 Cr/plant (~₹9.09 Cr/KLPD, 7–8-year payback); CBG ~₹100 Cr/plant; biomass power ~₹6 Cr/MW; procurement at ₹60–65/L ethanol and ₹54/kg CBG.

RE Manufacturing (Bio-energy) Value-Chain Architecture



Demand

- **Compliance demand:** E20, 5% CBG and SAMARTH co-firing are legally mandated recurring markets; OMCs (IOC, BPCL, GAIL) act as anchor off-takers de-risking high-capex plants under PPP.
- **Rural and community demand:** a second, closer market exists in briquettes and pellets for institutional and household cooking, thermal loads in agro-processing, bakeries, eateries and brick kilns, cluster gasifier power for RIPA enterprises, CBG for local transport and farm machinery, and by-products — biochar as soil amendment, fermented organic manure and livestock feed. This demand is currently unaggregated, and aggregating it is what makes short-haul collection viable where distances to a bio-refinery are uneconomic.
- **Pivot away from grid power:** CSPDCL's reluctance to sign biomass PPAs in a power-surplus state makes biofuels, CBG and co-firing — markets not requiring DISCOM offtake — the primary tracks.

Supply–demand gaps

- **Missing middle:** no biomass trading platform, no regional aggregation depots or storage hubs, and no farmer-side price signal — the single most critical intervention gap.
- **Farmer and household incentive gap:** a ~15× grain-to-straw price disparity leaves farmers no reason to collect residue; without compensation above the marginal collection cost, routed to whoever actually does the collecting, the supply side does not exist.
- **Rural demand-side gap:** no local market has been organised for briquettes, pellets or by-products, so village-scale pre-processing has no near buyer and the economics default to long-haul supply into distant plants.
- **Workforce gap:** bioenergy lacks a Suryamitra-equivalent skilling programme — the proposed Biomitra curriculum should be delivered through DWEEPTI's Oorja Sakhi cadre and Skill Council for Green Jobs partners rather than built from scratch.

7 Community & Stakeholder Insights

Field evidence draws on Agriculture and Biochar FGDs in Sonesarar (Rajnandgaon) and Sideswar (Kanker), March 2026, plus a CREDA in-depth interview — surfacing paddy-residue availability, current stubble burning, farmer willingness to aggregate, and FPO/SHG capacity.

Stakeholder group	Ground insights & core needs	Recommended action (DWEEPTI-aligned)
Farmers (Sonesarar & Sideswar FGDs)	Paddy dominant (70% of cropped area in Sonesarar); residue burning common; biomass availability rated sufficient; no organised buyer and a ~15× grain-to-straw price gap.	Establish a Chhattisgarh Biomass Trading Platform with a transparent price signal and farmer-side compensation above the marginal cost of straw collection, with Gram Sabha social audit of payments.

FPOs, SHGs, VOs & CLFs	130+ FPOs and numerous SHGs form the feedstock-aggregation and logistics backbone; CLFs can hold assets and franchise rights.	Channel MNRE CFA (balers, rakes, storage) through FPOs and SHGs as institutional aggregators; seat pre-processing units and franchise rights with CLFs under DWEEPTI's manufacturing provisions.
Gram Panchayats & Gram Sabhas	Depot siting, land access and local demand aggregation currently have no institutional owner in this value chain.	Lease common land for depots with Gram Sabha approval; allocate GPDP lines and MGNREGA (now VBGRAM-G) (now VBGRAM-G) civil works; act as market facilitator and earn own-source revenue from joint enterprises.
OMCs (IOC / BPCL / GAIL) — anchor off-takers	₹700 Cr committed (BPCL/GAIL CBG at Raipur and Bhilai) and a proposed 500 KLPD IOC ethanol plant — guaranteed offtake de-risks high-capex projects.	Structure PPP offtake guarantees; sequence OMC anchor plants with FPO and CLF-based feedstock supply so depots exist before commissioning.
CREDA / CBDA (state institutions)	Biomass-to-energy rolling with forest-area grid issues; CSPDCL reluctant on biomass PPAs; CBDA is state nodal for biofuels.	Pivot to biofuels, CBG and co-firing needing no DISCOM offtake; use CBDA single-window clearance and embed the bio-economy in Industrial Policy 2024–29.
Workforce (Biomitra skilling)	No Suryamitra-equivalent bioenergy skilling exists — a binding quality constraint on the 8,988+ FTE potential.	Launch a Biomitra / Jaiv-Urjamitra curriculum across aggregation, pre-processing and plant O&M, delivered through the Oorja Sakhi cadre and SCGJ-empanelled partners.

8 Triple-Bottom-Line & Feasibility

- **Economic:** two revenue tracks — one-time capex (₹2,122 Cr biomass power; ₹250–350 Cr per 2G plant; ~₹100 Cr per CBG plant) and recurring biofuel revenue (₹700+ Cr/yr), with 2G ethanol paying back in 7–8 years and OMC offtake de-risking the capex. The decisive economic variable is feedstock logistics cost, not conversion technology: the trading platform, depots and a local by-product market are what make plant economics work.
- **Social:** the largest employment multiplier in the RE portfolio — 8,988+ FTEs in dispersed rural aggregation, baling, transport, storage and pre-processing across the paddy belt, making this the strongest Just Transition livelihood instrument available. Monetising residue converts a burned liability into farm-gate income, and DWEEPTI's channel-partner and procurement mandates direct a defined share of that value to women-led enterprises.
- **Environmental:** diverting the 10.9 MMT straw surplus abates stubble burning — cutting black carbon, methane and N₂O — while biomass energy substitutes fossil fuel on a carbon-neutral basis. Crop residue becomes fuel, power and, via biochar, soil amendment: a closed rural loop that also supports the 40% reduction in traditional biomass and kerosene use targeted under DWEEPTI.

- **Technical:** biomass power (Hira Group), 2G ethanol, CBG and pellet co-firing are all field-demonstrated. The constraint is logistics and market design, not technology readiness — the trading platform, depots and a Biomitra-skilled workforce are the decisive prerequisites.

9 Success Stories & Proven Models

CASE STUDY 1 • Hira Group Biomass Power (Rajnandgaon) — in-state feasibility proof. Hira Group operates a biomass power plant in Rajnandgaon, one of 2–3 operational biomass plants state-wide, validating the technical and commercial feasibility of biomass energy in Chhattisgarh's paddy-belt context. *Relevance: proof of concept for conversion technology — the scaling gap is the feedstock trading platform and aggregation logistics, and, given CSPDCL's PPA reluctance, a pivot toward biofuels, CBG and co-firing.*

CASE STUDY 2 • OMC anchor commitments (BPCL/GAIL CBG + IOC 2G ethanol) — de-risked PPP offtake. ₹700 Cr is committed by BPCL and GAIL for CBG plants at Raipur and Bhilai, and a 500 KLPD ethanol plant is proposed under an IOC MOU (₹1,500–2,000 Cr), with PM JI-VAN VGF up to ₹150 Cr per project. OMCs act as anchor investors and guaranteed off-takers under a PPP model. *Relevance: the PPP template that de-risks high-capex bio-refineries — the state should sequence OMC anchor plants with CLF and FPO-based feedstock aggregation and the biomass trading platform.*

10 Bottlenecks, Risks & Mitigation

Risk category	Identified risk	Severity	Mitigation strategy
Market / price	Farmer incentive absent (~15× grain-to-straw price gap); stubble burning persists for lack of an organised buyer.	High	Establish the biomass trading platform with a transparent price signal and compensation above collection cost, routed to the collecting household or SHG and social-audited through the Gram Sabha.
Operational / logistics	Bioenergy is logistics-push, not technology-pull; without aggregation depots and storage, plants run at sub-economic feedstock cost.	High	Build regional depots and storage hubs through FPOs, SHGs and CLFs on panchayat land; channel MNRE CFA for balers, rakes and storage and MGNREGA (now VBGRAM-G) (now VBGRAM-G) for sheds and foundations.
Rural demand (new)	No organised local market for briquettes, pellets or by-products, leaving village-scale pre-processing without a near buyer.	Med	Aggregate institutional demand — school and community kitchens, agro-processing, brick kilns — through panchayats as market facilitators; seat CFC pre-processing in RIPA clusters with a captive enterprise load.
Policy / offtake	CSPDCL reluctant on biomass PPAs in a power-surplus state; procurement mandates absent from industrial policy.	Med	Pivot to biofuels, CBG and co-firing needing no DISCOM offtake; embed pellet-sourcing, 2G procurement and CBG offtake mandates in Industrial

			Policy 2024–29 alongside DWEEPTI's 20% women-led supplier window.
Workforce skills	/ No Suryamitra-equivalent bioenergy skilling — a binding quality constraint on the 8,988+ FTE potential.	Med	Launch the Biomitra / Jaiv-Urjamitra programme across aggregation, pre-processing and plant O&M, delivered through DWEEPTI's Oorja Sakhi cadre and SCGJ-empanelled partners.

11 Stakeholder Matrix for Scale — Recommendations & Actions

Stakeholder	Role in scale-up	Recommended action / point for action
Chhattisgarh Biofuel Development Authority (CBDA)	State nodal agency; single-window clearance; MOUs and PPP facilitation	Establish the Chhattisgarh Biomass Trading Platform; sequence OMC anchor plants against depot readiness
Dept. of Panchayati Raj & Rural Development (DWEEPTI nodal)	Scheme anchor; SLSC oversight; PRI enablement and GPDP integration	Notify scheme guidelines covering pre-processing units and CFCs; direct panchayats to allocate land and GPDP lines for depots and storage yards
Bihan / CGSRLM	Mobilisation; CLF enterprise and channel-partner development	Build CLF-run briquette and pellet units and depot enterprises; meet the 10–12% rising to 33.3% SHG channel-partner floor with suppliers
Gram Panchayats & Gram Sabhas	Land, consent, local demand aggregation, market facilitation, social audit	Lease common land for depots; aggregate institutional fuel demand; audit feedstock payments; generate own-source revenue from joint enterprises
MoPNG / OMCs (IOC, BPCL, GAIL)	E20 and CBG blending; anchor investment and guaranteed offtake	Structure PPP offtake guarantees and tie feedstock supply contracts to FPO and CLF aggregators rather than open-market purchase
Ministry of Power / MNRE / PM JI-VAN	SAMARTH co-firing mandate; CFA for cogeneration and pellet plants; 2G VGF	Channel CFA for balers, rakes, storage and pellet capacity through FPO, SHG and CLF aggregators; sustain VGF up to ₹150 Cr per 2G plant
Industries Dept. / Industrial Policy 2024–29	Bio-economy incentives and procurement mandates	Embed local pellet-sourcing mandates, 2G procurement guarantees and CBG offtake commitments; align with the 20% women-led supplier preference window

Agriculture Dept., FPOs, CREDA & CSPDCL	Crop-residue management and farmer aggregation; RE portfolio coordination and biomass-power PPAs	Run residue-collection campaigns in the post-harvest window and link biochar and fermented organic manure back to farmer demand; treat biomass power as residual to biofuels and CBG while maintaining the 20% women-led vendor preference window
Skilling institutions / SCGJ	Workforce development for aggregation, pre-processing and plant O&M	Deliver the Biomitra curriculum through the Oorja Sakhi cadre with placement linkage to OMC anchor plants and CLF enterprises
Banks / SLBC / NABARD	Enterprise and aggregation finance	Deploy PMMY Tarun and composite loans against the DWEEPTI ~75% credit guarantee; accord priority-sector treatment to bio-energy enterprises

12 Methodology & Basis

Employment: 8,988+ direct FTE is an illustrative aggregate = 353.7 MW × 16.24 FTE/MW (~5,744, of which ~3,300 permanent O&M) + ~1,200 per 2G ethanol plant + ~938 per MMT of pellets; realisation depends on the trading platform and aggregation network being built. Market: ₹700+ Cr/yr recurring = ₹570 Cr ethanol + ₹138 Cr CBG at ₹60–65/L and ₹54/kg; ₹2,122 Cr one-time power capex = 353.7 MW × ~₹6 Cr/MW; 2G ethanol ~₹9.09 Cr/KLPD (₹250–350 Cr/plant, 7–8-year payback); CBG ~₹100 Cr/plant. Feedstock: 10.9 MMT surplus paddy straw per year against a 9.51 crore-litre ethanol deficit. Support: PM JI-VAN VGF up to ₹150 Cr/plant; MNRE CFA ₹40 lakh/MW cogeneration and ₹21/₹42 lakh per MTPH for non-torrefied and torrefied pellets. Institutional, manufacturing and financial provisions are drawn from the DWEEPTI Yojana, 2026–2031, as approved by the Government of Chhattisgarh. Field evidence is from Agriculture and Biochar FGDs in Sonesarar (Rajnandgaon) and Sideswar (Kanker), March

Input / Output Flow

Value Chain Flow · RE Component Manufacturing

INPUTS



OUTPUTS

Electricity	Ethanol & CBG	Industrial pellets	Ash & bio-fertiliser
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Source: MNRE, MoPNG, CBDA, BPCL/GAIL

E07 Green Transport

ET · ENERGY TRANSITION

The full lifecycle of sustainable mobility — electric and low-emission vehicles, charging infrastructure, battery manufacturing, and circular-economy battery recycling — that transitions Chhattisgarh's transport system away from fossil-fuel dependence.

1 Executive Dashboard

EXECUTIVE DASHBOARD — GREEN TRANSPORT AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline vs 2035–36 target)

Employment — the ‘job-swap’ paradox. India’s EV sector is projected to generate ~10 million direct and ~50 million indirect jobs by 2030 — but EV manufacturing uses 20–25% fewer workers than ICE lines, in different skill categories. For CG the opportunity is industrial renewal (battery chemistry, power electronics, recycling, charging O&M) contingent on a ‘Great Reskilling’ programme; the source does not assign a state-level FTE count.

Market & Investment Opportunity. Three investment tiers: AC charging (₹20,000–55,000/unit), DC fast charging (₹11–15 lakh/30 kW, PM E-DRIVE ₹2,000 Cr charging fund), and industrial battery recycling (EPR-de-risked). The ₹267.40 Cr PM E-Bus Sewa project (240 buses, 4 cities, GCC @ ₹62.02/km) is the anchor public commitment.

Revenue & Consumer Economics. Economics already favour EVs — a passenger EV saves ~₹3.6 lakh in fuel over five years and commercial e-rickshaws break even in under two years at high utilisation. Circular revenue (material recovery + second-life storage) is de-risked by the BWM Rules 2022 90%-recovery mandate.

Strategic Outcome. An industrial-renewal story, not just a transport one: leveraging CG’s metallurgical base, the BWM Rules 2022 create a regulated ‘urban mining’ market. Highest-leverage moves are charging + swapping infrastructure, a state battery-recycling cluster, and government-fleet demand anchoring.

Methodology & assumptions.^[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Green Transport · Chhattisgarh EV, Charging & Battery Recycling

PM E-BUS SEWA	CHARGING DEFICIT	EV PENETRATION	CONSUMER SAVINGS
₹267.40 Cr	271 stations	15% by 2027	~₹3.6 lakh
240 electric buses across 4 cities (GCC @ ₹62.02/km)	just 1.08% of national total — the single largest bottleneck	CG EV Policy target; aligns to national EV30@30 (30% by 2030)	fuel saved per passenger EV over 5 yrs; e-rickshaw <2-yr breakeven

2 Contextual Overview

National Context

- **Policy push:** the EV30@30 campaign targets 30% EV penetration by 2030; PM E-DRIVE (₹10,900 Cr, incl. ₹2,000 Cr for charging) subsidises e-2W/3W, e-buses and e-trucks; national battery demand is projected at ~600 GWh by 2030.
- **Regulated circular market:** the Battery Waste Management Rules 2022 mandate EPR and require OEMs to recover 90% of battery materials by 2026-27 — creating a guaranteed-feedstock ‘urban mining’ market.

Chhattisgarh Context

- **Clear intent, uneven delivery:** CG EV Policy 2022 targets 15% EV penetration by 2027 with 100% road-tax/registration waivers and purchase subsidy; the ₹267.40 Cr PM E-Bus Sewa (240 buses, 4 cities) is the flagship.
- **Segment performance:** e-3W has exceeded targets (lowest upfront cost), 2W is the fastest-growing segment, 4W is concentrated on the Raipur–Naya Raipur corridor, CNG has not gained traction, and heavy freight remains a Centre–State highway-charging challenge.
- **Industrial fit:** a mineral-rich, metallurgically capable state well-placed to capture EV-component, battery-assembly and battery-recycling value — if the skilling pipeline is fixed in parallel.

3 Demand & Supply Assessment

Supply Analysis

- **Charging base:** only 271 public charging stations (1.08% of the national network) — the single largest bottleneck; the modest 300-station goal is mismatched to penetration targets. CSPDCL grid needs upgrades for concentrated fast-charging loads.
- **Investment inputs:** AC ₹20,000–55,000/unit; DC 30 kW ₹11–15 lakh; battery recycling is industrial-scale and EPR-de-risked; PM E-DRIVE provides ₹2,000 Cr for charging.
- **Industrial base:** industrial land, raw-material supply and logistics are available; the binding supply gap is skilled labour for EV manufacturing, battery handling and charging O&M.

Demand Dynamics

- **Where adoption leads:** 2W and 3W lead on total cost of ownership; government e-bus procurement drives public transport; green freight corridors (Raipur–Bilaspur–Bhilai) are a strategic heavy-duty opportunity.
- **Demand anchor:** phased conversion of government fleets sends a policy signal and builds the operating-data base private adoption needs.

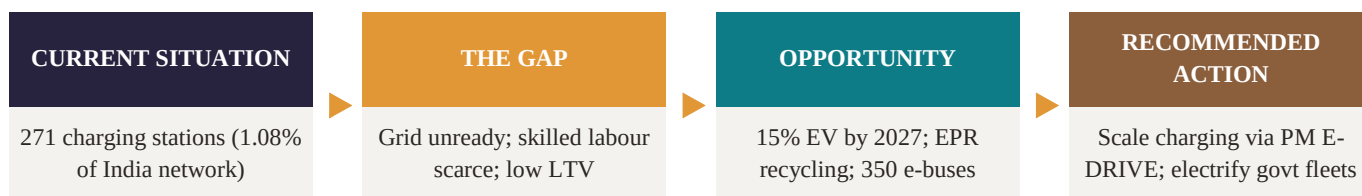
Supply–Demand Gaps

- **Charging deficit:** the 271-station base and utilisation trap deter private charge-point capital — the top constraint.
- **Skilling & financing:** ITI/polytechnic curricula are not industry-ready; high battery-replacement cost and short perceived lifecycle weaken resale value, lowering loan-to-value and raising EV finance rates — a self-reinforcing affordability problem.

- **Structural freight gap:** long-haul trucking needs cross-border highway charging — a Centre–State coordination issue the state cannot resolve alone.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Green Transport

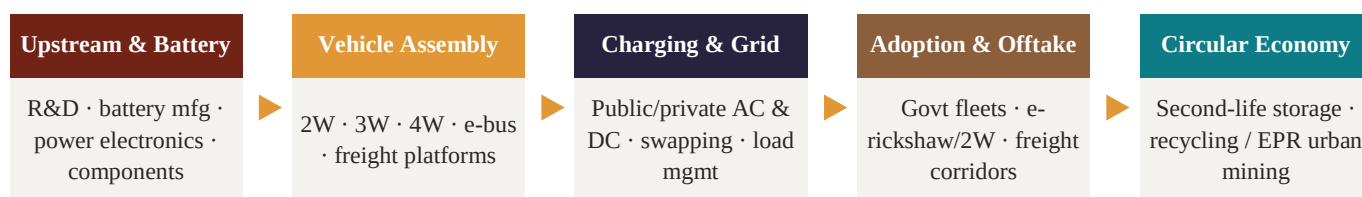


Source: PM E-DRIVE, PM E-Bus Sewa, CSPDCL, SUDA

4 Market Ecosystem for the Value Chain

The Green Transport value chain is a tightly-coupled, four-stage system: upstream R&D, battery manufacturing and power electronics; vehicle assembly (2W/3W/4W/bus/freight); mid-stream charging infrastructure and grid integration; and downstream circular-economy second-life and high-value recycling. Weakness in any one segment — especially charging or grid readiness — constrains the entire chain.

Green Transport Value-Chain Architecture



Market Ecosystem for the Green Transport Value Chain

Inputs & Technology	Batteries · power electronics · EV components · critical minerals · metallurgical base
Producers / Developers	EV OEMs (2W/3W/4W/bus) · battery assemblers · charge-point operators · recyclers
Charging & Grid Infra	AC/DC public charging · battery-swapping · depots · CSPDCL grid integration & load mgmt
Off-takers	Government fleets · e-rickshaw/2W consumers · green freight corridors (Raipur–Bilaspur–Bhilai) · urban transport
Enablers	PM E-DRIVE (₹10,900 Cr; ₹2,000 Cr charging) · CG EV Policy 2022 · BWM Rules 2022 (EPR) · Transport Dept · CREDA · Skill Council

5 Community & Stakeholder Insights

Data note. Green Transport is an urban-mobility and industrial value chain rather than a village-FGD one; stakeholder analysis covers the institutional, market and community-interface actors

across adoption, charging and recycling. Last-mile community roles (demand aggregation, loan co-guarantee, decentralised charging/swapping) are played by ULBs/PRIs, SHGs and CBOs.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Charge-point operators & OEMs	Charging faces a utilisation trap and long payback that deters private capital; 2W/3W adoption is ahead, 4W/freight lag.	Adopt a GCC-for-Charging model with availability payments (PM E-DRIVE ₹2,000 Cr) to crowd in private charging; scale swapping for 2W/3W.
Transport Department (state regulator)	EV Policy 2022 sets 15% by 2027 with tax waivers/subsidy; government fleet is an untapped demand anchor.	Phase-convert all government fleets to electric to signal demand and build the operating-data base for private adoption.
CSPDCL / CREDA (grid & energy)	Grid needs upgrades for concentrated fast-charging; behind-the-meter depot power is centrally funded (₹30.78 Cr).	Sequence grid modernisation and sector coupling (EV + solar) with charging rollout; manage depot BTM power and charging subsidies.
Recyclers (urban mining)	BWM Rules 2022 EPR guarantees battery-material feedstock (90% recovery by 2026-27); CG has metallurgical strengths.	Position CG as a national battery-recycling hub; integrate EPR-backed residual value into bank lending to raise LTV and lower EV finance rates.
ULBs/PRIs + SHGs/CBOs + Skill Council	ITI/polytechnic curricula not industry-ready; community roles in land, demand aggregation and last-mile charging.	Launch a Just Transition ‘Great Reskilling’ programme (ITIs, polytechnics, Skill Council for Green Jobs); use ULBs/PRIs for land and single-window clearance.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Consumer economics favour EVs:** ~₹3.6 lakh fuel saving per passenger EV over five years; e-rickshaw breakeven under two years at high utilisation; the ₹267.40 Cr PM E-Bus Sewa GCC pays operators ₹62.02/km, de-risking participation.
- **De-risked circular revenue:** EPR mandates guarantee battery residual value, underpinning B2B material-recovery and second-life revenue; charging economics need availability payments to escape the utilisation trap. The source assigns no project IRR — ROI would be an analyst estimate.

2. Social Benefits

- **Job-swap paradox:** EV manufacturing needs 20–25% fewer workers than ICE, in different skills — managed only by a Great Reskilling programme into battery chemistry, power electronics, software and recycling/charging O&M.

- **Rural livelihoods:** e-3W/e-rickshaw affordability and decentralised charging/swapping (SHG-run) extend benefits to rural mobility and last-mile enterprise.

3. Environmental & Climate Resilience

- **Air quality & GHG:** electrification targets the severe PM2.5/NOx burden of the Raipur–Durg–Bhilai industrial corridor and abates GHGs while cutting crude-oil import dependence.
- **Circularity:** second-life and high-value recycling close the battery loop under the 90%-recovery mandate.

4. Technical Feasibility

- **Adoption proven in lead segments:** 2W/3W economics are already favourable; the constraint is enabling infrastructure (charging, grid) and skills, not vehicle technology.
- **Binding enabler:** charging + swapping density and grid readiness (sector coupling with solar) are the decisive prerequisites for the whole chain.

7 Success Stories & Proven Models

CASE STUDY 1 · PM E-Bus Sewa in Chhattisgarh (₹267.40 Cr) — GCC-De-risked Public Transport

The ₹267.40 Cr PM E-Bus Sewa project deploys 240 electric buses across four cities (₹236.62 Cr depots + ₹30.78 Cr behind-the-meter power) under a Gross Cost Contracting model paying operators ₹62.02/km — de-risking private participation by separating operations from revenue risk.

Relevance: *the GCC template CG should extend to charging ('GCC-for-Charging' with availability payments) to break the utilisation trap and crowd in private charge-point capital.*

CASE STUDY 2 · BWM Rules 2022 'Urban Mining' — EPR-Guaranteed Recycling Feedstock

The Battery Waste Management Rules 2022 mandate EPR and require OEMs to recover 90% of battery materials by 2026-27, creating a regulated feedstock market for battery recycling — a segment structurally de-risked by guaranteed supply.

Relevance: *CG's metallurgical base positions it to host a national battery-recycling cluster; EPR-backed residual value should also be integrated into bank lending to improve EV-finance LTV and rates (cross-reference EV Battery VC).*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** only 271 public chargers (1.08% national) and a utilisation trap; CSPDCL grid needs upgrades for concentrated fast-charging.

- **Solution:** scale charging via PM E-DRIVE and a GCC-for-Charging availability-payment model; modernise the grid and pursue EV + solar sector coupling; deploy battery-swapping for 2W/3W.

Financial Barriers

- **Barrier:** short perceived battery lifecycle weakens resale, lowering LTV and raising EV-finance rates — a self-reinforcing affordability problem.
- **Solution:** integrate EPR-backed battery residual value into lending frameworks to unlock higher LTV and lower rates; use PM E-DRIVE demand incentives.

Knowledge & Technical Skill Gaps

- **Barrier:** ITI/polytechnic curricula are not industry-ready; the job-swap paradox requires different skills than ICE manufacturing.
- **Solution:** launch a Just Transition Great Reskilling programme (ITIs, polytechnics, Skill Council for Green Jobs) for battery chemistry, power electronics, recycling and charging O&M.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Charging utilisation trap and long payback deter private capital; heavy-freight adoption blocked by cross-border highway-charging gaps.	High	GCC-for-Charging availability payments (PM E-DRIVE ₹2,000 Cr); anchor demand via government-fleet conversion; flag freight charging in Centre-State advocacy.	
Production / Skills	Job-swap paradox — EV manufacturing needs 20–25% fewer, differently-skilled workers than ICE.	Med	Great Reskilling via ITIs/polytechnics and the Skill Council for Green Jobs into future-ready EV/battery roles.	
Operational / Grid	CSPDCL grid needs upgrades for concentrated fast-charging loads; charging density is low (271 stations).	High	Sequence grid modernisation and EV + solar sector coupling with charging rollout; scale AC/DC and swapping.	
Financial / Affordability	Short perceived battery lifecycle lowers resale, LTV and raises EV-finance rates.	Med	Integrate EPR-backed residual value into bank lending; stand up a state battery-recycling cluster to firm residual value.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tiers for CG Deployment

Tier	Focus	Cost / scale	Jobs
Tier 1 · AC Charging	Residential / office / municipal — low-capex, high-volume	₹20,000–55,000 / unit	—
Tier 2 · DC Fast Charging	Range anxiety, freight & inter-city — PM E-DRIVE ₹2,000 Cr fund	₹11–15 lakh / 30 kW	—
Tier 3 · Battery Recycling	Urban mining; EPR-guaranteed feedstock; 90% recovery by 2026–27	Industrial-scale	—

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Scale charging via PM E-DRIVE and GCC-for-Charging; anchor demand through phased government-fleet electrification; position CG as a national battery-recycling/urban-mining hub; launch a Great Reskilling programme; integrate EPR residual value into lending; flag cross-border freight charging in policy advocacy.

Private Sector & Investors

- Invest across AC/DC charging, battery-swapping and industrial recycling; bring EV-component and battery-assembly capacity leveraging CG's metallurgical base; operate under GCC availability payments and EPR-guaranteed feedstock; serve government fleets and freight corridors.

Development Agencies & NGOs

- Support last-mile adoption via SHG/CBO demand aggregation, loan co-guarantee and decentralised charging/swapping; help design the reskilling curriculum and EPR-linked financing; facilitate ULB/PRI land and single-window clearance.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Green Transport Value Chain
Ministry of Heavy Industries (Central)		PM E-DRIVE (₹10,900 Cr; ₹2,000 Cr charging); subsidies for e-2W/3W, e-buses, e-trucks.
MoEFCC / CPCB		Battery Waste Management Rules 2022 — EPR and 90% material recovery by 2026-27.
Chhattisgarh Department	Transport	CG EV Policy 2022; EV registration/permits; road-tax and fee waivers; purchase subsidy.
SUDA / Urban Local Bodies		Urban project implementation; PM E-Bus Sewa depots; land and local coordination.
CSPDCL (State DISCOM)		Grid integration, high-load EV connections, charging-hub power stability, behind-the-meter depot power.
CREDA		Decentralised-energy expertise and EV-charging deployment support; EV + solar sector coupling.

ULBs / PRIs	Land provisioning, permits and single-window clearance for charging infrastructure.
NSDC / Skill Council for Green Jobs	Green-skills curriculum, EV workforce training, Great Reskilling.
Private sector (OEMs, CPOs, recyclers)	Capital investment and operations across vehicles, charging and recycling.
SHGs / CBOs	Last-mile demand aggregation, loan co-guarantee, decentralised charging/swapping.

— Data Integrity & Currency Notes

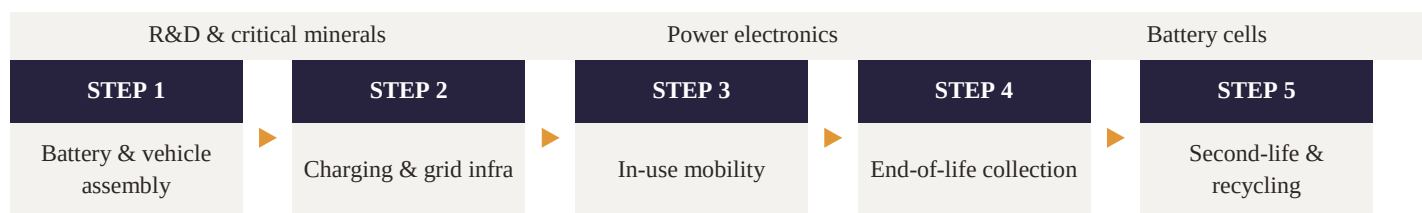
- **Employment is national/qualitative:** the ~10M direct / ~50M indirect figures are national 2030 projections; the source frames CG employment through the ‘job-swap’ paradox and does not assign a state-level FTE count — so the dashboard reports no CG headline job number.
- **Charging-share figures:** 271 stations = 1.08% of the national network at the time of the source; adoption-by-segment statements (e-3W exceeding targets, 2W fastest-growing) are directional field observations.
- **Fast-moving inputs:** charging-station counts, PM E-DRIVE allocations, EV penetration, battery demand and EPR timelines change frequently and may post-date this analysis — verify against MHI/MoEFCC/state primary sources before publication.
- **Analyst additions:** risk severities, the four diagrams and the ROI data-gap note are analytical framing; all quantitative headline metrics originate in the source document.

[1]**Methodology.** Employment: India ~10M direct + ~50M indirect EV jobs by 2030 are national projections; EV manufacturing uses 20–25% fewer workers than ICE (the ‘job-swap’ paradox) — the source does not assign a CG-specific FTE count. Investment tiers: AC charging ₹20,000–55,000/unit; DC 30 kW ₹11–15 lakh; industrial recycling EPR-de-risked; PM E-DRIVE ₹10,900 Cr total (₹2,000 Cr charging). Anchor: PM E-Bus Sewa ₹267.40 Cr (240 buses, 4 cities; ₹236.62 Cr depots + ₹30.78 Cr BTM; GCC @ ₹62.02/km). Consumer: ~₹3.6 lakh/5-yr passenger-EV fuel saving; e-rickshaw <2-yr breakeven. Charging base: 271 stations (1.08% national). EPR: 90% battery-material recovery by 2026-27 (BWM Rules 2022). All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow • Green Transport

INPUTS



OUTPUTS

Clean passenger/freight km	Second-life storage	Recovered Li/Co/Ni
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Source: PM E-DRIVE, PM E-Bus Sewa, CSPDCL, SUDA

E08 Electric Vehicle Battery Manufacturing

ET · ENERGY TRANSITION

The production of Advanced Chemistry Cells (ACCs) and their assembly into battery modules and packs — spanning cell-component processing, cell fabrication, battery-management-system electronics, and pack assembly — increasingly integrated with closed-loop recycled-content feedstock.

1 Executive Dashboard

EXECUTIVE DASHBOARD — EV BATTERY MANUFACTURING AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline is greenfield/zero; figures are the 2030–32 opportunity)

Direct FTE Employment. 3,000–8,000 new direct jobs across battery-pack assembly, BMS electronics, cell-component manufacturing and closed-loop recycled-content integration, plus substantial indirect EV-ecosystem employment. CG's current direct battery-manufacturing employment is zero — the state is entirely greenfield.

Market & Investment Opportunity. ₹1,000–4,000 Cr opportunity envelope over GETM 2026–32 on a realistic Tier-1 + Tier-2 first wave (₹20–200 Cr pack-assembly units and ₹100–1,000 Cr cell-component plants), with a ₹3,000–13,000 Cr full ACC gigafactory (₹225 Cr/GWh) as a later-horizon aspiration.

Revenue & Market Pull. India's battery demand surges from ~40 GWh (2025) to 150–210 GWh (2030); gigafactory capacity reached 68 GWh in 2025 (+40% YoY) with commitments >150 GWh, against ~₹20,000 Cr/yr of battery-storage imports the chain can substitute.

Closed-Loop & Strategic Outcome. The Battery Waste Management Rules recycled-content mandate (5% FY2027-28 → 20% FY2030-31) makes domestically-recovered lithium, cobalt and nickel a regulated input — uniquely pairing CG's proposed Li-ion recycling cluster with cell-component manufacturing (the Tata closed-loop model at regional scale).

Methodology & assumptions.^[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · EV Battery Manufacturing · Chhattisgarh 2026–32 Opportunity Envelope

DIRECT JOBS	INVESTMENT	NATIONAL DEMAND	RECYCLED CONTENT
3,000–8,000	₹1,000–4,000 Cr	40 → 210 GWh	5% → 20%
across pack assembly, BMS, cell-component & recycled-content integration	Tier 1 + Tier 2 first-wave; Tier 3 gigafactory a later-horizon aspiration	India battery demand 2025–2030; capacity 68 GWh (2025, +40% YoY)	BWMR mandate FY2027-28 → FY2030-31 — the closed-loop feedstock lever

2 Contextual Overview

National Context

- **Policy propulsion:** the ₹18,100 Cr ACC-PLI scheme targets 50 GWh domestic cell capacity (30 GWh allocated — Ola 20, Reliance 15, Rajesh Exports 5); supplemented by PM E-DRIVE (₹10,900 Cr, Oct 2024) and customs-duty exemptions on battery inputs, cobalt powder and Li-ion scrap extended to March 2028.
- **The defining structural gap:** most Indian players do pack assembly, not true cell manufacturing — cells and key components (CAM, anode, electrolyte, separator) are still largely China-imported (Exide–SVOLT, Amara Raja–Gotion).
- **Slow localisation:** only 1.4 GWh (2.8% of the 50 GWh target) was commissioned by October 2025 (all Ola); most PLI beneficiaries sought 18-month extensions, citing supply-chain disruption and China dependence.

Chhattisgarh Context

- **Entirely greenfield:** CG hosts no gigafactory, no cell-manufacturing facility and no organised pack-assembly cluster; its EV 2W/3W and e-rickshaw demand is met entirely by out-of-state and imported packs.
- **The closed-loop advantage:** a CG Li-ion Battery Waste Recycling cluster would supply recovered Li/Co/Ni that the recycled-content mandate makes a regulated input — a uniquely integrated recycling-to-manufacturing loop.
- **Supporting fundamentals:** central-India logistics location; mineral-state status; industrial base and power (SAIL Bhilai, NTPC Korba); a fast-growing EV 2W/3W fleet where Li-ion already beats lead-acid on total cost of ownership; and renewable-storage offtake from the USS/WSH/MMG/Rooftop portfolio.

3 Demand & Supply Assessment

Supply Analysis

- **Production base:** zero operational capacity in CG; national capacity 68 GWh (2025) with commitments >150 GWh (Tata Agratas 20, Reliance 30, Amara Raja 16, Exide 12 GWh), but cell manufacturing needs ₹225 Cr/GWh and profitability typically above 8–10 GWh scale.
- **Cost & build inputs:** Tier-1 pack assembly ₹20–200 Cr (12–24-month build); Tier-2 cell-component ₹100–1,000 Cr; Tier-3 ACC gigafactory ₹3,000–13,000 Cr (24–48-month build); working capital ₹5–30 Cr (T1) to ₹300 Cr+ (T3).
- **Recycled-content feedstock:** the domestic LIB recycling cluster's recovered critical minerals become a cost-advantaged, import-substituting input for CG cell-component manufacturing.

Demand Dynamics

- **EV-fleet anchor:** fast-growing electric 2W/3W and e-rickshaw segments — Ola's S1 pack at ~₹45,000 already undercuts lead-acid TCO; three-wheeler packs trending sub-₹50,000 by late 2026.
- **Storage & second-life:** stationary-storage demand from the renewable portfolio (USS/WSH/MMG/Rooftop) and second-life integration add offtake, complementing grid-scale BESS (43.2 GWh under the VGF scheme nationally).

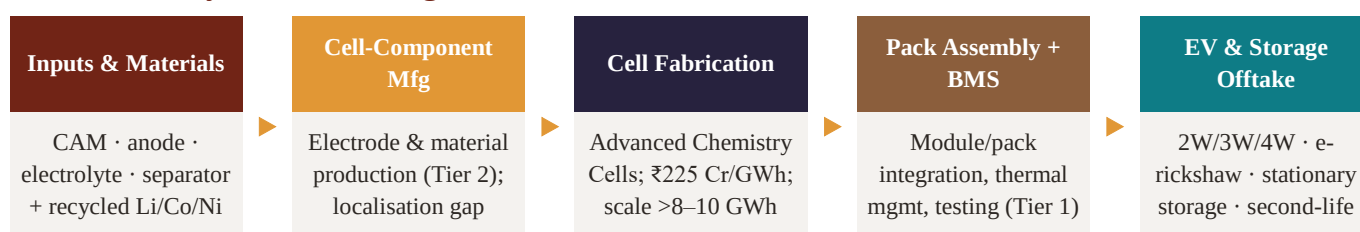
Supply–Demand Gaps

- **Six structural gaps:** (1) zero existing base; (2) no state battery-manufacturing policy; (3) cell-technology dependence on China/national players; (4) scale-economics (profitability >8–10 GWh); (5) EV-demand traction still building (lead-acid 53.2% share in 2025); (6) absent skill base and component supply chain.
- **Clarifying reality:** even the leading PLI beneficiary reached only 1.4 GWh — so CG’s defensible entry is pack assembly + cell-component before frontier cell manufacturing.

4 Market Ecosystem for the Value Chain

EV Battery Manufacturing is the demand-anchor and technology-frontier value chain of the entire battery ecosystem: material and cell-component inputs are fabricated into Advanced Chemistry Cells, integrated into modules and packs with battery-management systems, and supplied to EV and stationary-storage off-takers — with the Battery Waste Management Rules recycled-content mandate closing the loop back to inputs via domestically-recovered critical minerals. It is industrial-scale and coordinated top-down across central, state and industry layers.

EV Battery Manufacturing Value-Chain Architecture



Market Ecosystem for the EV Battery Manufacturing Value Chain

Inputs & Technology	CAM · anode · electrolyte · separator · cells · recycled Li/Co/Ni feedstock · SVOLT / Gotion tech transfer
Producers / Developers	Tata Agratas (20 GWh) · Reliance (30 GWh) · Amara Raja (16 GWh) · Exide (12 GWh) · Ola (Bharat cell)
Processing & Logistics	Pack assembly · BMS electronics · thermal management · welding & testing · central-India distribution
Off-takers	EV 2W/3W/4W OEMs · e-rickshaw fleet · stationary storage (USS/WSH/MMG/Rooftop) · second-life
Enablers	ACC-PLI ₹18,100 Cr · PM E-DRIVE ₹10,900 Cr · BWMR recycled-content · CSIDC · BIS (AIS-156) · Critical Mineral Mission

5 Community & Stakeholder Insights

Data note. EV Battery Manufacturing has no community FGD anchor — it is capital-intensive and industrial-scale (gigafactory / pack-assembly siting). Stakeholder analysis covers the closed-loop integration opportunity, the national manufacturer ecosystem and the staged CG entry;

downstream demand has rural relevance via EV 3W/e-rickshaw fleets and stationary storage for rural electrification.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Tata Agratas + Tata Chemicals (closed-loop integrated group)	₹13,000 Cr / 20 GWh Sanand gigafactory integrated with Tata Chemicals recycling and Tata Motors captive EV demand — the purest closed-loop model.	Court as the primary anchor for a recycled-content-anchored Tier-2 cell-component facility; deploy state capital subsidy + dedicated industrial zone + power-tariff support.
Amara Raja + Exide (technology-transfer players)	Amara Raja ₹9,500 Cr Giga Corridor (Gotion tech, 16 GWh cell + 5 GWh assembly by H1 2027, phased pilot-to-scale); Exide ₹6,000 Cr Bengaluru (SVOLT). Legacy-to-lithium templates.	Pursue technology-transfer partnerships for CG Tier-2 cell-component manufacturing on a phased pilot-to-scale basis.
Ola Electric / Ola Cell Technologies (ACC-PLI pioneer)	Largest 20 GWh allocation; first PLI disbursement ₹73.7 Cr; only firm with commissioned cell capacity (1.4 GWh by Oct 2025); indigenous Bharat cell. Template + cautionary lesson.	Learn from ACC-PLI difficulty — sequence pack assembly and cell-component before frontier cell manufacturing; leverage CG's recycled-content advantage PLI pioneers lacked.
State institutions (CSIDC, Industries, CREDA, Transport)	No state EV/battery-manufacturing policy; CSIDC governs zone allocation and single-window clearance; CREDA mediates stationary-storage/second-life; Transport holds EV-fleet data.	Notify a CG EV & Battery Manufacturing Policy by Q4 2026 (mega-project capital subsidy, industrial zone, power-tariff support, single-window).
CG Li-ion recycling cluster (cross-VC feedstock)	Proposed recycling cluster supplies recovered Li/Co/Ni for the recycled-content mandate (5%→20%) — the distinctive CG input advantage.	Sequence recycling and manufacturing clusters together to realise the integrated recycling-to-manufacturing loop.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Revenue streams:** pack/cell-component sales, ACC-PLI component-linked incentives, PM E-DRIVE and state EV-manufacturing incentives, customs-duty exemptions (to March 2028), and cost-advantaged recycled-content feedstock.
- **Scale-economics — data caveat:** the source does not state a project IRR or payback; cell manufacturing needs 8–10+ GWh for profitability. Any ROI figure would be an analyst estimate requiring a primary cost-and-revenue build-up — hence the staged Tier-1/Tier-2 first wave.

2. Social Benefits

- **Employment breadth:** 3,000–8,000 direct jobs across assembly, BMS, cell-component and integration, plus indirect EV-ecosystem employment, drawing on CG's existing industrial workforce.
- **Rural relevance:** EV 3W/e-rickshaw fleets and stationary storage for rural electrification and solar-rooftop integration extend benefits beyond the industrial cluster.

3. Environmental & Climate Resilience

- **Import substitution & circularity:** domestic manufacturing substitutes ~₹20,000 Cr/yr of imports; the recycled-content loop cuts virgin-mineral extraction and China-import dependence.
- **Clean-mobility enablement:** batteries underpin EV adoption and renewable-energy storage — the storage backbone of the wider energy transition.

4. Technical Feasibility

- **Staged, proven templates:** pack assembly is India-competent today (Tier 1); Amara Raja's phased pilot-to-scale and Tata's vertical integration are field-demonstrated routes for Tier 2.
- **Binding enabler:** technology-transfer partnerships (SVOLT/Gotion-style) and recycled-content feedstock are the decisive prerequisites for CG cell-component ambition.

7 Success Stories & Proven Models

CASE STUDY 1 · Tata Agratas — Integrated Recycling-to-Manufacturing Closed-Loop (₹13,000 Cr / 20 GWh, Sanand)

Tata Agratas (20 GWh Sanand gigafactory) combined with Tata Chemicals (recycling) and Tata Motors (captive EV demand) is India's most complete closed-loop model — recovered critical minerals from end-of-life batteries feed back into new cell production, exactly what the recycled-content mandate incentivises. The Sanand siting was secured through a state-government deal.

Relevance: *CG's proposed Li-ion recycling cluster provides precisely this recycled-content feedstock — CG is uniquely positioned to replicate the Tata closed loop at regional scale via state policy levers.*

CASE STUDY 2 · Amara Raja + Ola — Technology-Transfer Entry and the ACC-PLI Lesson

Amara Raja's ₹9,500 Cr Giga Corridor (Gotion partnership; 2 GWh pilot → 16 GWh cell + 5 GWh assembly by H1 2027) shows the phased, technology-transfer route from lead-acid legacy to lithium. Ola — the largest ACC-PLI allocation (20 GWh) and only firm to commission cell capacity (1.4 GWh) — shows both the captive-demand-anchored indigenous-cell model and the difficulty of cell manufacturing.

Relevance: CG should adopt technology-transfer partnerships and a phased pilot-to-scale approach, sequencing pack assembly and cell-component before frontier cell manufacturing.

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no existing manufacturing base, component supply chain or industrial-zone infrastructure for battery manufacturing in CG.
- **Solution:** earmark a dedicated battery-manufacturing industrial zone with power-tariff support and single-window clearance; co-locate with the Li-ion recycling cluster for feedstock proximity.

Financial Barriers

- **Barrier:** high capex and scale-economics (₹225 Cr/GWh; profitability >8–10 GWh) make greenfield cell manufacturing hard; ACC-PLI disbursements have been slow and condition-heavy.
- **Solution:** stack PM E-DRIVE + state mega-project incentives + AIF/concessional debt on lower-capex Tier-1/Tier-2 first-wave; defer Tier-3 gigafactory until demand aggregation and anchor-investor commitment mature.

Knowledge & Technical Skill Gaps

- **Barrier:** absent battery-manufacturing skill base; cell-manufacturing technology dependence on China and national players.
- **Solution:** build skilling centres (IIT Bhilai, NIT Raipur, battery-technology institutes) for pack assembly, BMS and cell-component work; secure technology-transfer partnerships (SVOLT/Gotion model).

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	EV-demand traction still building (lead-acid 53.2% share in 2025); offtake viability hinges on EV-market growth and the 35%-by-2030 goal.	High	Anchor on fast-growing EV 2W/3W + e-rickshaw where Li-ion already wins on TCO; aggregate stationary-storage and second-life demand.	
Production / Technology	Cell-manufacturing technology dependence on China; localisation (25%→60%) has proven difficult across national players.	High	Pursue technology-transfer partnerships (SVOLT/Gotion); enter via pack assembly + cell-component, not frontier cell manufacturing from a standing start.	
Operational / Supply Chain	Scale-economics (profitability >8–10 GWh; ₹225 Cr/GWh) and	Med	Sequence lower-capex Tier-1/Tier-2 viable at smaller scale; co-locate with recycling	

	absent CG component supply chain and skill base.		cluster; build skilling and supplier depth.
Policy Governance	No notified state policy; ACC-PLI progress slow (1.4 GWh / 2.8% by Oct 2025) with show-cause notices and 18-month extensions.	High	Notify a CG EV & Battery Manufacturing Policy by Q4 2026 with capital subsidy, industrial-zone allocation, power-tariff support and single-window clearance.

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks for CG Deployment

Tier	Focus	Cost / scale	Jobs
Tier 1 • Pack Assembly	Cells → modules/packs + BMS	₹20–200 Cr	100–400 FTE / facility
Tier 2 • Cell-Component	CAM/electrode + recycled content	₹100–1,000 Cr	200–600 FTE / facility
Tier 3 • ACC Gigafactory	Integrated cell mfg (₹225 Cr/GWh)	₹3,000–13,000 Cr	1,000–4,000 FTE / facility

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a CG EV & Battery Manufacturing Policy (Q4 2026) on the Gujarat/Telangana/Karnataka model — mega-project capital subsidy, dedicated industrial zone, power-tariff support, single-window clearance and skilling; position CSIDC/Industries as nodal and CREDA for storage/second-life integration.

Private Sector & Investors

- Bring Tier-1 pack-assembly + BMS facilities (2027–28) and Tier-2 cell-component plants (2029–30) via established manufacturers and technology partners; sign captive/anchor offtake; integrate recycled-content feedstock; access AIF and concessional debt.

Development Agencies & NGOs

- Support state policy design, cross-VC coordination with the Li-ion recycling and renewable-energy VCs, and skilling partnerships (IIT Bhilai, NIT Raipur) for pack assembly, BMS and cell-component competencies.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the EV Battery Manufacturing Value Chain
Ministry of Heavy Industries (Central)		Administers ACC-PLI (₹18,100 Cr) and PM E-DRIVE (₹10,900 Cr); scheme conditions and disbursement.
Ministry of Finance		Customs-duty exemptions on battery inputs, cobalt powder and Li-ion scrap (to March 2028).

MoEFCC / CPCB	Battery Waste Management Rules recycled-content mandate (5%→20%) — the closed-loop feedstock rule.
Ministry of Mines / Critical Mineral Mission	Critical-mineral supply security for cathode materials.
Bureau of Indian Standards	Battery-safety standards (AIS-156, IS 16893).
CSIDC + CG Industries Department	State EV/battery policy, mega-project industrial-zone allocation, capital subsidy, single-window clearance.
CREDA	Stationary-storage and second-life integration with the renewable-energy portfolio.
CG Transport Department	EV-fleet demand data to anchor pack-assembly planning.
IIT Bhilai · NIT Raipur · battery-technology institutes	Skilling for pack assembly, BMS, cell-component and eventual cell manufacturing.

— Data Integrity & Currency Notes

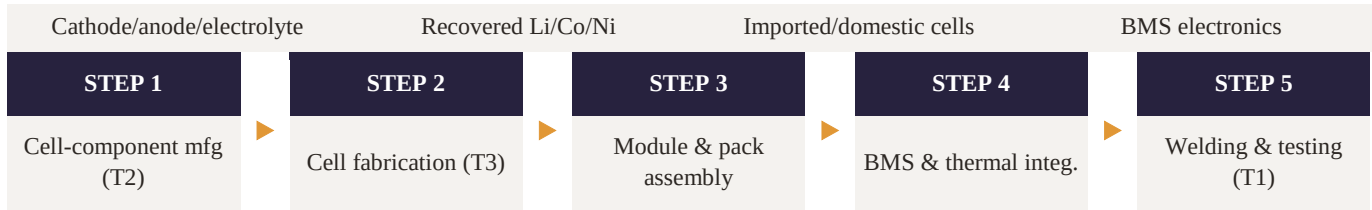
- **Baseline is greenfield/zero:** CG has no operational base — the dashboard shows a 2030–32 opportunity envelope, not a baseline-to-target delta.
- **Job-coefficient basis:** 3,000–8,000 direct is the source’s build-up applying pack-assembly/BMS (100–400 FTE), cell-component (200–600 FTE) and partial cell coefficients to a 1–2-facility first wave — a range, not a point estimate.
- **Fast-moving inputs:** GWh capacity/demand, ACC-PLI progress, pack prices and duty exemptions change frequently and may post-date this analysis — verify against primary sources before publication.
- **Analyst additions:** risk severities, the four diagrams and the ROI data-gap note are analytical framing; all quantitative headline metrics originate in the source document (references [1]–[12]).

[1]**Methodology.** Employment: 3,000–8,000 direct is the source build-up applying pack-assembly/BMS (100–400 FTE/facility), cell-component (200–600 FTE/facility) and partial cell-manufacturing coefficients to a realistic 1–2-facility Tier-1 + Tier-2 first wave over 2026–32, plus indirect EV-ecosystem jobs. Investment: ₹1,000–4,000 Cr reflects Tier-1 pack assembly (₹20–200 Cr) + Tier-2 cell-component (₹100–1,000 Cr); Tier-3 ACC gigafactory is ₹3,000–13,000 Cr at ₹225 Cr/GWh per ACC-PLI norms. Market context: India battery demand ~40 GWh (2025) → 150–210 GWh (2030); capacity 68 GWh (2025, +40% YoY); recycled-content mandate 5% (FY2027-28) → 20% (FY2030-31). All figures originate in the source diagnostic; its endnotes [1]–[12] (ORF, MarqStats, Mongabay, Business Standard, Invest India, MHI) are the primary references. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · EV Battery Manufacturing

INPUTS



OUTPUTS

EV battery packs 2W/3W/4W	Bus & storage packs	Second-life feedstock
---------------------------	---------------------	-----------------------

Source: ACC-PLI, PM E-DRIVE, CSIDC, NITI Aayog

E09 Wind and Solar Hybrid (WSH)

ET · ENERGY TRANSITION

The co-location of wind turbine generators and solar photovoltaic plants at a single site with a common grid interconnection point, optionally paired with battery energy storage systems (BESS) for round-the-clock renewable power supply.

1 Executive Dashboard

EXECUTIVE DASHBOARD — WIND-SOLAR HYBRID AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline is zero installed wind; figures are the 2030–32 opportunity)

Direct FTE Employment. 2,000–5,000 direct jobs across WSH project execution, 1–2 demonstration projects and 200–500 wind-technician/O&M roles — from a base of zero direct WSH employment (CG has never commissioned a single wind turbine). Applies ~8–15 MW/construction-FTE and ~0.5–1.5 MW/O&M-FTE coefficients to the deployment pipeline.

Market & Investment Opportunity. ₹2,000–6,000 Cr opportunity envelope over GETM 2026–32 (a realistic 1–2% national WSH share) across Tier-1 demonstration (₹400–1,500 Cr), Tier-2 grid-scale + BESS (₹1,500–4,000 Cr) and a Tier-3 coal-transition cluster (₹4,000–12,000 Cr).

Resource & Configuration. CG wind is modest — 349 MW at 120m hub rising to 2,749 MW at 150m tall-hub (NIWE iFOREST 2024) — so the strategy is solar-dominant hybrid (5.0–5.5 kWh/m²/day irradiance) with a modest wind component, 150m+ hubs and BESS/PSH pairing at CREDA-identified sites.

Strategic Outcome. WSH is the scale-frontier value chain that pushes CG beyond single-technology solar into co-located, storage-paired 24/7 RE — best deployed at retiring thermal sites (Korba, Surguja, Raigarh) that offer existing evacuation and a Just-Transition workforce.

Methodology & assumptions.[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Wind-Solar Hybrid (WSH) · Chhattisgarh 2026–36 Opportunity Envelope

DIRECT JOBS	INVESTMENT	CG WIND POTENTIAL	SOLAR IRRADIANCE
2,000–5,000	₹2,000–6,000 Cr	349 → 2,749 MW	5.0–5.5
WSH execution + demonstration + wind technician/O&M jobs	demonstration → grid-scale+BESS → coal-transition cluster	NIWE: 120m hub → 150m tall-hub (from zero installed)	kWh/m ² /day — solar-dominant hybrid with modest wind

2 Contextual Overview

National Context

- **Hybrid is the fastest-growing RE segment:** India's non-fossil capacity reached 283.46 GW (Mar 2026); the 160 GW RE pipeline includes 70 GW of hybrid (with/without storage); MNRE's National Wind-Solar Hybrid Policy 2018 has driven 15+ GW issued and 6.26 GW awarded; SECI has executed 60+ GW of PSAs.
- **Global-scale flagships:** Adani's Jaisalmer 2,140 MW is the world's largest operational WSH cluster; the Khavda 30 GW Hybrid RE Park (₹1.5 lakh Cr, completion 2029) is the world's largest single-site park; Engie's SECI 200 MW solar + 100 MW/600 MWh BESS (6-hr storage) is the storage-paired template.

Chhattisgarh Context

- **Zero installed wind:** unlike Gujarat, Rajasthan, Karnataka or Tamil Nadu, CG has not deployed a single grid-scale WSH project; central CREDA project size lags leading states by 1–2 orders of magnitude.
- **Meaningful modest endowment:** 349 MW at 120m rising to 2,749 MW at 150m tall-hub; five CREDA-identified sites (Rajmargharh Bilaspur — wind monitoring since 2005-06; Kameleshwarpur+Rouni Jashpur; Chipani+Kukdur Kabirdham); robust 5.0–5.5 kWh/m²/day solar.
- **Two structural advantages:** coal-transition convergence (retiring thermal sites offer existing evacuation and workforce) and PSH integration (the ~10,000 MW CSPGCL-VAPCOS pipeline is a natural storage-pairing partner).

3 Demand & Supply Assessment

Supply Analysis

- **Production base:** zero installed wind in CG; national developer ecosystem (Adani Green, ReNew, Tata Power RE, Hero Future, Engie) has minimal CG presence. Tall-hub turbines (Vestas V162, Suzlon S133, Siemens Gamesa) unlock the 150m resource.

- **Cost & build inputs:** ₹6–10 Cr/MW (without BESS), ₹8–15 Cr/MW (with BESS); 18–30-month builds; 70:30 debt-equity; SECI hybrid tariffs ~₹2.50–3.00/kWh, storage-paired ~₹3.50–4.50/kWh.
- **Resource shape:** modest wind CUF at conventional hubs is the binding supply variable — resolved by 150m+ hubs paired with high-CUF solar and BESS.

Demand Dynamics

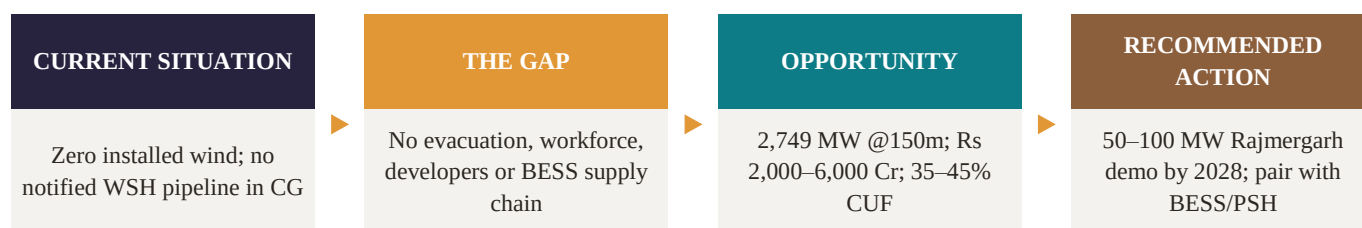
- **Policy-mandate pull:** the unified Renewable Consumption Obligation (June 2025) and RE + BESS ISTS-waiver trajectory (CERC Fourth Amendment 2025) create compliance-driven demand; corporate ESG captive offtake (Mahindra, Reliance, Tata, Adani) adds a market channel.
- **System value:** storage-paired WSH delivers 24/7 RE — the scale-frontier product for CG’s coal-transition districts.

Supply–Demand Gaps

- **Six structural gaps:** (1) zero installed wind; (2) sub-scale CREDA RE financing; (3) absent ISTS evacuation at CREDA sites; (4) non-existent wind workforce/O&M skills; (5) storage economics needing RCO/PSH underpricing; (6) emerging-but-absent BESS supply chain in-state.
- **Tariff-bankability gap:** BESS-paired WSH tariffs (₹3.50–4.50/kWh) exceed CG’s avoided thermal cost (₹3.00–3.80/kWh) — closing this needs RCO compliance and PSH integration.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Wind & Solar Hybrid

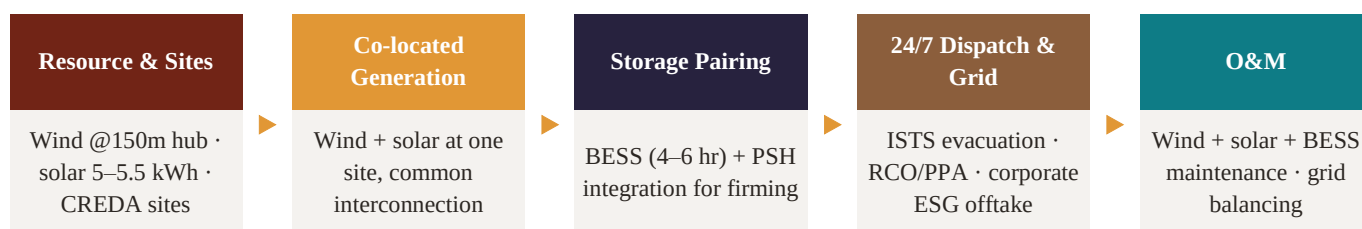


Source: MNRE, NIWE, CREDA, SECI, PFC/REC/IREDA

4 Market Ecosystem for the Value Chain

WSH co-locates wind turbines and solar PV at a single site with a common grid interconnection point, optionally paired with BESS for round-the-clock supply. Upstream is tall-hub turbines, modules and storage; midstream is CREDA-site development, ISTS connectivity and clearances; downstream is O&M and grid balancing. It is capital-intensive and policy-mandate-dependent, with developer pre-commitment and central RE finance dominating economics.

Wind-Solar Hybrid Value-Chain Architecture



Market Ecosystem for the Wind-Solar Hybrid Value Chain

Inputs & Technology	Tall-hub turbines (Vestas V162, Suzlon S133, Siemens Gamesa) · solar modules · BESS · common grid interconnection
Producers / Developers	Adani Green · ReNew · Tata Power RE · AZURE · ACME · Hero Future Energies · Engie India
Development & Grid Infra	CREDA wind sites · ISTS connectivity · retired-thermal evacuation reuse · land · FCA clearance
Off-takers	CSPDCL · RCO compliance · corporate ESG captive (Mahindra/Reliance/Tata/Adani) · coal-transition districts
Enablers	MNRE WSH Policy 2018 · RCO (June 2025) · CERC ISTS waiver · SECI · PFC/REC/IREDA · Just Transition finance (WB/ADB/AfD)

5 Community & Stakeholder Insights

Data note. WSH is policy-mandate-dependent with limited direct FGD anchor (developer pre-commitment and central RE financing dominate). Stakeholder analysis covers the developer/institutional ecosystem, CREDA-identified sites and coal-transition convergence; Jashpur forest FGDs (Sogda — 20 SHGs; Luikona — forest income) are cross-referenced for the Kameleshwarpur+Rouni site's community-institutional readiness. The Bio-Manufacturing IDI supplies transferable cluster-development architecture.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CREDA (state nodal — wind sites)	19-year Rajmergarh wind-monitoring history; five identified sites; sub-scale RE financing lags leading states.	Commission a 50–100 MW WSH demonstration at Rajmergarh by 2028 (150m hub + paired solar + 50–100 MWh BESS) via SECI competitive bidding and PFC/REC/IREDA debt.
National WSH developers (Adani, ReNew, Tata, Engie)	Minimal CG presence relative to Gujarat/Rajasthan; Engie's SECI 200 MW + 600 MWh BESS is the storage-paired template.	Engage developers for a 200–500 MW WSH+BESS grid-scale tender in a coal-transition district (Korba) using the Engie model.

Coal-transition districts (Korba, Surguja, Raigarh)	Retiring thermal sites offer existing grid evacuation and a skilled workforce.	Co-locate a Tier-3 WSH cluster at retiring thermal sites under a Just Transition framework (WB/ADB/AfD financing).
Jashpur forest communities (Sogda/Luikona FGDs)	Strong community-institutional readiness (20 SHGs at Sogda; ₹30–40K/HH/yr forest income at Luikona) around the Kameleshwarpur+Rouni site.	Replicate WSH demonstration at Jashpur/Kabirdham with FCA clearance and SHG-benefit-sharing; use forest-governance institutions for siting mediation.
Grid & storage institutions (CSPTCL/CSPGCL/PSH)	ISTS absent at CREDA sites; PSH pipeline (~10,000 MW) is a natural storage partner.	Sequence ISTS/evacuation with tenders; integrate WSH with PSH + BESS for 24/7 RE under a unified GETM RE strategy.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Bankability levers:** SECI competitive bidding, CERC ISTS waiver, PFC/REC/IREDA concessional debt (up to 70%), green bonds and corporate ESG offtake support economics; Just Transition finance underwrites Tier-3.
- **Tariff-gap caveat:** storage-paired tariffs (₹3.50–4.50/kWh) exceed avoided thermal cost — viability needs RCO compliance and PSH integration; the source states no project IRR, so ROI would be an analyst estimate.

2. Social Benefits

- **Employment & skills:** 2,000–5,000 direct jobs, creating a new CG wind-technician/O&M workforce — best sequenced through coal-transition-district skilling at retiring thermal sites.
- **Community readiness:** Jashpur’s forest-governance institutions (Sogda SHGs, Luikona forest income) provide a benefit-sharing and siting-mediation base at CREDA’s Kameleshwarpur+Rouni site.

3. Environmental & Climate Resilience

- **24/7 clean power:** co-located + storage-paired WSH firms variable RE into round-the-clock supply, deepening decarbonisation beyond daytime solar.
- **Land & siting caution:** Rajmergarh and Kameleshwarpur overlap forest-belt geographies requiring FCA clearance — siting must respect forest and community rights.

4. Technical Feasibility

- **Unlocked by tall hubs:** the jump from 349 MW (120m) to 2,749 MW (150m) shows commercially-available tall-hub turbines can unlock material CG capacity when paired with high-CUF solar and BESS.
- **Binding enabler:** ISTS/evacuation sequencing and storage integration (BESS + PSH) are the decisive technical prerequisites.

7 Success Stories & Proven Models

CASE STUDY 1 · Engie SECI 200 MW Solar + 100 MW/600 MWh BESS — The Storage-Paired Template

Engie won SECI's national tender for a 200 MW solar + 100 MW/600 MWh BESS hybrid providing 6 hours of storage (2028 commissioning) — the operational template for firm, dispatchable hybrid power under competitive bidding and the CERC ISTS-waiver trajectory.

Relevance: *the direct model for CG's Tier-2 200–500 MW WSH+BESS grid-scale tender in a coal-transition district (Korba), leveraging existing thermal-plant evacuation.*

CASE STUDY 2 · Adani Khavda & Jaisalmer (India) — Global-Scale Hybrid Flagships

Adani's Jaisalmer 2,140 MW is the world's largest operational WSH cluster and the Khavda 30 GW park (₹1.5 lakh Cr, completion 2029, ~20 GW solar + ~10 GW wind, 18-million-home target) the world's largest single-site RE park — demonstrating hybrid scale, co-developer ecosystems (TotalEnergies, NTPC Green, SECI) and international finance.

Relevance: *CG's modest resource means it replicates the co-located + storage-paired principle at demonstration and cluster scale, not gigawatt scale — anchored on solar with a modest tall-hub wind component.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** ISTS evacuation is absent at CREDA-identified sites (Rajmergarh, Kameleshwarpur, Chipani), which need fresh transmission capacity.
- **Solution:** co-locate WSH with retiring thermal-plant evacuation in Korba/Surguja/Raigarh under a Just Transition framework; sequence ISTS ahead of generation; extend the CERC ISTS waiver.

Financial Barriers

- **Barrier:** storage-paired tariffs exceed avoided thermal cost; sub-scale CREDA financing lags leading states.
- **Solution:** use RCO compliance and PSH integration to underpin storage economics; stack SECI bidding, concessional debt, green bonds, ESG offtake and Just Transition finance (WB/ADB/AfD).

Knowledge & Technical Skill Gaps

- **Barrier:** wind project-development and O&M skills, and an in-state BESS deployment supply chain, do not yet exist.
- **Solution:** build wind/BESS skilling at coal-transition sites; engage national developers and tall-hub OEMs; link to the emerging domestic Li-ion/BESS supply chain (cross-reference EV Battery VC).

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	BESS-paired WSH tariffs (₹3.50–4.50/kWh) exceed CG avoided thermal cost (₹3.00–3.80/kWh); developer ecosystem has minimal CG presence.	High	Underpin via RCO compliance + PSH integration; use SECI bidding and corporate ESG offtake; extend the ISTS waiver.	
Production / Resource	Modest wind at conventional hubs (349 MW @120m); sub-5.5 m/s across most of the state.	High	Deploy 150m+ tall-hub turbines (2,749 MW @150m) paired with high-CUF solar and BESS at CREDA-identified sites.	
Operational / Supply Chain	No ISTS at CREDA sites; absent wind workforce/O&M and in-state BESS supply chain.	High	Co-locate at retiring thermal evacuation; build wind/BESS skilling; link to the domestic BESS supply chain.	
Policy / Governance	Zero installed wind; no notified WSH pipeline; forest-belt siting (Rajmergarh, Kameleshwarpur) needs FCA clearance.	Med	Anchor CREDA demonstration projects; sequence FCA clearance and community benefit-sharing; integrate under a unified GETM RE strategy.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks for CG Deployment

Tier	Focus	Cost / scale	Jobs
Tier 1 • Demonstration	50–200 MW solar+wind (+BESS)	₹400–1,500 Cr	200–500 constr / project
Tier 2 • Grid-scale + BESS	200–500 MW, 4–6 hr BESS (Engie model)	₹1,500–4,000 Cr	800–2,000 constr / project
Tier 3 • Coal-transition cluster	500–1,500 MW at retiring thermal sites	₹4,000–12,000 Cr	3,000–7,500 constr / cluster

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Commission a 50–100 MW WSH demonstration at Rajmergarh by 2028 and replicate at Jashpur/Kabirdham by 2030; build a 200–500 MW WSH+BESS coal-transition tender (Korba); sequence ISTS/evacuation; integrate WSH with PSH + BESS under a unified GETM RE strategy.

Private Sector & Investors

- Bring tall-hub turbines, solar and BESS via national developers (Adani, ReNew, Tata, Engie) and OEMs; structure SECI-bid projects with concessional debt, green bonds and corporate ESG offtake; anchor Tier-3 clusters at retiring thermal sites.

Development Agencies & NGOs

- Support Just Transition financing (WB/ADB/AfD), coal-transition-district skilling, and forest-community benefit-sharing and FCA-clearance mediation (Jashpur/Kabirdham) using local forest-governance institutions.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Wind-Solar Hybrid Value Chain
MNRE (Central)		National Wind-Solar Hybrid Policy 2018; RE-target framework; NIWE wind resource assessment.
SECI		Tariff-based competitive bidding; hybrid + BESS tenders (Engie template); PSA execution.
CERC		ISTS-waiver regulations (RE + BESS) and connectivity framework.
PFC / REC / IREDA		Concessional debt (up to 70%) for WSH + BESS projects.
CREDA (State Nodal Agency)		Wind-resource assessment (Rajmergarh since 2005-06), site identification, demonstration-project anchoring.
Energy Department, GoCG		WSH policy notification authority; cross-departmental coordination.
CSPDCL / CSPTCL / CSPGCL		Distribution/offtake; STU transmission; state generation and PSH storage-pairing.
Industries Department / CSIDC		Tier-2/3 industrial-zone access and cluster facilitation.
Forest Department		FCA clearance and siting mediation in forest-belt zones (Rajmergarh, Kameleshwarapur).
World Bank / ADB / AfD		Just Transition financing for coal-transition WSH clusters.

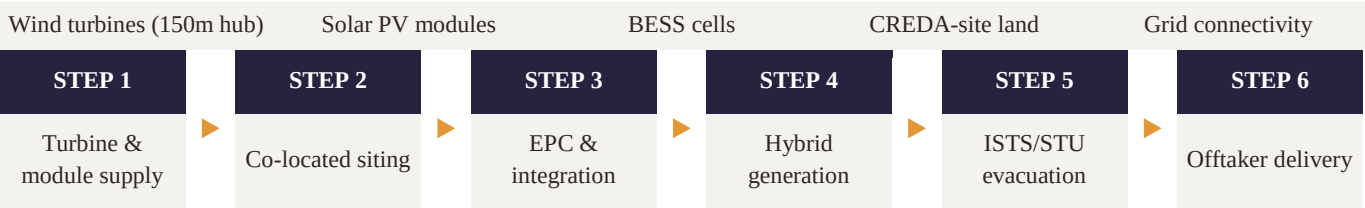
— Data Integrity & Currency Notes

- **Baseline is zero installed wind:** the dashboard shows a 2030–32 opportunity envelope, not a baseline-to-target delta; CG has never commissioned a wind turbine.
- **Resource-figure basis:** 349 MW @120m and 2,749 MW @150m are NIWE iFOREST 2024 reassessment figures; the large scale-up reflects tall-hub technology, not new wind speed.
- **Job-coefficient basis:** 2,000–5,000 direct applies ~8–15 MW/construction-FTE and ~0.5–1.5 MW/O&M-FTE to a 200–500 MW demonstration + 1–2 grid-scale WSH+BESS + one 500–1,500 MW cluster — a range, not a point estimate.
- **Fast-moving inputs & analyst additions:** tariffs, ISTS-waiver terms, national pipeline figures and RCO rules change frequently and may post-date this analysis — verify against MNRE/CERC/SECI primary sources. Risk severities, the four diagrams and the ROI data-gap note are analytical framing; all headline metrics originate in the source (references [1]–[7]).

[1]**Methodology.** Employment: 2,000–5,000 direct applies ~8–15 MW per construction-FTE and ~0.5–1.5 MW per O&M-FTE to a deployment of 200–500 MW demonstration + 1–2 grid-scale 200–500 MW WSH+BESS + one 500–1,500 MW coal-transition cluster over 2026–32. Investment: ₹2,000–6,000 Cr envelope (Tier-1 ₹400–1,500 Cr; Tier-2 ₹1,500–4,000 Cr; Tier-3 ₹4,000–12,000 Cr) at ₹6–15 Cr/MW depending on BESS pairing. Resource: NIWE iFOREST 2024 — 349 MW @120m hub, 2,749 MW @150m tall-hub; solar 5.0–5.5 kWh/m²/day. Tariffs: SECI hybrid ~₹2.50–3.00/kWh; storage-paired ~₹3.50–4.50/kWh vs avoided thermal ₹3.00–3.80/kWh. All figures originate in the source diagnostic and its endnotes (MNRE, S&P Global, SECI, NIWE/iFOREST, CERC). Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

INPUTS



OUTPUTS

Dispatchable RE power	Lower transmission cost	Higher plant load factor
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Source: MNRE, NIWE, CREDA, SECI, PFC/REC/IREDA

E10 Green Hydrogen

ET · ENERGY TRANSITION

Renewable-powered electrolytic hydrogen and its derivatives (ammonia, methanol, e-fuels) — produced via electrolysis of water using renewable electricity with lifecycle emissions below 2 kg CO₂-equivalent per kg of hydrogen — as the long-horizon decarbonisation infrastructure for hard-to-abate industry.

1 Executive Dashboard

EXECUTIVE DASHBOARD — GREEN HYDROGEN AT A GLANCE

(Chhattisgarh · GETM 2026–2036 · baseline is near-zero; figures are the 2030–32 opportunity)

Direct FTE Employment. 500–1,500 new direct jobs by 2030 from a pilot-plus-demonstration-plus-mid-scale deployment (5–50 MW pilot + 50–200 MW mid-scale + electrolyser-component partnership), rising with a Tier-3 coal-transition cluster. Chhattisgarh’s current direct GH₂ employment is effectively zero — there is no operational project in the state.

Market & Investment Opportunity. ₹2,000–5,000 Cr opportunity envelope over GETM 2026–32, based on a realistic 1–2% CG share of the national market. Deployment is structured across three capex tiers — ₹15–150 Cr pilots, ₹750–3,000 Cr mid-scale plants, and ₹7,500–30,000 Cr integrated clusters — spanning electrolyzers, round-the-clock RE feedstock, storage and balance of plant.

Revenue Potential. Anchored on derivative sales validated by the SECI green-ammonia auction at ₹55.75/kg (USD 641/MT, Sep 2025) for 75,000 MT/year to Paradeep Phosphates — with a national pipeline of 13 auctions aggregating 7.24 lakh MT/year. Green-hydrogen production cost is USD 3–5/kg today against a USD 1/kg-by-2030 target; the green premium over grey ammonia (USD 515/MT) has narrowed to ~24%.

Carbon & Strategic Outcome. Green Hydrogen is the long-horizon industrial-decarbonisation value chain that the entire upstream RE portfolio (utility solar + wind-solar hybrid + pumped storage + BESS) ultimately serves. It targets Scope-1/2 abatement at SAIL Bhilai, NTPC Korba and NMDC — CG’s 14+ GW coal-fired, steel and mining base.

Methodology & assumptions.^[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Green Hydrogen · Chhattisgarh 2026–32 Opportunity Envelope

DIRECT JOBS	INDIRECT JOBS	INVESTMENT	DEPLOYMENT
500–1,500	2,000–5,000	₹2,000–5,000 Cr	5 → 2,000 MW
from pilot + demonstration + mid-scale deployment by 2030	across RE + electrolyser supply chains & industrial offtake	opportunity envelope; ~1–2% realistic national GH ₂ share	pilot 5–50 MW → mid-scale 50–200 MW → cluster 500–2,000 MW

2 Contextual Overview

National Context

- **National Green Hydrogen Mission (NGHM):** launched 4 January 2023 with ₹19,744 Cr outlay (₹17,490 Cr SIGHT + ₹1,466 Cr pilots + ₹400 Cr R&D + ₹388 Cr other); targets 5 MMT/year green-hydrogen production by 2030, 125 GW associated RE, ₹1 lakh Cr fossil-import substitution and 50 MMT/year CO₂ abatement.

- **SIGHT programme, on the ground:** 1,500 MW electrolyser manufacturing awarded to 8 firms (Reliance, John Cockerill, Adani/ANIL, Ohmium, L&T, Jindal India, Homihydrogen, Advait) and 862,000 TPA hydrogen-production capacity awarded to 19 firms by 2025. Operational proof-points: Adani's off-grid 5 MW Kutch pilot (Jun 2025) and Deendayal Port's 1 MW port-based plant (Jul 2025).
- **Demand-aggregation works; hubs did not:** SECI's first green-ammonia auction discovered a record-low ₹55.75/kg (Sep 2025), while the SECI Green Hydrogen Hubs proposal was terminated in July 2025 — signalling that direct industrial-offtaker partnerships, not centralised hubs, are the viable pathway.

Chhattisgarh Context

- **Largest hard-to-abate customer base, zero projects:** CG hosts SAIL Bhilai (steel), NTPC Korba (thermal), NMDC Bailadila (mining), 14+ GW coal-fired capacity, and cement/fertiliser units — the natural decarbonisation demand — yet has no operational GH₂ project, no SIGHT awardee with declared CG presence, and no notified state Green Hydrogen Mission.
- **Strong upstream RE fundamentals:** 5.0–5.5 kWh/m²/day solar irradiance; 349 MW wind potential at 120 m (2,749 MW at 150 m, per NIWE/iFOREST 2024); ~10,000 MW pumped-storage potential across 7 CSPGCL–VAPCOS sites — the ingredients for round-the-clock electrolyser feedstock.
- **Just-Transition convergence:** the Korba–Surguja–Raigarh thermal-decommissioning pipeline offers repurposing sites with existing grid evacuation, skilled industrial workforce and concessional financing access (World Bank, ADB, AfD).

3 Demand & Supply Assessment

Supply Analysis

- **Production base:** zero operational GH₂ capacity in CG; the national supply chassis is 1,500 MW awarded electrolyser manufacturing (limited against a ~4 GW/year global manufacturing ceiling vs India's 200 GW-by-2030 target) and 862,000 TPA awarded production.
- **Feedstock supply:** commercial electrolyzers need >80% capacity factor — solar alone gives ~25%, wind ~30–35%, wind-solar hybrid 35–45%, hybrid-plus-storage 80–95% — so supply is contingent on USS + WSH + PSH + BESS build-out (cross-referenced VCs).
- **Cost inputs:** integrated capex ₹15–30 Cr/MW; 24–48-month build periods; working capital ₹5–25 Cr per 50 MW for membrane spares, thermal management and feedstock buffer.

Demand Dynamics

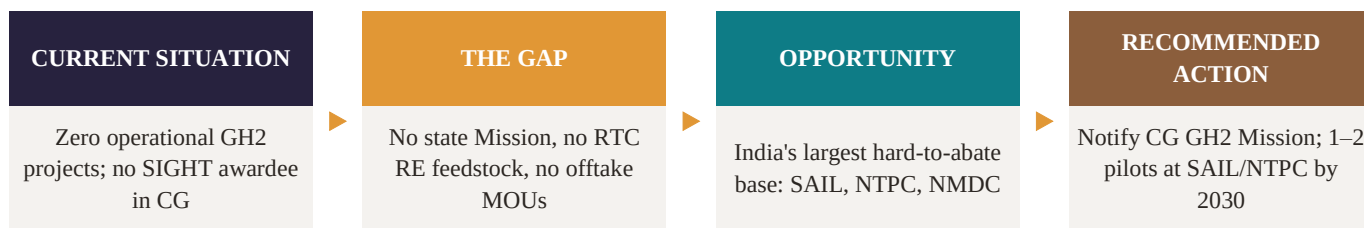
- **Anchor industrial demand:** steel decarbonisation (DRI at SAIL Bhilai replacing grey-hydrogen/natural-gas feedstock), thermal repurposing (NTPC Korba), mining (NMDC), fertiliser and refining — all facing structural Scope-1/2 mandates.
- **Bankable offtake precedent:** the Paradeep Phosphates 10-year fixed-price contract (75,000 MT/year @ ₹55.75/kg) shows demand-aggregation eliminates merchant risk; a 13-auction pipeline aggregates 7.24 lakh MT/year nationally.

Supply–Demand Gaps

- **Six structural gaps:** (1) no notified state Mission; (2) zero operational projects; (3) no SIGHT awardee with CG presence; (4) round-the-clock RE feedstock absent at scale; (5) no industrial-offtaker pre-commitment MOUs; (6) electrolyser-supply dependence on national SIGHT awardees.
- **Tariff-bankability gap:** GH₂ at USD 3–5/kg is still 3–5× grey hydrogen (USD 1.50–2.00/kg); closing it needs either policy-mandated consumption or offtaker willingness to pay the green premium.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Green Hydrogen

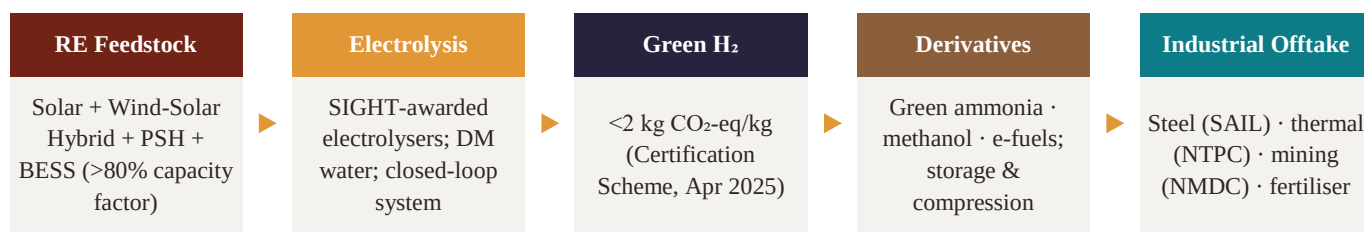


Source: MNRE NGHM, SECI, SIGHT

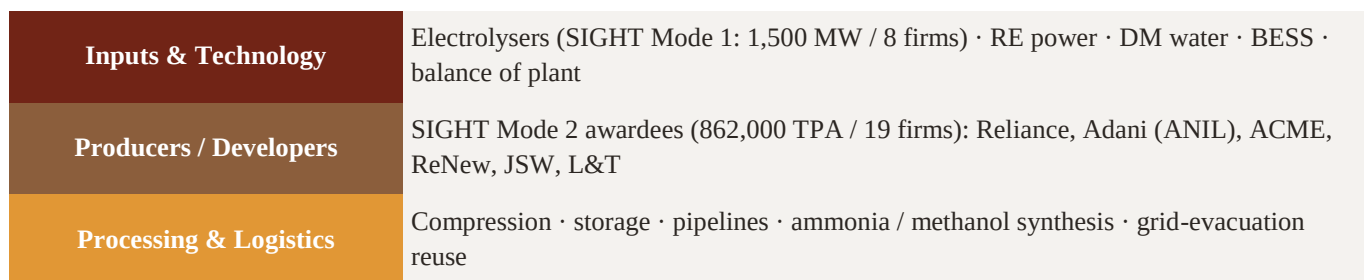
4 Market Ecosystem for the Value Chain

The Green Hydrogen value chain is a capital-intensive, policy-mandate-dependent ecosystem: renewable feedstock is converted through electrolysis into certified green hydrogen and its derivatives (ammonia, methanol, e-fuels), then supplied to hard-to-abate industrial off-takers. Unlike community-anchored VCs, it is sited at industrial locations and coordinated top-down across central, state and developer/offtaker layers.

Green Hydrogen Value-Chain Architecture



Market Ecosystem for the Green Hydrogen Value Chain



Off-takers	SAIL Bhilai (steel) · NTPC Korba (thermal) · NMDC (mining) · fertiliser & cement units · refineries
Enablers	NGHM / SIGHT (₹19,744 Cr) · SECI · GH ₂ Certification · CREDA · IREDA/PFC/REC · Just Transition finance

5 Community & Stakeholder Insights

Data note. *Green Hydrogen is the one GETM value chain with no community FGD anchor — it is purely industrial and policy-mandate-dependent. Stakeholder analysis therefore covers industrial off-takers, SIGHT awardees and institutional agencies rather than village-tier producers.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Anchor industrial off-takers (SAIL Bhilai, NTPC Korba, NMDC)	Face Scope-1/2 mandates but have signed no GH ₂ procurement MOUs; need bankable, fixed-price offtake before committing to green-steel/thermal-repurposing pathways.	Broker pre-committed offtake MOUs (target 100,000–300,000 MT/year cumulative); replicate the SECI Mode-2A fixed-price contract structure at CG tier.
National SIGHT awardees (Reliance, ANIL, ACME, ReNew, JSW, L&T)	Hold 1,500 MW electrolyser + 862,000 TPA production allocations but have minimal declared CG presence.	Actively court a SIGHT-awardee CG deployment by 2028–30 with dedicated industrial-zone allocation and state capital subsidy.
SECI (NGHM Implementing Agency)	Ran the record-low Sep-2025 green-ammonia auction; the demand-aggregation mechanism is proven and replicable.	Request a CG-anchored Mode-2A green-ammonia/hydrogen auction with SAIL/fertiliser/refinery off-takers by 2028–30.
State institutions (CREDA, Energy Dept, CSIDC, Industries Dept)	CG state architecture is under-developed for GH ₂ ; CREDA has not committed to hydrogen specifically; no state Mission, subsidy or zone allocation exists.	Notify a CG State Green Hydrogen Mission by Q4 2026 with nodal roles, capital subsidy and industrial-zone earmarks.
Cross-VC RE developers (USS, WSH, PSH, BESS)	Round-the-clock feedstock is the binding technical constraint; solar-only capacity factor (~25%) is far below the >80% electrolyzers require.	Sequence GH ₂ with upstream RE VCs to deliver firm hybrid-plus-storage supply at electrolyser sites.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Revenue streams:** derivative sales (green ammonia/methanol), SIGHT Mode-2 production incentive (₹50/kg Yr-1 → ₹40 Yr-2 → ₹30 Yr-3), 30–50% pilot capex subsidy from the ₹1,466 Cr NGHM pilot pool, and Just-Transition concessional debt.
- **Payback / IRR — data gap:** the source does not state a payback timeline or IRR. GH₂ remains 3–5× grey-hydrogen cost, so viability is contingent on subsidy, offtake price and RE-feedstock cost — none reconciled into a project IRR in the document. Any ROI figure would be an analyst estimate requiring a primary cost-and-revenue build-up before investor use.

2. Social Benefits

- **Just-Transition livelihoods:** co-location at Korba/Surguja/Raigarh converts a retiring coal workforce into electrolyser O&M, construction and derivative-plant roles — 500–1,500 direct and 2,000–5,000 indirect jobs, stabilising coal-dependent district economies.
- **Skilling:** a CG Hydrogen Valley Innovation Cluster (with IIT Bhilai, NIT Raipur, BIT Durg, CSIR-AMPRI) would seed electrolyser-O&M and hydrogen-safety skills locally.

3. Environmental & Climate Resilience

- **Deep decarbonisation:** green hydrogen (<2 kg CO₂-eq/kg under the April-2025 Certification Scheme) abates Scope-1/2 emissions in steel, thermal, mining and fertiliser — sectors with no other viable decarbonisation route.
- **Resource caution:** electrolysis is water-intensive; siting must account for DM-water availability and competing demand — a constraint the source flags implicitly through its feedstock focus.

4. Technical Feasibility

- **Proven template:** Adani's off-grid 5 MW Kutch pilot (solar + BESS + closed-loop electrolyser) is a field-demonstrated architecture directly transferable to CG coal-transition sites.
- **Binding enabler:** round-the-clock RE via WSH + PSH + BESS to reach >80% electrolyser utilisation is the decisive technical prerequisite.

7 Success Stories & Proven Models

CASE STUDY 1 · Adani (ANIL) Kutch — India's First Off-Grid 5 MW Green Hydrogen Pilot (Jun 2025)

ANIL commissioned India's first off-grid 5 MW green-hydrogen pilot at Kutch, Gujarat — 100% solar-powered with BESS integration and a fully automated, closed-loop electrolyser that responds dynamically to real-time renewable inputs. It is part of ANIL's 5 GW cumulative electrolyser-manufacturing target (USD 3 bn under SIGHT).

Relevance: *the direct template for a Tier-1 demonstration pilot in CG — a 5–10 MW off-grid plant at NTPC Korba or SAIL Bhilai, using CG’s 5.0–5.5 kWh/m²/day irradiance, is the concrete near-term ask.*

CASE STUDY 2 · SECI–Paradeep Phosphates — India’s First Green-Ammonia Demand-Aggregation Auction (Sep 2025)

SECI’s first Mode-2A green-ammonia auction discovered a record-low ₹55.75/kg (USD 641/MT) for 75,000 MT/year supplied to Paradeep Phosphates, Odisha, on a 10-year fixed-price contract — down from ₹100.28/kg (H2Global 2024) and only ~24% above grey ammonia (USD 515/MT). It is the first of 13 auctions aggregating 7.24 lakh MT/year.

Relevance: *the demand-aggregation blueprint for CG — a state-anchored auction with SAIL, fertiliser and refinery off-takers can convert scattered industrial demand into bankable, fixed-price offtake.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** round-the-clock RE feedstock is absent at scale; electrolyzers idle without firm hybrid-plus-storage power, and derivative logistics (storage, compression, pipelines) are undeveloped in CG.
- **Solution:** sequence GH₂ deployment behind USS + WSH + PSH + BESS build-out; prioritise coal-transition sites that already have grid evacuation and skilled workforce.

Financial Barriers

- **Barrier:** very high upfront capex (₹15–30 Cr/MW), 24–48-month builds, and a persistent green premium make merchant offtake unbankable; central hub-tier aggregation (SECI Hubs) has already been terminated.
- **Solution:** stack SIGHT Mode-2 incentives, NGHM pilot capex subsidy (30–50%) and Just-Transition concessional debt (World Bank/ADB/AfD/EIB) against fixed-price anchor offtake to close the bankability gap.

Knowledge & Technical Skill Gaps

- **Barrier:** no state-level electrolyser O&M workforce, hydrogen-safety standards or application R&D; electrolyser supply depends entirely on national SIGHT awardees.
- **Solution:** establish the CG Hydrogen Valley Innovation Cluster (2028–30) with IIT Bhilai, NIT Raipur, BIT Durg and CSIR-AMPRI for O&M training, safety standards, and SIGHT-awardee technology transfer.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	GH ₂ remains 3–5× grey-hydrogen cost; without policy-mandated or fixed-price offtake, merchant sales are unbankable.	High	Anchor SECI Mode-2A fixed-price offtake with SAIL/fertiliser/refinery; stack SIGHT Mode-2 incentive to underprice the green premium.	
Production / Climate	Electrolysers need >80% capacity factor; solar-only (~25%) and intermittency make firm feedstock the binding constraint; electrolysis is water-intensive.	High	Integrate USS + WSH + PSH + BESS for round-the-clock supply; site with DM-water availability assessed upfront.	
Operational / Supply Chain	Global electrolyser manufacturing (~4 GW/yr) lags India's 200 GW-by-2030 target; CG has no local supply or O&M workforce.	Med	Partner SIGHT awardees for technology transfer + CG-anchored deployment; front-load Hydrogen Valley Cluster skilling.	
Policy / Governance	No notified state Mission, subsidy or zone allocation; central hub aggregation (SECI Hubs) terminated Jul 2025, raising execution uncertainty.	High	Notify the CG State Green Hydrogen Mission by Q4 2026 with nodal roles, capital subsidy, industrial-zone earmarks and offtaker-MOU targets.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk (three are named as 'execution-defining'); they are directional, not quantified.

Three Investment Tracks for CG Deployment

Tier	Focus	Cost / scale	Jobs
Tier 1 • Demonstration	1–10 MW pilot, co-located with offtaker	₹15–150 Cr	50–150 constr + 8–20 O&M
Tier 2 • Mid-scale	50–200 MW industrial decarbonisation	₹750–3,000 Cr	300–800 constr + 50–150 O&M
Tier 3 • Cluster	500–2,000 MW coal-transition cluster	₹7,500–30,000 Cr	1,500–4,000 + 1,000–3,000 indirect

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify the CG State Green Hydrogen Mission (Q4 2026); position CREDA/CSIDC/Energy Dept as nodal; earmark industrial zones and state capital subsidy; direct CSPDCL/CSPTCL for grid integration and Green Open Access enablement.

Private Sector & Investors

- Deploy Tier-1 pilots and Tier-2 mid-scale plants via SIGHT awardees (Reliance/ANIL/ACME/L&T); bring electrolyser technology, capital and vertically-integrated developer models; sign anchor offtake with SAIL/NTPC/NMDC; access IREDA/PFC/REC debt.

Development Agencies & NGOs

- Channel Just-Transition financing (World Bank/ADB/AfD/EIB) into coal-district repurposing; mobilise skilling through the Hydrogen Valley Cluster; support state Mission design and cross-VC coordination with upstream RE VCs.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Green Hydrogen Value Chain
MNRE (Central)		Administers NGHM (₹19,744 Cr) and SIGHT (₹17,490 Cr); Green Hydrogen Certification Scheme; pilot capex subsidy.
SECI (Implementing / Central Nodal Agency)		Runs electrolyser (Mode-1), production (Mode-2) and green-ammonia (Mode-2A) auctions; demand-aggregation counterpart for a CG-anchored auction.
CG Energy Department + CSIDC + Industries Dept		State Mission notification, industrial-zone allocation, capital subsidy, nodal coordination.
CREDA (State Nodal RE Agency)		Round-the-clock RE feedstock coordination; state RE-portfolio integration (currently uncommitted to GH ₂ — the key gap to close).
CSPDCL / CSPTCL / CSPGCL		Grid integration, evacuation, Green Open Access enablement for captive electrolyser power.
SAIL Bhilai · NTPC Korba · NMDC		Anchor industrial off-takers for green steel, thermal repurposing and mining decarbonisation.
IREDA / PFC / REC / SBI		Concessional and specialised debt for GH ₂ and derivative projects.
World Bank / ADB / AfD / EIB		Just-Transition concessional financing for coal-district GH ₂ repurposing.
IIT Bhilai · NIT Raipur · BIT Durg · CSIR-AMPRI		CG Hydrogen Valley Innovation Cluster — O&M training, safety standards, application R&D, technology transfer.

— Data Integrity & Currency Notes

- **Baseline is genuinely zero:** unlike capacity-based VCs, CG has no operational GH₂ base — the dashboard therefore shows a 2030–32 opportunity envelope, not a baseline-to-target delta.
- **Job-coefficient basis:** the 500–1,500 direct range is the source’s own build-up from typical 5–10 MW/direct-construction-FTE and 50–200 MW/permanent-O&M-FTE coefficients across pilot + mid-scale + manufacturing partnership — a range, not a point estimate.

- **Fast-moving inputs:** GH₂/grey-hydrogen costs, the USD 1/kg-by-2030 trajectory, SIGHT incentive tapers and Sep-2025 auction prices change frequently and may post-date this analysis — verify against primary sources before publication.
- **Analyst additions:** risk severities, the four diagrams, and the ROI data-gap note are analytical framing; all quantitative headline metrics originate in the source document, whose own references [1]–[12] should be cited for external use.

[1]**Methodology.** Employment: 500–1,500 direct jobs is the source build-up applying ~5–10 MW/direct-construction-FTE and ~50–200 MW/permanent-O&M-FTE coefficients to a 5–50 MW pilot + 50–200 MW mid-scale + electrolyser-component-manufacturing partnership over 2026–32, with 2,000–5,000 indirect across RE and electrolyser supply chains. Investment: ₹2,000–5,000 Cr reflects a realistic 1–2% CG share of the national market, decomposed into three capex tiers — Tier 1 ₹15–150 Cr (₹15 Cr/MW), Tier 2 ₹750–3,000 Cr, Tier 3 ₹7,500–30,000 Cr. Tariff economics: green ammonia ₹55.75/kg (USD 641/MT, SECI Sep-2025) vs grey ammonia USD 515/MT (Mar-2025); GH₂ USD 3–5/kg today vs USD 1/kg-by-2030 target. All figures originate in the source diagnostic; the source’s own endnotes [1]–[12] (PIB, MNRE/SECI, IEEFA, OECD, Adani/Reliance releases) are the primary references. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Green Hydrogen

INPUTS



OUTPUTS

Green hydrogen	Green ammonia	Methanol / e-fuels	Oxygen (by-product)
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Source: MNRE NGHM, SECI, SIGHT

E11 Floating Solar Photovoltaics (FSPV)

ET · ENERGY TRANSITION

Solar photovoltaic installations mounted on engineered buoyant platforms anchored to water bodies — hydro reservoirs, industrial ponds and select village water bodies — providing land-neutral, hydropower-complementary generation.

1 Executive Dashboard

EXECUTIVE DASHBOARD — FLOATING SOLAR (FSPV) AT A GLANCE (Chhattisgarh · GETM 2026–2036 · baseline vs 2030–36 target)

Direct FTE Employment. ~1,700–2,700 long-term FTEs on a 500–800 MW build-out at the CEEW coefficient of ~3.36 FTE/MW — almost 4× ground-mount solar (0.87 FTE/MW). 62% of jobs are construction-phase and 60% semi-skilled (anchoring, mooring, marine-grade installation), creating a new ‘floating-solar fabricator/installer’ workforce category.

Market & Investment Opportunity. ₹2,850–4,560 Cr pipeline for 500–800 MW at ~₹5.7 Cr/MW (a 20–25% premium over ground-mount that is shrinking ~2.5%/yr). Land-neutral, no agricultural-displacement risk, and it exploits existing hydro-reservoir evacuation infrastructure.

Revenue & System Value. Recent FSPV tariffs range ₹3.21–4.15/kWh nationally (CG likely ₹3.50–4.00/kWh for hydro-co-located); LCOE projected ₹3.72/kWh by 2030. Hydro-FSPV co-location addresses the ~3,000 MW day-night PV gap — ‘solar by day, hydro by night, same reservoir, same line’.

Water & Carbon Outcome. ~700 million m³ of evaporation prevented and ~1.0–1.6 MT CO₂/yr avoided at 500 MW (~1,395 m³/MWp and 28,330 tCO₂/yr at Maroda-1) — evaporation savings with direct fiscal value to state irrigation budgets.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Floating Solar (FSPV) · Chhattisgarh 2026–36

FSPV CAPACITY	INVESTMENT	LONG-TERM FTE	WATER + CARBON
15 → 500–800 MW	₹2,850–4,560 Cr	1,700–2,700	~700 M m³
hydro reservoirs, industrial ponds & select village water bodies	at ~₹5.7 Cr/MW; LCOE → ₹3.72/kWh by 2030	at 3.36 FTE/MW (CEEW) — ~4× ground-mount; 60% semi-skilled	evaporation prevented + ~1.0–1.6 MT CO ₂ /yr avoided at 500 MW

2 Contextual Overview

National Context

- **Large technical potential:** 206.7 GWp technical potential (Indo-German IN Solar/GIZ); TERI 2025 reassesses ~100 GW practical (55 GW reservoirs, 37 GW tanks/ponds, 8 GW aquaculture); ~600–700 MW commissioned + ~1 GW under construction nationally.
- **Policy templates exist:** Odisha issued FSPV-specific guidelines (January 2025) and Telangana a reservoir-allocation mechanism — the most evolved Indian templates for the overlapping water-body jurisdiction FSPV requires.

Chhattisgarh Context

- **A structural advantage no state matches as cleanly:** large hydro reservoirs (Hasdeo Bango 120 MW, Gangrel 10 MW, Tandula, Maroda) each a ready-built FSPV anchor with existing transmission — plus captive industrial ponds and thousands of village ponds.
- **Proven in-state:** the 15 MW SAIL-Bhilai Maroda-1 (NTPC-SAIL JV/NSPCL) on a 2.1 sq km reservoir generates ~34.26 MU/yr captive for Bhilai Steel and avoids ~28,330 tCO₂/yr — the state's first and only commissioned FSPV.
- **Hydro complementarity (CREDA IDI):** co-location resolves the ~3,000 MW day-night PV gap; the retired Chief Engineer's framing that 'FPV and hydropower are natural allies' is the deployment pathway the policy should codify.

3 Demand & Supply Assessment

Supply Analysis

- **Installed base:** 15 MW (Maroda-1); NTPC has additional FSPV planned at Korba and other CG sites. Upstream supply: modules (52.6% of capex), HDPE pontoons, anchoring/mooring, marine cabling, inverters (Floatex, Tata, Vikram, AMPIN).
- **Cost & tariff inputs:** ~₹5.7 Cr/MW (2024), premium shrinking; LCOE ₹3.72/kWh by 2030; recent tariffs ₹3.21–4.15/kWh; hydro co-location cuts per-MW evacuation cost.
- **Deployable-potential filters:** the 500–800 MW target is filtered by reservoir surface availability, the CEEW 40% maximum-coverage biodiversity threshold, and the 25 km / 132 kV substation-distance constraint.

Demand Dynamics

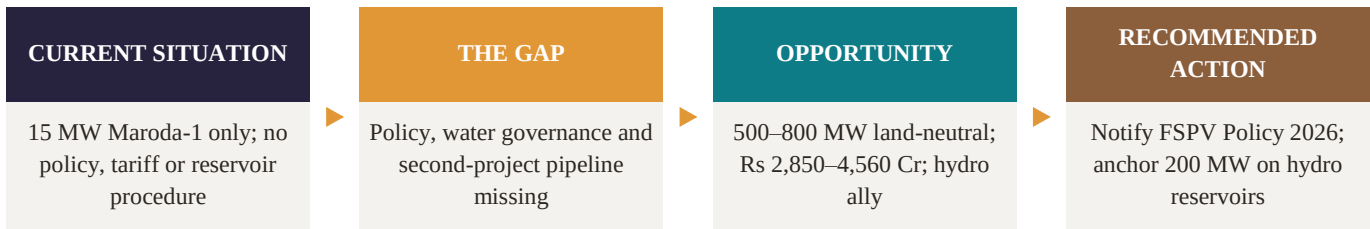
- **Three demand pathways:** captive industrial (Maroda-1 model for steel/cement/aluminium); utility-scale RPO compliance (every MW counts toward the 12.50% Solar RPO, land-neutral); and hydro complementarity providing dispatchable day-power system value.
- **Anchor entity:** the NTPC-SAIL JV (NSPCL) provides the established EPC and offtake architecture for early-stage CG deployment.

Supply–Demand Gaps

- **No state FSPV policy:** Chhattisgarh has no FSPV-specific guidelines; each project needs bespoke sequenced clearances across Irrigation/Forest/Revenue/Panchayat — delaying, inflating and politicising siting.
- **Fisheries coexistence:** active fishing contracts (Bargaon, Dashpur, Tumdibod) collapse acceptance where ignored; FSPV must coexist (≤40% coverage) or defer.
- **Siting sensitivity:** viability is highly sensitive to substation proximity — a usable pond is unviable without nearby substation land (Bargaon vs Mandari).

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Floating Solar PV

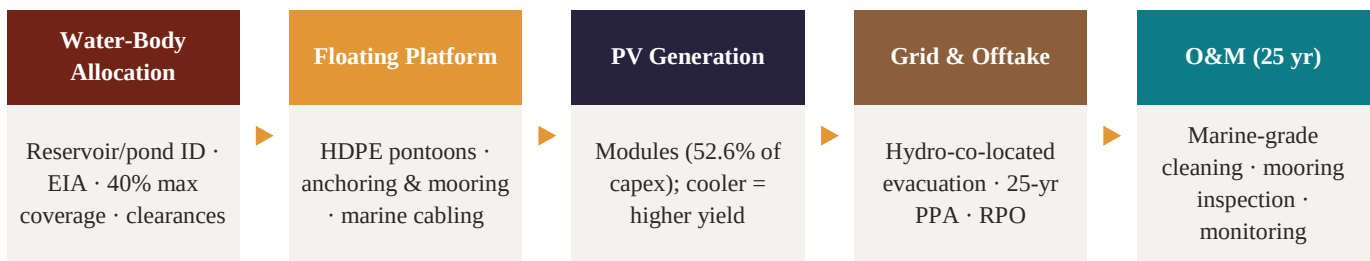


Source: NTPC/NSPCL, SAIL-Bhilai, CREDA, CSERC, SECI

4 Market Ecosystem for the Value Chain

FSPV mounts solar PV on engineered buoyant platforms anchored to water bodies. Upstream is modules, HDPE floats, anchoring/mooring, marine cabling and inverters; midstream is water-body allocation, EIA, hydrological-load modelling and sequenced clearances from Irrigation/Forest/Revenue/Panchayat; downstream is 25-year marine-grade O&M. Its defining advantage is land neutrality and hydro-reservoir evacuation reuse.

Floating Solar (FSPV) Value-Chain Architecture



Market Ecosystem for the Floating Solar Value Chain

Inputs & Technology	Solar modules · HDPE floating platforms/pontoons · anchoring & mooring · marine cabling · inverters — Floatex, Tata, Vikram, AMPIN
Producers / Developers	NTPC/NSPCL (Maroda-1, Korba pipeline) · SECI · SAIL-Bhilai · GAIL · pure-play FSPV providers
Development & Grid Infra	Water-body allocation · EIA · hydrological modelling · Irrigation/Forest/Revenue/Panchayat clearances · hydro evacuation
Off-takers	Captive industry (SAIL/NTPC/NMDC/SECL) · CSPDCL (25-yr PPA) · Solar RPO · day-power for the PV gap
Enablers	CREDA (FSPV Policy 2026) · CSERC · Water Resources Dept · Fisheries Dept · PRIs/SHGs · MNRE/SECI · NISE skilling

5 Community & Stakeholder Insights

Data note. FSPV field evidence draws on the CREDA IDI (institutional layer) and two contrasting FGDs, March 2026: Bargaon (Rajnandgaon) — large ponds but active fishing contracts and no

substation land → low acceptability; Mandari (Kanker) — pond with no fisher opposition and nearby substation land → high acceptability. Inland Fisheries FGDs (Bargaon-Mathaldabri, Dashpur, Tumdibod) set the livelihood envelope.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CREDA (state nodal — IDI anchor)	Direction toward open access, virtual net metering, RESCO and a unified DRE framework; hydro-FSPV co-location resolves the ~3,000 MW day-night PV gap.	Notify a Chhattisgarh FSPV Policy 2026 (reservoir allocation, ownership clarity, 40% coverage threshold, tariff/PPA structure) using Odisha/Telangana templates.
High-acceptance communities (Mandari FGD)	Pond available, no fisher opposition, substation land nearby, acceptability high — a textbook village-pond pilot site.	Site the first village-pond FSPV pilot at Mandari with SHG-led benefit-sharing and Panchayat-utility tripartite ownership.
Fisher communities (Bargaon FGD + Inland Fisheries)	Active fishing contracts make FSPV acceptability low; ignoring fishing rights collapses acceptance immediately.	Mandate EIA (Sembcorp Tengeh model) and fisher-livelihood compensation on any water body with active fisheries; enforce $\leq 40\%$ coverage.
Reservoir-owning departments (Irrigation/Water Resources)	Water bodies carry overlapping jurisdiction (Irrigation, Forest, Revenue, Panchayat), each requiring sequenced clearance.	Establish reservoir-allocation procedures and tripartite agreements; anchor the first 200 MW on Hasdeo Bango, Gangrel, Maroda-2 and Tandula.
NTPC/NSPCL + SECI (EPC & aggregation)	NSPCL delivered Maroda-1 and has a Korba pipeline; SECI holds FSPV tendering precedent (Getalsud 100 MW).	Leverage NSPCL as principal EPC/offtake partner; use SECI aggregation for hydro-reservoir utility-scale tenders.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Bankable, land-neutral returns:** ₹3.50–4.00/kWh expected for hydro-co-located FSPV, with existing evacuation improving per-MW LCOE; evaporation savings carry direct fiscal value to irrigation budgets and carbon-credit eligibility.
- **Premium caveat:** the ~20–25% capex premium over ground-mount persists today (shrinking ~2.5%/yr); the source does not state a project IRR — any ROI figure would be an analyst estimate requiring a primary build-up.

2. Social Benefits

- **Higher employment multiplier:** ~1,700–2,700 long-term FTEs (~4× ground-mount); a new semi-skilled marine-installation workforce category for tribal-belt and coal-transition districts (Korba, Surajpur, Raigarh).

- **Community ownership:** village-pond micro-FSPV enables SHG-led deployment and Panchayat-utility tripartite ownership where fisheries and siting permit.

3. Environmental & Climate Resilience

- **Water + carbon co-benefits:** ~700 million m³ evaporation prevented and ~1.0–1.6 MT CO₂/yr avoided at 500 MW — land-neutral with no agricultural displacement.
- **Biodiversity guardrail:** the CEEW 40% maximum-coverage threshold protects aquatic ecology; full-coverage is biologically destructive and must be barred by policy.

4. Technical Feasibility

- **Proven & complementary:** Maroda-1 demonstrates the captive model; hydro co-location (solar by day, hydro by night, same line) is the field-validated deployment architecture.
- **Binding enabler:** substation proximity (≤ 25 km / 132 kV) and reservoir-allocation clarity are the decisive technical and institutional prerequisites.

7 Success Stories & Proven Models

CASE STUDY 1 · SAIL-Bhilai Maroda-1 (Chhattisgarh) — In-State Captive FSPV Proof

The 15 MW Maroda-1 plant, implemented by the NTPC-SAIL JV (NSPCL) on a 2.1 sq km / 19 million m³ reservoir in Durg, generates ~34.26 MU/yr of captive power for Bhilai Steel and avoids ~28,330 tCO₂/yr — the state's first commissioned FSPV and a working captive-industrial template.

Relevance: *proof that captive FSPV is commercially viable for CG's steel/cement/aluminium plants with NTPC as EPC/offtake partner; the second-project pipeline (Korba, Maroda-2) is the concrete next step.*

CASE STUDY 2 · Omkareshwar & Getalsud FSPV Tenders (India) — Utility-Scale Tariff Discovery

National FSPV tenders discovered ₹3.21/kWh at Omkareshwar (Phase I) and ₹3.50/kWh at Getalsud (SECI, Jharkhand), with awards clustering around ₹3.50–3.93/kWh — demonstrating that utility-scale FSPV is tariff-competitive, especially where evacuation infrastructure already exists.

Relevance: *the aggregation-and-tariff template CG can replicate on its hydro reservoirs, where existing evacuation should push tariffs toward the lower band.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** FSPV viability is highly sensitive to substation distance (≤ 25 km / 132 kV); a usable pond is unviable without nearby substation land.
- **Solution:** anchor the first 200 MW on hydro reservoirs with built-in evacuation (Hasdeo Bango, Gangrel, Maroda-2, Tandula); use geography-specific siting filters.

Financial Barriers

- **Barrier:** a persistent 20–25% capex premium over ground-mount and higher marine-grade O&M cost.
- **Solution:** prioritise hydro-co-located sites (lower evacuation cost), monetise evaporation and carbon co-benefits, and use SECI aggregation and captive-industrial offtake to de-risk.

Knowledge & Technical Skill Gaps

- **Barrier:** a semi-skilled marine-installation workforce and reservoir-allocation know-how do not yet exist in the state.
- **Solution:** build a dedicated Chhattisgarh FSPV Skills Programme (CREDA, NISE, SAIL-Bhilai) sequenced in coal-transition districts; adopt Odisha/Telangana allocation procedures.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	~20–25% capex premium over ground-mount; tariff realisation sensitive to evacuation cost and site geography.	Med	Prioritise hydro-co-located sites with existing evacuation; use SECI aggregation and captive offtake; monetise evaporation/carbon co-benefits.	
Production / Climate	Substation-proximity dependence (≤ 25 km / 132 kV) filters technical into deployable potential; hydrological/reservoir variability.	Med	Site by substation-distance filter; anchor on hydro reservoirs; pair with hydro for the day-night PV gap.	
Operational / Supply Chain	Fishing-rights conflict collapses acceptance; full-coverage is biologically destructive; specialised marine O&M scarce.	High	Enforce $\leq 40\%$ coverage and EIA + fisher compensation; build the FSPV skills programme; SHG-led benefit-sharing on village ponds.	
Policy Governance	No state FSPV policy; overlapping water-body jurisdiction (Irrigation/Forest/Revenue/Panchayat) delays and politicises siting.	High	Notify the Chhattisgarh FSPV Policy 2026 with reservoir allocation, ownership clarity, 40% threshold and tariff/PPA structure (Odisha/Telangana templates).	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Baseline vs 2030–36 Target (bar graph → editable data table)

Indicator	Baseline 2024–25	Target 2030–36
FSPV Capacity (MW)	15	650
Long-term FTE (jobs)	50	2,200
Investment Pipeline (₹ Cr)	86	3,705

Target capacity = midpoint of 500–800 MW; FTE at 3.36 FTE/MW (CEEW); investment at ~₹5.7 Cr/MW. Source: value-chain document (Table

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify the Chhattisgarh FSPV Policy 2026 (reservoir allocation, ownership clarity, 40% coverage, tariff/PPA); anchor the first 200 MW on hydro reservoirs; establish tripartite agreements with reservoir-owning departments; build the FSPV skills programme in coal-transition districts.

Private Sector & Investors

- Deploy via NSPCL/NTPC EPC and SECI aggregation; bring HDPE-float, mooring and marine-cabling supply and marine-grade O&M; pursue captive-industrial (SAIL/NTPC/NMDC/SECL) and utility-scale hydro-co-located FSPV under 25-year PPAs.

Development Agencies & NGOs

- Mediate fishing-rights via EIA and compensation mechanisms; govern SHG-led village-pond benefit-sharing and Panchayat-utility tripartite ownership; support reservoir-allocation clarity and community acceptance (Mandari pilot).

11 Key Departments & Institutional Alignment

Nodal Department / Institution	Primary Responsibility in the Floating Solar Value Chain
MNRE (Central)	National FSPV policy guidance and RE-target alignment.
SECI	FSPV tendering precedent (Getalsud 100 MW), central aggregation, concessional finance mobilisation.
NTPC / NSPCL	Principal EPC and offtake partner (Maroda-1, Korba pipeline); long-term O&M.
CREDA (State Nodal Agency)	Chhattisgarh FSPV Policy 2026 notification, reservoir-allocation procedure, tariff/PPA structuring.
CSPDCL / CSERC	25-year FSPV PPAs and offtake; tariff and PPA regulation; tripartite agreements with reservoir-owning departments.
Water Resources / Irrigation Department	Reservoir-use authority; evaporation-benefit accounting; ecological-flow coordination.
Forest / Revenue Departments	Sequenced clearances for water bodies under overlapping jurisdiction.
Fisheries Department	Fishing-rights mediation and EIA on water bodies with active fisheries.

PRIs / Panchayats + SHGs/CBOs	Local water-body permissions; village-pond FSPV benefit-sharing governance.
NISE / SAIL-Bhilai	FSPV skills programme — semi-skilled marine-grade installation workforce.

— Data Integrity & Currency Notes

- **Capacity/FTE basis:** the 500–800 MW target is filtered from technical potential by reservoir surface availability, the CEEW 40% coverage threshold and the 25 km/132 kV substation constraint; FTE uses the CEEW ~3.36 FTE/MW coefficient — ranges, not point estimates.
- **Water/carbon figures:** ~1,395 m³/MWp evaporation and 28,330 tCO₂/yr are Maroda-1-scale; the ~700 million m³ and ~1.0–1.6 MT CO₂/yr are scaled to a 500 MW build-out.
- **Fast-moving inputs:** capex premium, LCOE trajectory and FSPV tariff awards change frequently and may post-date this analysis — verify against CSERC/CEEW/TERI primary sources before publication.

Analyst additions: risk severities, the four diagrams and the ROI/IRR data-gap note are analytical framing; all quantitative headline metrics

[1]**Methodology.** Employment: ~1,700–2,700 long-term FTEs = 500–800 MW × ~3.36 FTE/MW (CEEW); 62% construction-phase, 60% semi-skilled; ~50 FTE on the 15 MW base. Investment: ₹2,850–4,560 Cr = 500–800 MW × ~₹5.7 Cr/MW (2024 benchmark, 20–25% premium over ground-mount, shrinking ~2.5%/yr); LCOE → ₹3.72/kWh by 2030. Deployable potential filtered by 40% max coverage (CEEW biodiversity) and 25 km/132 kV substation distance. Water/carbon: ~1,395 m³/MWp evaporation and 28,330 tCO₂/yr at Maroda-1, scaled to ~700 million m³ and ~1.0–1.6 MT CO₂/yr at 500 MW. Tariffs ₹3.21–4.15/kWh nationally; CG likely ₹3.50–4.00/kWh hydro-co-located. All figures originate in the source diagnostic and its endnotes (IN Solar/GIZ, TERI, CEEW, NSPCL, CSERC). Fast-moving inputs should be re-verified before external citation.

Part II — Circular Economy Value Chains

Waste-to-resource recovery and recycling value chains that close material loops and build a formal circular-materials economy.

Turning waste into wealth — keeping materials in use and regenerating natural systems.

The **circular economy** is a system in which materials never become waste and nature is regenerated: products and materials are kept in circulation through maintenance, reuse, refurbishment, remanufacture, recycling and composting. As CEEW notes, India is projected to generate on the order of **165 million tonnes of waste a year by 2030**, so recovering resources from waste streams — and returning them to the economy — is central to an environmentally sustainable and job-rich growth path.

Chhattisgarh is well placed to lead. Its steel, aluminium, cement, coal and power industries generate large and concentrated **industrial, construction-and-demolition, and process-waste** streams, while urbanisation and the EV transition add municipal, plastic, e-waste and **lithium-ion battery** streams. The last of these closes a loop with the energy-transition cluster: the Battery Waste Management Rules' recycled-content mandate (rising from **5% to 20%**) makes domestically recovered lithium, cobalt and nickel a regulated input to battery manufacturing — recycling and manufacturing reinforcing each other within the state.

Critically, this is a **jobs engine**. CEEW's Odisha analysis found the circular economy creates roughly **12 direct jobs per ₹ crore of investment** — about eight to nine times the ratio for the energy transition — because recovery, sorting, dismantling and reprocessing are inherently labour-intensive and need comparatively modest capital. That makes the cluster a natural fit for MSME- and enterprise-led rural and peri-urban employment.

Value chains in this cluster (Chhattisgarh's GETM portfolio)

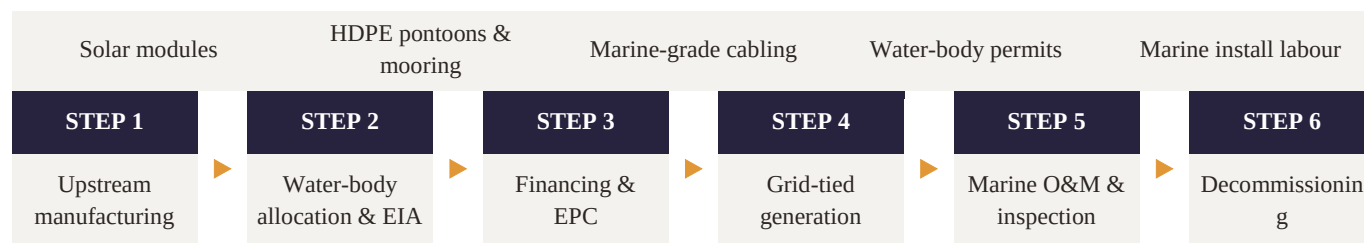
Plastic Waste · E-Waste · Construction & Demolition Waste · Li-ion Battery Waste · Industrial Waste · Agri-Residue · Bio-Medical Waste · Packaging Materials · Tyre Recycling · Household FMCG Waste · Solid & Liquid Waste

Chhattisgarh anchor: *a dense industrial and mineral base that generates high-value recoverable waste, plus a closed-loop link between Li-ion battery recycling and EV-battery manufacturing.*

Input / Output Flow

Value Chain Flow · Floating Solar PV

INPUTS



OUTPUTS

Captive / grid power	Evaporation reduction	Efficiency-gain cooling	Recoverable module material
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Source: NTPC/NSPCL, SAIL-Bhilai, CREDA, CSERC, SECI

C01 Plastic Waste Recycling

CE · CIRCULAR ECONOMY

The collection, segregation, cleaning, and mechanical and chemical reprocessing of post-consumer and post-industrial plastic waste into recycled granules, flakes, fibre, and finished products, integrated with the Extended Producer Responsibility (EPR) credit framework.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
15,000–35,000 direct jobs across collection, segregation, mechanical + chemical recycling, and EPR services (incl. informal-sector formalisation)	20–80 MRFs, MSMEs	₹1,500–4,000 Cr opportunity envelope over GETM 2026–32. Tier 1 MRFs ₹20 lakh–5 Cr; Tier 2 mechanical recycling MSMEs ₹50 lakh–8 Cr; Tier 3 chemical recycling + cement co-processing ₹5–50 Cr per unit	Tier 1	Dual revenue — recycled-material sales (rPET/granules ₹40–90/kg) + verifiable EPR-credit revenue; anchored in India's waste plastic recycling market of 11.92 MT (2025) → 25.88 MT by 2034 at 9.0% CAGR

Methodology: The 15,000–35,000 job range applies typical MRF (20–80 FTE/facility), mechanical recycling MSME (15–50 FTE/unit), and chemical-recycling/co-processing (30–80 FTE/unit) coefficients to a deployment of MRF networks across 4–6 urban centres + mechanical recycling MSMEs + chemical-recycling units + informal-sector formalisation over 2026–32. Market/CAGR figures are drawn from IMARC (11.92→25.88 MT at 9.0%) and ResearchAndMarkets (recycled plastics 6.06 MT FY21 → 20.5 MT FY27 at 15.9%) at conservative national benchmarks; the ₹1,500–4,000 Cr envelope reflects CG's realistic share of the CEEW-identified eastern-India recycling opportunity.

Value Chain / Circular Flow — Plastic Waste Recycling



↻ Circular loop — recovered material re-enters the economy

Source: CEEW, India Plastics Pact, CPCB, PWM Rules 2016

Metric	2024–26 Baseline	2030–36 Target
National industry size	India waste plastic recycling 11.92 MT (2025); ~26,000 TPD generation (~9 MT/yr); ~40% uncollected	25.88 MT by 2034 at 9.0% CAGR; recycled-plastics 20.5 MT by FY27 at 15.9% CAGR
Regulatory mandate	EPR recycling 50% (2024-25); recycled content 30% rigid; QR-coded packaging from July 2025; IS 14534:2023	EPR recycling 80% by 2028-29; recycled content 60% by 2028-29; full digital EPR traceability
CG position	GG Wastech Raipur EPR + cement co-processing; CEEW-identified plastic-waste source; recyclable plastic channelled out-of-state	Dedicated CG plastic-recycling cluster/plastic park; in-state mechanical + chemical recycling; EPR-credit capture
CG job potential	Informal waste-picker economy + small Raipur recyclers; limited formal MSME units	15,000–35,000 direct jobs across collection, segregation, MRFs, recycling, and EPR services
Cross-VC integration	Feedstock to Packaging, Bio-Textiles (rPET), cement co-processing (AFR)	Integrated MRF + recycling-park hub serving Solid/Liquid Waste, Packaging, E-waste, C&D, Industrial Waste

2. Contextual Overview

National Context

- India generates ~26,000 TPD plastic waste (~9 MT/yr, one-fifth of global total); ~40% remains uncollected; processing plants handle ~91,000 TPD (up from 50,000 in 2018).
- India waste plastic recycling market reached 11.92 MT (2025) → projected 25.88 MT by 2034 at 9.0% CAGR; recycled-plastics market 6.06 MT (FY21) → 20.5 MT by FY27 at 15.9% CAGR.
- PWM Rules 2016 (amended 2022, 2025): EPR recycling target 50% (2024-25) → 80% by 2028-29; recycled-content mandate 30% rigid → 60% by 2028-29; QR-coded packaging traceability mandatory from July 2025.
- Structural demand gap: brands placed 788,027 tonnes of plastic packaging on market in 2023-24 — 71% recyclable but only 1% used recycled content.
- Dual-revenue basis: recyclers issue verifiable Category I/II/III EPR credits to PIBOs through the centralised CPCB online portal.

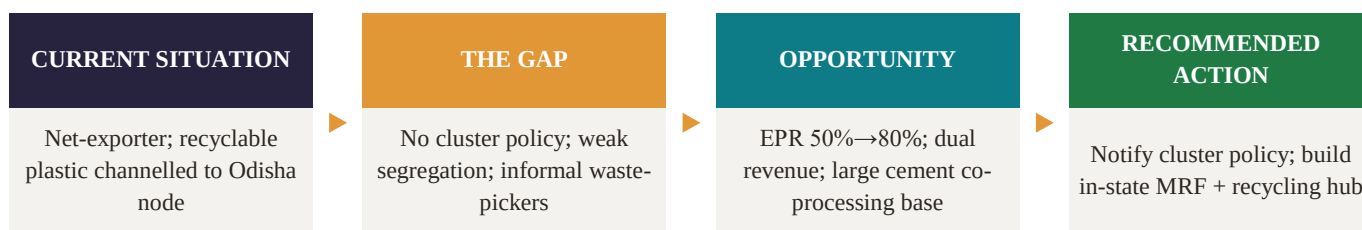
Chhattisgarh Context

- Position is nascent-formal with a net-exporter structure; CEEW identifies CG (with Jharkhand, West Bengal) as a plastic-waste source channelised to the Odisha recycling node.
- Established EPR service-provider ecosystem — GG Wastech (Raipur), 5+ years, plastic-waste + legacy + MSW + AFR cement co-processing.
- Large cement-industry base (Ultratech, ACC, Ambuja, Shree Cement around Raipur/Baloda Bazar/Janjgir) provides ready AFR co-processing capacity for non-recyclable plastic with zero residue — a differentiated advantage.
- Urban waste-generation clusters (Raipur, Bhilai-Durg, Bilaspur, Korba) provide concentrated feedstock; existing informal waste-picker workforce available for formalisation.
- Structural gaps: no notified state plastic-park / recycling-cluster policy; weak segregation-at-source; limited in-state mechanical + chemical recycling MSME capacity.

3. Demand & Supply Assessment

- **Supply:** ~26,000 TPD national plastic waste (~40% uncollected); recycling capacity grew 60,000 TPA (2005) → 500,000+ TPA. CG feedstock concentrated in urban clusters (Raipur, Bhilai-Durg, Bilaspur, Korba) + informal waste-picker collection; feedstock quality constrained by weak segregation-at-source.
- **Demand:** EPR recycling mandate (50%→80%) + recycled-content mandate (30%→60%) create assured, legally-mandated offtake; FMCG virgin-plastic-elimination commitments; verifiable EPR-credit market via CPCB portal; cement co-processing (AFR) offtake for non-recyclable fractions.
- **Supply–Demand Gap:** The 1% recycled-content vs 71% recyclability gap (2023-24) is the structural deficit the recycled-content mandate closes; CG's net-exporter structure means recycling value currently captured out-of-state rather than in-state.

Demand → Gap → Opportunity → Action · Plastic Waste Recycling



Source: CEEW, India Plastics Pact, CPCB, PWM Rules 2016

4. Market Ecosystem

The value chain spans collection through EPR-credit monetisation, anchored on CG's cement-industry co-processing base and informal-sector formalisation.

- **Input Suppliers:** Informal waste-pickers; urban municipal collection (Raipur, Bhilai, Bilaspur, Korba, Durg); SHG/cooperative collection entities.
- **Primary Producers & Aggregators:** MRFs at urban clusters; SHG/cooperative aggregators; municipal corporations (segregation-at-source).

- **Processing & Logistics:** Mechanical recycling MSMEs (washing, shredding, agglomeration, granulation → rPET/granules); chemical recyclers (pyrolysis, depolymerisation); GG Wastech collection-to-co-processing logistics.
- **Off-takers & Retail:** PIBOs / FMCG brand-owners; cement co-processors (Ultratech, ACC, Ambuja, Shree Cement); Packaging (recycled materials) and Bio-Textiles (rPET fibre) value chains.
- **Enablers:** CPCB (EPR portal, credits); CECB (State Pollution Control Board); MoEFCC; Dept of Chemicals & Petrochemicals (Plastic Parks); Swachh Bharat Mission (urban); PMFME + AIF + state capital subsidy.

Market Ecosystem — Plastic Waste Recycling

Input & Feedstock	Informal waste-pickers · Urban municipal collection · SHG/cooperative collection
Producers & Aggregators	MRFs (urban clusters) · Municipal corporations · SHG aggregators
Processing & Logistics	Mechanical recycling MSMEs · Chemical recyclers (pyrolysis) · GG Wastech co-processing logistics
Off-takers & Markets	PIBOs / FMCG brands · Cement co-processors · Packaging & Bio-Textiles VCs
Enablers	CPCB EPR portal · CECB / MoEFCC · PMFME + AIF + capital subsidy

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Informal Waste-pickers / SHGs	Low-income, unaccounted, outside formal EPR traceability; rural SHG readiness (Sogda 20 SHGs, Berchegondi 8 SHG/CLFs + 50 women, Luikona 9 SHGs) transferable	Formalise into SHG/cooperative collection with fair pricing, dignified employment, social security (Nepra/Gem Enviro/Shakti templates)
MSME Recyclers	Limited in-state mechanical + chemical recycling capacity; need viable dual-revenue model	Channel PMFME + AIF 3% interest subvention + state capital subsidy; register as Plastic Waste Processors on CPCB portal
EPR Service Providers (GG Wastech)	Established zero-residue co-processing + national client network; feedstock-aggregation challenge for stand-alone recyclers	Anchor CG cluster on GG Wastech model; scale co-processing agreements with cement plants
Cement / Industry Off-takers	Under-leveraged AFR co-processing despite large cement base	Formalise co-processing agreements integrated with EPR-credit framework for verified diversion

Brand / PIBO Buyers	Only 1% recycled content vs 71% recyclability; need assured compliant offtake	Leverage rising recycled-content mandate (30%→60%) + CPCB-portal EPR credits for revenue stability
CG Regulators (CECB)	No notified plastic-park / recycling-cluster policy; net-exporter structure	Notify CG Plastic Waste Recycling Cluster Policy by Q4 2026 (Rajasthan model) + segregation-at-source enforcement

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Moderate capex (3–18 month build periods); distinctive dual revenue (recycled-material sales at ₹40–90/kg + EPR-credit revenue) materially de-risks recycler economics vs commodity-only recycling. Working capital ₹3–15 lakh (Tier 1), ₹20 lakh–1.5 Cr (Tier 2), ₹2–15 Cr (Tier 3). Viability favours Tier 1 + Tier 2 first-wave.
- **Social Benefits:** Formalises the existing informal waste-picker economy into dignified, higher-income recycling-sector employment — among the most socially impactful tiers in the GETM portfolio; SHG/women inclusion via cooperative collection.
- **Environmental & Climate Resilience:** Diverts plastic from landfill/uncollected streams (~40% national uncollected); AFR co-processing achieves energy recovery with zero residue for non-recyclable fractions; closes resource loop feeding Packaging and Bio-Textiles.
- **Technical Feasibility:** Mechanical recycling is mature and India has existing competency; chemical recycling + cement co-processing (GG Wastech model) proven in CG; scalability depends on MRF investment + segregation quality.

7. Success Stories & Proven Models

Proven Models & Benchmarks

GG Wastech (Raipur) — CG-anchored EPR + AFR cement co-processing provider (5+ years, zero-residue "leaving no residue" model, national client network incl. Zigma, Nepra, Gem Enviro) proves CG's cement base can be leveraged for co-processing of non-recyclable plastic; the anchor CG asset.

Nepra Resource Management — technology-enabled MRF integrating informal waste-pickers into dignified employment with EPR + FMCG brand partnership; the template for informal-sector-integrated MRFs across CG's 4–6 urban clusters.

Shakti Plastic Industries — registered Plastic Waste Processor issuing Category I/II/III EPR credits via CPCB portal + IS 14534:2023-compliant recycled products; the dual-revenue (EPR-credit + recycled-content) compliance template.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Weak segregation-at-source → feedstock contamination. Solution: segregation-at-source mandates (2025 rules) + MRF investment across 4–6 urban centres + informal-sector integration for high-quality manual segregation.
- **Financial barriers:** Limited MSME capacity + EPR-credit price volatility. Solution: PMFME + AIF 3% interest subvention + state capital subsidy (Rajasthan model) + Plastic Parks scheme + EPR-credit revenue layer for de-risked economics.
- **Knowledge & skill gaps:** Informal, unaccounted workforce outside traceability. Solution: SHG/cooperative formalisation modelled on Nepra/Gem Enviro/Shakti; PWP registration training; Ambikapur/FGD SHG enterprise readiness as base.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Recycled-content offtake + EPR-credit price volatility for recycler viability	Medium	Rising recycled-content mandate (30%→60%) + brand commitments + verifiable CPCB-portal EPR credits for revenue stability
Production / Feedstock	Weak segregation-at-source → contamination → reduced recycling efficiency	High	Segregation-at-source mandates + MRF investment + informal-sector manual segregation + producer-funded EPR collection
Operational / Supply Chain	Informal-sector dependence; net-exporter structure channelling waste to Odisha node	High	SHG/cooperative formalisation into EPR-credit chain; in-state cluster + co-processing to retain value
Policy / Governance	No notified state plastic-park / recycling-cluster policy	High	Notify CG Plastic Waste Recycling Cluster Policy by Q4 2026 (Rajasthan model) under PWM + Plastic Parks + SBM convergence

10. Stakeholder Matrix & Action Domains

Stakeholder	Role in Scale-Up	Recommended Action / Point for Action
MoEFCC / CPCB (central)	Administer PWM Rules; operate EPR portal and credit framework	Fast-track CG recycler/PWP registration; support QR-traceability rollout
Dept. of Chemicals & Petrochemicals (central)	Administer Plastic Parks scheme	Sanction a CG plastic-park/recycling cluster under the scheme
CECB (state SPCB)	Recycler registration, credit issuance, EPR-PWM enforcement	Enforce segregation-at-source; register CG recyclers as PWPs
Urban Admin & Dev. Dept. + Municipal Corporations	MSW collection and segregation across urban clusters	Partner on MRF network; enforce segregation; converge with Swachh Bharat (urban)
CSIDC + Industries Dept. (state)	Recycling-cluster industrial-zone allocation	Notify a CG Plastic Waste Recycling Cluster Policy by Q4 2026 (Rajasthan model)
Mechanical + chemical recycling MSMEs	Produce rPET/granules; process non-recyclable fractions	Access PMFME/AIF/state subsidy; register as PWPs for dual revenue
CG cement industry (co-processors)	AFR co-processing of non-recyclable plastic	Formalise co-processing agreements linked to EPR verified-diversion
EPR providers / PROs (e.g., GG Wastech)	Integrated collection-logistics-co-processing; anchor asset	Scale the co-processing + collection model as cluster anchor
SHGs / cooperatives / waste-pickers (community/PRI)	Formalised collection and segregation	Formalise into collection cooperatives with fair pricing and social security
Finance (PMFME, AIF, corporate ESG)	Concessional capital and working capital	Deploy interest subvention and state capital subsidy to first-wave MRFs and MSMEs

11. Key Departments & Institutional Alignment

- **MoEFCC:** Administers PWM Rules 2016 (amended 2022, 2025) and the EPR framework.
- **CPCB:** Operates centralised EPR online portal; registers PIBOs and Plastic Waste Processors; manages digital EPR-credit framework.
- **Department of Chemicals & Petrochemicals:** Administers Scheme for setting up of Plastic Parks.

- **Ministry of Housing & Urban Affairs:** Swachh Bharat Mission (urban) waste-management convergence.
- **Bureau of Indian Standards:** IS 14534:2023 (recycled plastic) + IS/ISO 17088:2021 (compostable plastic) standards.
- **CECB (Chhattisgarh Environment Conservation Board):** State Pollution Control Board — recycler registration, EPR-credit issuance, PWM enforcement.
- **Urban Administration & Development Department + Municipal Corporations:** MSW collection + segregation-at-source across Raipur, Bilai, Bilaspur, Korba, Durg.
- **CSIDC + Industries Department:** Plastic-park / recycling-cluster industrial-zone allocation.
- **NABARD / SIDBI (via PMFME, AIF):** Concessional finance + interest subvention + capital subsidy for recycler MSMEs.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Plastic Waste Recycling

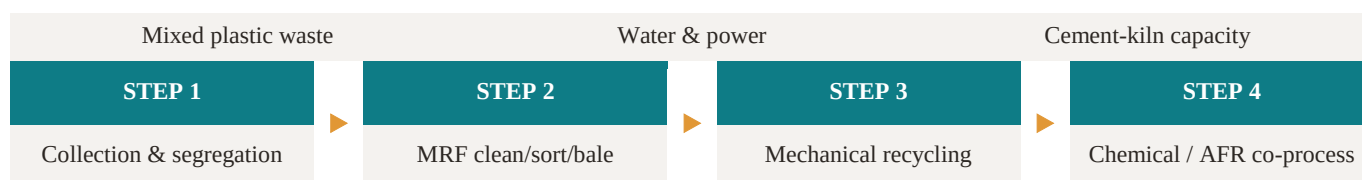


Source: CEEW, India Plastics Pact, CPCB, PWM Rules 2016

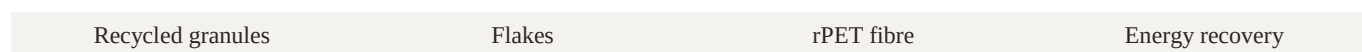
Input / Output Flow

Value Chain Flow · Plastic Waste Recycling

INPUTS



OUTPUTS



Source: CEEW, India Plastics Pact, CPCB, PWM Rules 2016

C02 E-Waste Recycling

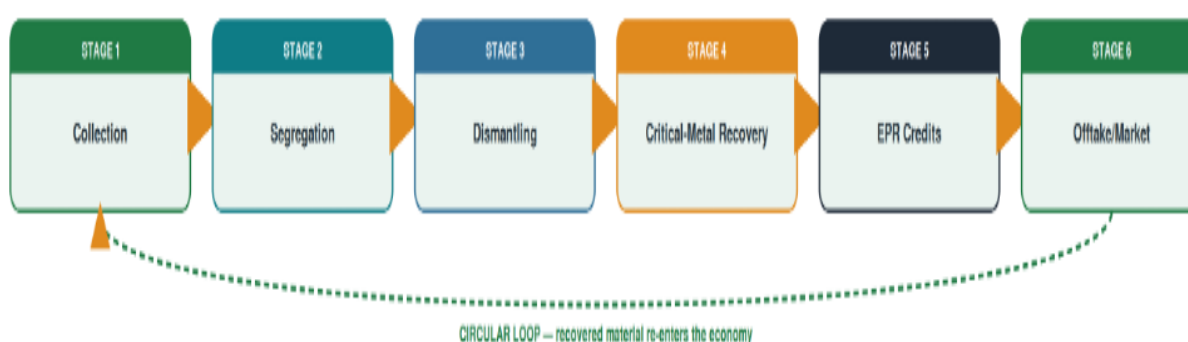
CE · CIRCULAR ECONOMY

The collection, dismantling, and processing of end-of-life Electrical and Electronic Equipment (EEE) with recovery of precious metals, base metals, strategic critical materials, and recyclable plastics, glass, and circuit-board components.

1. Executive Dashboard

DIRECT EMPLOYMENT 8,000–18,000 direct jobs across collection, dismantling, recycling, and EPR-services (incl. informal-sector formalisation)	FTE direct jobs collection, recycling, and EPR-services (incl. informal-sector formalisation)	MARKET INVESTMENT ₹1,000–3,000 Cr opportunity envelope (GETM 2026–32); Tier 1 collection ₹30 lakh–3 Cr; Tier 2 dismantling ₹1–15 Cr; Tier 3 ZLD+AMR recycler ₹25–200 Cr	& Cr envelope Tier 1 collection ₹30 lakh–3 Cr; Tier 2 dismantling ₹1–15 Cr; Tier 3 ZLD+AMR recycler ₹25–200 Cr	REVENUE POTENTIAL Highest value-per-tonne waste stream; dual revenue (recovered metals at LBMA/LME + CPCB EPR credits); national benchmark Attero FY26 ~₹2,000 Cr at 100% YoY growth
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Value Chain / Circular Flow — E-Waste Recycling



Metric	2024–26 Baseline	2030–36 Target
National industry size	India e-waste generation 1.40 MT (FY2024-25, +11.4%); formal recovery 70.71% (up from 61.94%); 106+ EEE categories; 17% CAGR forecast	Sustained 17% CAGR through 2030; full ZLD+AMR formal recycler base; informal-to-formal transition of remaining ~30%
Regulatory mandate	E-Waste Rules 2022 (amended 2024, 2025, 2026); EPR target 60% FY2024-25; ZLD+AMR by 2026; CPCB portal mandatory	EPR target 70% FY2025-26 → 80% FY2027-28 onwards; full ZLD+AMR compliance; mature CPCB EPR-credit market
CG position	Urban-industrial generation (Raipur, Bhilai-Durg, Bilaspur, Korba); ZERO major CPCB-authorized recyclers; bulk exported	2-3 in-state CPCB-authorized ZLD+AMR recyclers + 6-10 dismantling units capturing CG EPR-credit revenue
Value density	Highest-value-per-tonne waste stream — PCBs contain gold (~300 g/T), silver, palladium,	Critical-metal recovery (lithium, cobalt, rare earths)

Metric	2024–26 Baseline	2030–36 Target
	copper, tin; Li-ion cells contain lithium, cobalt, nickel	feeding EV-battery and electronics supply chains
CG job potential	Informal kabadi-economy collection; minimal formal workforce; ~90-95% informal historical share nationally	8,000–18,000 direct jobs across collection, dismantling, recycling, and EPR services

2. Contextual Overview

National Context

- India e-waste generation **1,397,955 MT (FY2024-25)**, up 11.4% from 1,254,286 MT (FY2023-24); 106+ EEE categories.
- Formal recovery rose sharply from **61.94% to 70.71%** in a single fiscal year — among the fastest formalisation transitions of any waste category globally.
- **E-Waste (Management) Rules 2022** (eff. 1 April 2023; amended 2024/2025/2026): EPR targets 60% (FY23-24 & FY24-25) → 70% (FY25-26 & FY26-27) → 80% (FY27-28 onwards).
- **2026 ZLD + AMR mandate** (Zero-Liquid Discharge + Advanced Material Recovery) sets a high-quality formal-sector floor; CPCB EPR-credit market is India's most mature.
- NITI Aayog projects **17% CAGR** for the formal e-waste recycling sector through 2030; recyclers concentrated in 19 states.

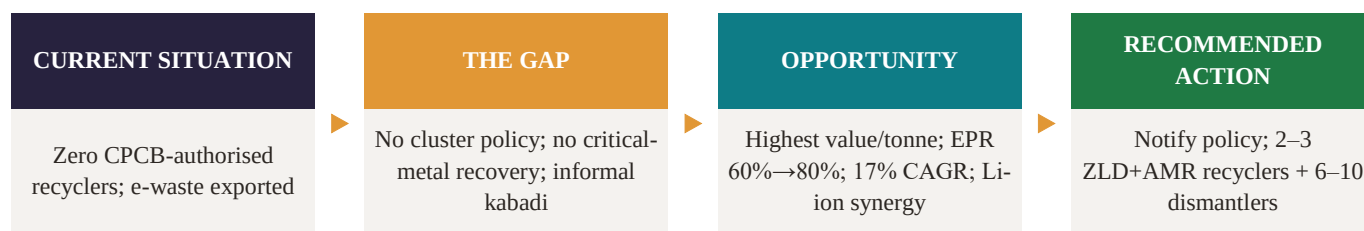
Chhattisgarh Context

- **Zero major CPCB-authorized e-waste recyclers** in state — a pure-exporter structure sending volume to Attero Roorkee, E-Parisaraa Bengaluru, Maharashtra, and Tamil Nadu.
- Urban-industrial generation clusters: **Raipur** (capital + IT/govt EEE), **Bhilai-Durg** (steel/industrial electronics), **Bilaspur** (commercial), **Korba** (power/industrial).
- Established multi-stream EPR-provider base: **GG Wastech Raipur** (cross-reference Plastic Waste Recycling VC).
- Existing **informal kabadi-network** collection workforce available for formalisation; cross-VC integration with Li-ion Battery Recycling (Attero dual-portfolio template).
- No notified state e-waste recycling cluster policy; absent critical-metal recovery capability.

3. Demand & Supply Assessment

- **Supply:** Concentrated urban-industrial feedstock at Raipur/Bhilai-Durg/Bilaspur/Korba, currently aggregated by informal kabadi networks and channelled out-of-state; large IT-asset stream from state government, SAIL Bhilai, NTPC Korba, NMDC; no in-state authorised dismantling/recycling capacity.
- **Demand:** Regulatory-mandate demand-pull from rising EPR targets (60%→80%) and the 2026 ZLD+AMR mandate; producers (PIBOs) must buy EPR certificates; critical-metal demand from EV/electronics supply chains; corporate ESG-driven takeback.
- **Supply–Demand Gap:** CG generates but cannot process — all EPR-credit and critical-metal value captured out-of-state. Intervention converts CG from pure exporter into an in-state ZLD+AMR critical-metal recovery hub.

Demand → Gap → Opportunity → Action · E-Waste Recycling



4. Market Ecosystem

CG must build the full chain from informal collection to critical-metal recovery.

- **Input Suppliers / Feedstock:** Informal kabadi-network collectors; urban households; IT-asset holders (govt, PSU, SAIL/NTPC/NMDC); corporate/brand takeback.
- **Primary Producers & Aggregators:** SHG/cooperative collection entities; urban collection-and-aggregation centres; municipal collection drives.
- **Processing & Logistics:** Authorised dismantling units; Tier 3 ZLD+AMR recyclers (hydro-/pyrometallurgical); Attero Selsmart D2C + MetalMandi B2B platform models.
- **Off-takers & Retail:** PIBOs buying EPR credits; precious/base-metal buyers (LBMA/LME-priced); EV & electronics manufacturing supply chains.
- **Enablers:** MoEFCC, CPCB (EPR portal), CECB (CTO/audit), CSIDC + Industries Dept, Urban Admin & Dev Dept + municipal corporations, PROs (Karo Sambhav, Hulladek), GG Wastech; finance via PMFME/PFC/REC/IREDA/SIDBI + state capital subsidy.

Market Ecosystem — E-Waste Recycling

Input & Feedstock	Kabadi collectors · IT-asset holders (govt/PSU) · Corporate takeback
Producers & Aggregators	SHG/cooperative collectors · Urban aggregation centres · Municipal drives
Processing & Logistics	Authorised dismantlers · ZLD+AMR recyclers · Selsmart D2C / MetalMandi B2B
Off-takers & Markets	PIBOs (EPR credits) · LBMA/LME metal buyers · EV/electronics supply chain
Enablers	CPCB / CECB · CSIDC + Industries Dept · PROs (Karo Sambhav, Hulladek) · PFC/REC/IREDA/SIDBI

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Action	Policy
Informal kabadi-network collectors	~90-95% of e-waste historically informal; hazardous open-burning/acid-leaching; no traceability, low incomes	Formalise into SHG/cooperative collection with fair pricing, social security, CPCB-portal integration	

Rural SHG enterprise base (Berchegondi, Sogda, Luikona)	8 SHG/CLFs + 50 women (Berchegondi), 20 SHGs (Sogda), 9 SHGs (Luikona); readiness transferable to peri-urban collection	Mobilise for end-of-life appliance collection cooperatives in peri-urban geographies
MSME dismantlers / recyclers	Absent in-state authorised dismantling & critical-metal recovery capacity	State cluster policy + industrial-area allocation + capital subsidy + CTO facilitation
Institutional / IT-asset buyers (govt, PSU)	Large IT-asset e-waste stream needs data-secure destruction	Corporate/PSU takeback tie-ups with data-destruction; R2/ISO 14001/RoHS standards
National flagship recyclers (Attero, RecycleKaro)	Seeking anchor sites; capable of low-cost, low-capacity plants	Offer capital subsidy + dedicated industrial-area + EPR-credit revenue floor
CECB + municipal corporations	Fragmented collection; enforcement/audit gaps	CECB CTO licensing + geo-tagged inspection; municipal Swachh Bharat (Urban) convergence

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Highest unit-economics per tonne in the Waste & Recycling cluster via precious-metal-bearing PCBs; dual revenue (recovered materials + EPR credits); Tier 1 + Tier 2 first-wave (Raipur, Bhilai-Durg) with Tier 3 ZLD+AMR scaling as feedstock consolidates; Attero FY26 ₹2,000 Cr at 100% YoY validates the ceiling.
- **Social Benefits:** Formalises informal kabadi-network collectors into dignified higher-income recycling employment; women/SHG inclusion via peri-urban collection cooperatives.
- **Environmental & Climate Resilience:** Diverts hazardous open-burning/acid-leaching; recovers critical metals (gold, palladium, lithium, cobalt) supporting strategic-mineral self-reliance; cement co-processing for non-recoverable residuals.
- **Technical Feasibility:** Attero NASA-recognised end-to-end benchmark; low-cost/low-capacity plant capability makes sub-flagship CG entry feasible; RecycleKaro AI-sorting + ISO 14001/R2/RoHS template.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Attero Recycling (Roorkee) — India's largest CPCB-authorised e-waste + Li-ion recycler; NASA-recognised technology; FY26 ~₹2,000 Cr at 100% YoY growth; targets 750,000 tons by March 2026 via Selsmart D2C; proves end-to-end critical-metal recovery and validates a sub-flagship ₹50-150 Cr CG-anchored ZLD+AMR facility.

Karo Sambhav — PRO/EPR operator with multi-state collection and informal-sector integration, providing the demand-side aggregation template to anchor CG Tier 1/Tier 2 investment.

RecycleKaro — technology-first, AI-sorting, ISO 14001/R2/RoHS recycler providing a realistic sub-flagship ₹25-75 Cr Tier 3 ZLD+AMR entry model for CG.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Zero in-state recyclers + limited dismantling capacity → notify a CG E-Waste Recycling Cluster Policy (Q4 2026); build urban collection-and-dismantling networks across 4 clusters; anchor 2-3 ZLD+AMR recyclers + 6-10 dismantling units by 2030.
- **Financial barriers:** ZLD+AMR capex intensity (₹25-200 Cr) → staged deployment (Tier 1/2 first, Tier 3 as demand consolidates); PMFME + AIF + capital subsidy + concessional debt (PFC/REC/IREDA/SIDBI) + corporate ESG partnership.
- **Knowledge & skill gaps:** 106+ EEE categories create compliance complexity → professional EPR-services partnerships (Karo Sambhav, Hulladek PRO models) + digital compliance (CPCB-portal integration, geo-tagged plant videos, automated quarterly returns) + safe-handling skilling of formalised collectors.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Precious/critical-metal prices at volatile LBMA/LME benchmarks; EPR-credit price uncertainty	Med	Dual revenue (materials + EPR credits); PIBO offtake aggregation via PRO; portfolio of metal streams
Production Feedstock	Dispersed generation below scale; informal kabadi dominance (90-95%) outside traceability	High	SHG/cooperative formalisation + corporate/PSU takeback (Selsmart D2C template); EPR-credit channelled only to authorised recyclers

Operational Supply Chain	/	ZLD+AMR capex intensity + hydro/pyrometallurgical + effluent infrastructure	High	Staged deployment; concessional debt + state subsidy + corporate ESG anchor; low-capacity plant designs
Policy Governance	/	106+ EEE categories + boundary disputes; no state cluster policy	Med	Notify CG cluster policy Q4 2026; professional EPR-services + CPCB-portal digital compliance

10. Stakeholder Matrix & Action Domains

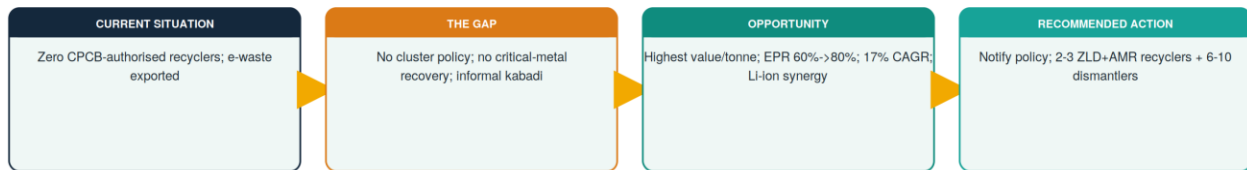
- **State Government / Public Sector:** CECB (CTO licensing, geo-tagged audit, EPR enforcement); CSIDC + Industries Dept (cluster industrial-zone allocation); Urban Admin & Dev Dept + Raipur/Bhilai/Bilaspur/Korba/Durg municipal corporations (collection drives, Swachh Bharat Urban convergence); notify state cluster policy + dedicated industrial-area + EPR-credit revenue floor.
- **Private Sector & Investors:** Attero/RecycleKaro (Tier 3 ZLD+AMR anchors); Karo Sambhav/Hulladek (PRO collection); GG Wastech Raipur (multi-stream EPR); corporate ESG/OEM takeback partnerships; PFC/REC/IREDA/SIDBI debt.
- **Development Agencies & NGOs:** SHG/cooperative mobilisation of kabadi collectors; peri-urban women's collection cooperatives; safe-handling and data-destruction skilling; TA for CPCB-portal onboarding.

11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies E-Waste (Management) Rules 2022 and amendments.
- **CPCB:** Operates centralised EPR portal; registers PIBOs/recyclers; issues EPR certificates; audits returns.
- **CECB (State PCB):** Grants Consent to Operate under plant-and-machinery capacity; geo-tagged inspection; recycler material-flow audit.
- **CSIDC + Industries Department:** E-waste recycling cluster industrial-zone allocation and capital subsidy.
- **Urban Administration & Development Department + Municipal Corporations:** Municipal e-waste collection and Swachh Bharat (Urban) convergence.
- **MeitY / State IT Departments:** PLI for electronics/IT hardware; mediation of government/PSU IT-asset e-waste streams.
- **Bureau of Indian Standards (BIS):** Electronics-recycling standards.
- **NABARD / SIDBI / PFC / REC / IREDA:** Concessional debt and financing for tiered facilities.

Demand & Gap Assessment

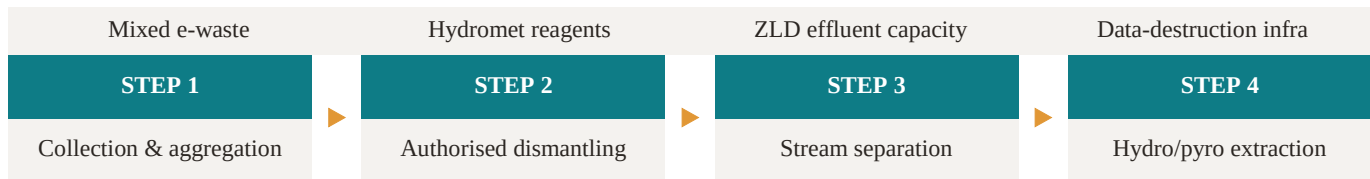
Demand → Gap → Opportunity → Action · E-Waste Recycling



Source: CPCB EPR portal, NITI Aayog, E-Waste Rules 2022

Input / Output Flow

INPUTS



OUTPUTS

Precious metals	Base metals	Critical minerals	Recovered plastics/glass
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Source: CPCB EPR portal, NITI Aayog, E-Waste Rules 2022

C03 Lithium-ion Battery Waste Recycling

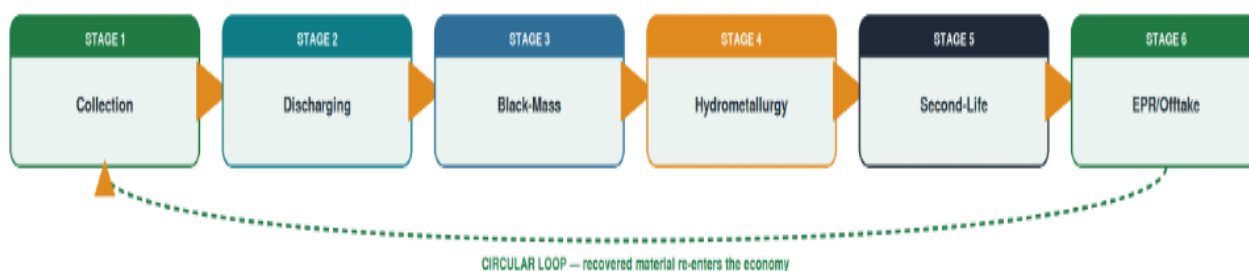
CE · CIRCULAR ECONOMY

The collection, black-mass production, and hydrometallurgical or pyrometallurgical recovery of critical minerals from end-of-life lithium-ion batteries, together with second-life refurbishment of automotive batteries for stationary storage.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
4,000–10,000 direct jobs across collection, black-mass, hydrometallurgy, second-life refurbishment, and EPR services		₹800–2,500 Cr opportunity envelope (GETM 2026–32); Tier 1 collection/black-mass ₹3–4 Cr per 1 TPD; Tier 2 hydrometallurgy ₹25–150 Cr; Tier 3 second-life ₹2–25 Cr		Triple revenue — critical minerals (lithium carbonate USD 11,000–15,000/MT; cobalt USD 33,000–37,000/MT) + BAT-LI EPR credits (₹5–20/kg) + second-life sales/OEM buy-backs (₹10,000–40,000/battery); national resource recovery ~₹2,000 Cr/yr

Value Chain / Circular Flow — Lithium-ion Battery Waste Recycling



Metric	2024–26 Baseline	2030–36 Target
National industry size	India battery recycling USD 152.68M (2025); >50,000 TPA LIB waste; ~60,000 TPA capacity (Lohum 20,000 + Attero 17,500 + Rubamin 10,000)	USD 1,996M by 2034 at 17.98% CAGR; NITI Aayog 128 GWh by 2030; 40x scale-up (2 GWh → ~80 GWh)
Regulatory mandate	BWMR 2022 (amended 2023-2025); material recovery 70% (2024-25); EV collection 70% (2025); CPCB portal 4,022 producers + 487 recyclers (Dec 2025)	Recovery 80% (2025-26) → 90% (2026-27+); collection 100% (2027); recycled content 5% (FY2027-28) → 20% (FY2030-31)
CG position	Urban-industrial battery waste (Raipur, Bhilai-Durg, Bilaspur, Korba); growing EV 2W/3W fleet; ZERO CPCB-registered LIB recyclers; no second-life ecosystem	1-2 in-state CPCB-registered hydrometallurgical recyclers + black-mass units + second-life refurbishment hub; EPR-credit capture
Strategic value	Critical-mineral security — lithium, cobalt, nickel import-dependent; >95% recovery via hydrometallurgy; ₹2,000 Cr/yr resource recovery nationally	Domestic critical-mineral self-reliance feeding EV-battery manufacturing; reduced forex outflow and strategic vulnerability
CG job potential	Informal collection; minimal formal LIB workforce; no second-life skill base	4,000–10,000 direct jobs across collection, black-mass, hydrometallurgy, second-life, and EPR services

2. Contextual Overview

National Context

- India battery recycling market **USD 152.68M (2025) → USD 1,996M by 2034 at 17.98% CAGR** (Inkwood); alt. USD 235.57M by 2030 at 9.06% CAGR (Mordor).

- India generates **>50,000 tonnes LIB waste/yr (CPCB 2024)**; current capacity ~60,000 TPA (Lohum ~20,000, Attero ~17,500, Rubamin ~10,000); 40x scale-up to ~80 GWh by 2030; NITI Aayog 128 GWh demand by 2030.
- BWMR 2022** (amended through 2025): material recovery 70% (2024-25) → 80% (2025-26) → 90% (2026-27+); EV-battery collection 70% (2025) → 100% (2027); recycled-content mandate 5% (FY2027-28) → 20% (FY2030-31).
- Recycled-content mandate** creates structural guaranteed offtake; >95% recovery achievable via hydrometallurgy (seven Indian companies).
- CPCB portal: **4,022 producers + 487 recyclers (Dec 2025)**, over 58 lakh tonnes battery waste processed; second-life market USD 1.70B (2026) → USD 224.24B (2040) at 41.72% CAGR.

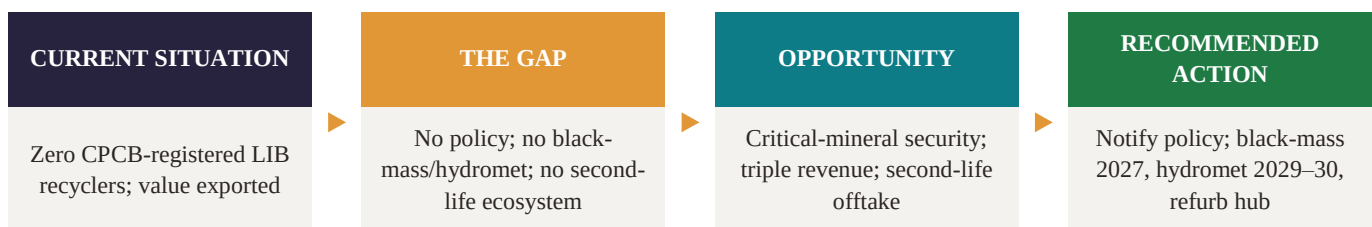
Chhattisgarh Context

- Zero CPCB-registered LIB recyclers**; capacity concentrated in Uttarakhand, NCR, Gujarat, Maharashtra, Telangana.
- Battery-waste from growing EV 2W/3W fleet + electronics + telecom backup + industrial UPS across Raipur, Bhilai-Durg, Bilaspur, Korba — currently informal or out-of-state.
- Critical-mineral-security alignment** — mineral-rich state; positioning as lithium/cobalt/nickel recovery hub aligns with national self-reliance.
- Ready **second-life offtake** via CREDA solar-rooftop + rural electrification + USS/WSH/MMG; upstream cross-VC integration with E-Waste cluster (Attero dual-portfolio); cement co-processing for residuals.
- No state battery-recycling cluster policy; no second-life refurbishment ecosystem.

3. Demand & Supply Assessment

- Supply:** Dispersed, young EV fleet (most batteries not yet end-of-life); telecom/UPS lead-acid + LIB mix; unsafe informal discharging/handling; below hydrometallurgical scale threshold in near term.
- Demand:** Aggressive recovery mandate (70%→90%) + collection 100% by 2027; recycled-content mandate (5%→20%) as guaranteed demand anchor from FY2027-28; second-life offtake from CG renewable-energy portfolio; OEM buy-back tie-ups.
- Supply–Demand Gap:** No in-state black-mass, hydrometallurgical, or second-life capacity — all critical-mineral and BAT-LI credit value captured out-of-state. Intervention establishes CG as a critical-mineral recovery and second-life battery hub.

Demand → Gap → Opportunity → Action · Li-ion Battery Recycling



Source: CPCB, NITI Aayog, Mordor Intelligence, Inkwood Research

4. Market Ecosystem

CG must build collection through critical-mineral recovery plus a second-life segment.

- **Input Suppliers / Feedstock:** EV 2W/3W fleet; consumer electronics; telecom-tower/UPS batteries; informal collectors (to be formalised with safe-handling training).
- **Primary Producers & Aggregators:** Collection + discharging units; black-mass production units; OEM collection tie-ups (Lohum-Tork, Tata Chemicals-Tata Motors models); Gravita tier-2/3 regional collection.
- **Processing & Logistics:** Hydrometallurgical recyclers (>95% recovery); second-life refurbishment/BMS integration; Attero dual-portfolio hydrometallurgy platform.
- **Off-takers & Markets:** EV battery manufacturers (recycled-content mandate); PIBOs buying BAT-LI credits; CREDA/USS/WSH/MMG stationary-storage buyers; OEM buy-back.
- **Enablers:** MoEFCC, CPCB (EPR portal), CECB, CSIDC + Industries Dept, CREDA, Transport Dept, Min. of Heavy Industries (ACC-PLI), Min. of Mines/Critical Mineral Mission, NITI Aayog, BIS; finance via PMFME/AIF/PFC/REC/SIDBI/IREDA + state subsidy.

Market Ecosystem — Lithium-ion Battery Waste Recycling

Input & Feedstock	EV 2W/3W fleet · Electronics batteries · Telecom/UPS + informal collectors
Producers & Aggregators	Collection/discharging units · Black-mass units · OEM tie-ups (Lohum-Tork)
Processing & Logistics	Hydrometallurgical recyclers · Second-life refurbishment · Attero dual-portfolio
Off-takers & Markets	EV battery makers (recycled-content) · PIBOs (BAT-LI credits) · CREDA/USS/WSH storage
Enablers	CPCB / CECB · CSIDC + Industries Dept · CREDA · PFC/REC/SIDBI/IREDA + subsidy

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Informal LIB collectors	Unsafe discharging/handling of hazardous LIBs; thermal-runaway/fire risk; no traceability	Safe-handling skilling (BIS standards) + SHG formalisation + CPCB-portal onboarding
Rural SHG enterprise base (Berchegondi, Sogda, Luikona)	8 SHG/CLFs + 50 women, 20 SHGs, 9 SHGs; transferable to second-life rural energy enterprises	Enable second-life-battery solar+storage micro-utility enterprises
Black-mass hydrometallurgy MSMEs /	Absent in-state black-mass and hydrometallurgical capacity	State cluster policy + hazardous-waste industrial-area allocation + capital subsidy
EV OEMs	Growing 2W/3W fleet needs collection tie-ups and buy-back	Replicate Lohum-Tork / Tata Chemicals-Tata Motors buy-back

		back (₹10,000-40,000/battery)
National recyclers (Attero, Lohum, Tata Chemicals, Gravita)	Seeking anchor sites; low-capacity plant capability	Capital subsidy + industrial-area + recycled-content-mandate offtake floor
CECB + CREDA + Industries	Regulatory consent, second-life deployment, cluster allocation	Recycler/refurbisher CTO + CREDA second-life procurement + cluster policy

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Tier 1 black-mass ROI in 3-4 years (esp. with EPR-credit trading); triple revenue model; Tier 1 + Tier 3 first-wave (lower capex, faster ROI) with Tier 2 hydrometallurgy scaling as feedstock matures and recycled-content mandate takes effect (FY2027-28); Attero FY26 ₹2,000 Cr at 100% YoY validates ceiling.
- **Social Benefits:** Formalises informal collectors with safe-handling livelihoods; SHG-enabled second-life rural energy enterprises; women's inclusion.
- **Environmental & Critical-Mineral Security:** Diverts soil/groundwater contamination and fire hazards; recovers >95% of contained materials; every kg of lithium recovered cuts forex outflow; second-life storage serves rural electrification, telecom backup, solar-rooftop.
- **Technical Feasibility:** Hydrometallurgy pioneered by Lohum/Attero/Tata Chemicals/Rubamin/LICO/SungEel/RecycleKaro; low-capacity plant capability enables sub-flagship CG entry; requires ZLD effluent treatment + process control.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Attero Recycling — India's largest CPCB-authorised e-waste + LIB recycler; NASA-recognised technology; USD 361.5M five-year expansion (May 2024); 4,000→19,500 TPA + 300,000 MT target; FY26 ~₹2,000 Cr at 100% YoY — the dual-portfolio combined e-waste+LIB cluster benchmark for CG (₹50-150 Cr facility, Raipur/Bhilai-Durg, 2029-30). **Lohum Cleantech** — ~20,000→50,000 TPA; only firm licensed to import Li-ion scrap; Tork Motors OEM tie-up (Jan 2024); integrated recycling-plus-second-life — the CG collection/OEM-tie-up + second-life template. **Tata Chemicals** (Tata Motors closed-loop) proves recycled-content circularity; **Gravita India** proves tier-2/3 regional collection matching CG's dispersed geography.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** No black-mass/hydrometallurgy/second-life capacity → notify CG Battery Recycling & Critical-Mineral Recovery Cluster Policy (Q4 2026); launch Tier 1 + Tier 3 first-wave co-located with E-Waste cluster (2027-28); attract Tier 2 hydrometallurgy by 2029-30.
- **Financial barriers:** Tier 2 capex intensity (₹25-150 Cr) → PMFME + AIF + concessional debt (PFC/REC/SIDBI/IREDA) + state capital subsidy + OEM/corporate ESG anchor offtake + recycled-content-mandate guaranteed demand.

- **Knowledge & skill gaps:** Unsafe informal discharging + technology intensity → safe-handling/transport skilling (BIS standards); technology transfer from Attero/Lohum/Tata Chemicals/Gravita/RecycleKaro; battery-passport/QR traceability.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Volatile lithium/cobalt prices; BAT-LI EPR-credit price volatility; recycled-content anchor only from FY2027-28	High	Rising recycled-content mandate + OEM closed-loop supply agreements + long-term offtake contracts + battery-passport traceability
Production Feedstock /	Young EV fleet, dispersed volumes below hydrometallurgical scale	High	Staged deployment — Tier 1 black-mass + import while aggregating; Tier 2 scales as fleet ages + OEM tie-ups mature
Operational Supply Chain /	Thermal-runaway/fire hazards; capex-intensive hydrometallurgy + ZLD effluent	High	Technology partnership (Attero/Lohum/Tata Chemicals) + BIS safe-handling protocols + concessional debt + state subsidy
Policy Governance /	No state cluster/critical-mineral-recovery policy; no second-life ecosystem	Med	Notify cluster policy Q4 2026; CREDA second-life procurement policy; CPCB-portal registration

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (recycler/refurbisher consent, hazardous-waste clearance, audit); CSIDC + Industries Dept (cluster industrial-zone allocation); CREDA (second-life stationary-storage deployment); Transport Dept (EV-fleet data for collection planning); notify cluster policy + critical-mineral-recovery strategy + second-life procurement policy.
- **Private Sector & Investors:** Attero/Lohum/Tata Chemicals/Gravita/RecycleKaro (recycler anchors); EV OEMs (collection tie-ups, buy-back); GG Wastech Raipur (multi-stream EPR); PFC/REC/SIDBI/IREDA debt + corporate ESG.

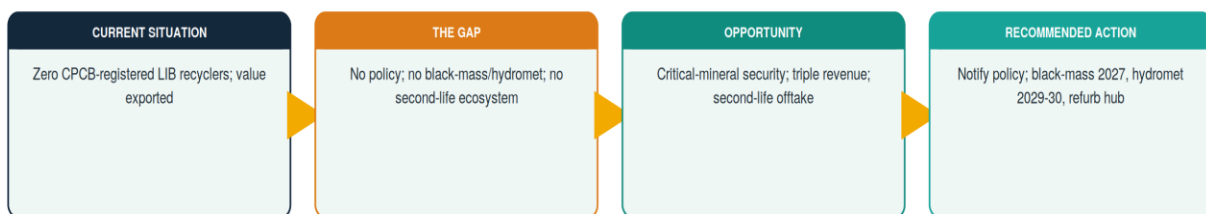
- **Development Agencies & NGOs:** SHG formalisation of collectors with safe-handling training; second-life rural energy micro-utility enterprises; TA for CPCB-portal and battery-passport onboarding.

11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies Battery Waste Management Rules 2022 and amendments.
- **CPCB:** Operates EPR portal; registers producers/recyclers/refurbishers; issues/validates BAT-LI credits; administers Environmental Compensation.
- **CECB (State PCB):** Recycler/refurbisher consent and audit; hazardous-waste handling clearance.
- **CSIDC + Industries Department:** Battery-recycling cluster industrial-zone allocation.
- **CREDA:** Second-life stationary-storage deployment for solar-rooftop and rural electrification.
- **Ministry of Heavy Industries:** EV-adoption schemes + ACC-PLI anchoring domestic battery manufacturing (recycled-content demand).
- **Ministry of Mines / Critical Mineral Mission:** Strategic-mineral-security framing.
- **NITI Aayog:** Battery-demand and critical-mineral roadmap (128 GWh by 2030).
- **Bureau of Indian Standards (BIS):** Battery safe-transport, handling, and recycling standards.

Demand & Gap Assessment

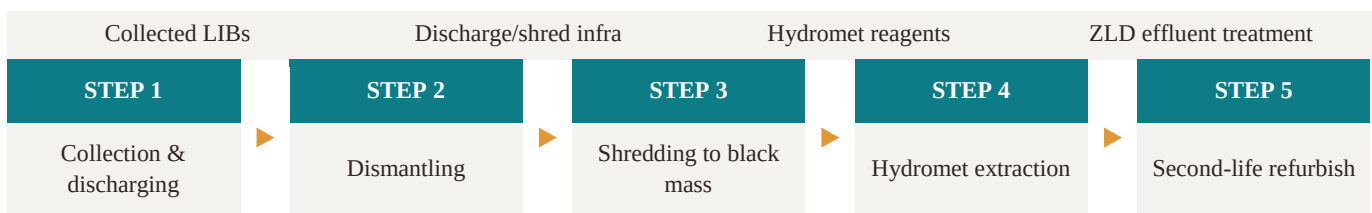
Demand → Gap → Opportunity → Action · Li-ion Battery Recycling



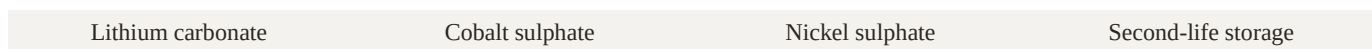
Source: CPCB, NITI Aayog, Mordor Intelligence, Inkwood Research

Input / Output Flow

INPUTS



OUTPUTS



Source: CPCB, NITI Aayog, Mordor Intelligence, Inkwood Research

C04 Tyre Recycling

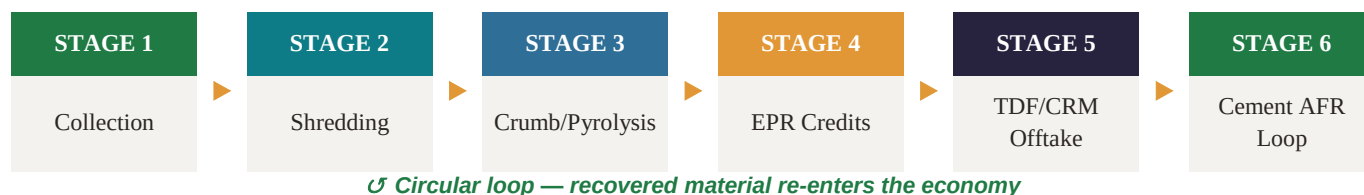
CE · CIRCULAR ECONOMY

The collection, characterisation, processing, and circular recovery of end-of-life tyres (ELTs) into value-added recycled products through mechanical (crumb rubber, reclaimed rubber, steel, fibre), thermal (advanced batch automated pyrolysis producing pyrolysis oil, recovered carbon black, steel and gas), and cement-industry Tyre-Derived Fuel (TDF) co-processing pathways.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
3,500–9,000 direct jobs across organised tyre recycling, transport-and-collection logistics, EPR-portal compliance, and TDF cement co-processing logistics		₹600–1,800 Cr opportunity envelope (GETM 2026–32); Tier 1 mechanical crumb rubber ₹5–30 Cr; Tier 2 advanced batch automated pyrolysis ₹15–80 Cr; Tier 3 TDF cement co-processing logistics ₹2–15 Cr		Dual revenue — physical products (crumb rubber, pyrolysis oil, recovered carbon black, steel) + EPR Certificates ₹15,000–35,000/tonne (20–40% of organised plant revenue)

Value Chain / Circular Flow — Tyre Recycling



Metric	2024–26 Baseline	2030–36 Target
National industry size	~1.5–2.0 MT/yr waste tyre generation (NITI 2026); 1.5–1.8 MT/yr (industry); India = world's 3rd-largest producer/consumer; informal-sector dominance	Full EPR-compliant circular recycling at 100% target; informal sector formalised; ~2.5 MT/yr by 2030 (indicative); G20 Resource Efficiency goal
Regulatory mandate	EPR Regulations 2022 (targets 35%→70%→100%); 2024 CPCB SOP advanced batch automated pyrolysis	Full producer + importer compliance via CPCB portal; advanced pyrolysis SOP enforced; EPR-certificate market matured
Revenue architecture	Dual streams — physical products + EPR Certificates	Stabilised certificate market + matured physical offtake

Metric	2024–26 Baseline	2030–36 Target
	₹15,000–35,000/tonne (20–40% of organised plant revenue)	(CRM roads, sports surfaces, TDF cement)
CG position	Growing vehicle fleet (Raipur/Bhilai-Durg/Bilaspur/Korba); industrial fleets (SAIL/NTPC/NMDC/BALCO); minimal organised capacity; no state policy	3–6 CPCB-EPR-registered organised recyclers; structured TDF supply to CG cement industry; CRM-rubberised state PWD road programme; informal sector formalised
Job potential (CG)	Informal collection + a few small (often non-compliant) pyrolysis units; formal sector minimal	3,500–9,000 direct jobs

2. Contextual Overview

National Context

- India waste tyre generation ~**1.5–2.0 MT/yr (NITI Aayog 2026)**; industry estimate 1.5–1.8 MT/yr for 2025-26; narrow passenger-and-commercial-only estimate 400,000 t (2025) → 600,000 t (2030); India is world's 3rd-largest tyre producer and consumer.
- **EPR Regulations for Waste Tyres 2022** (notified July 2022, operational April 2023, under HOWM Rules 2016 / 2022 Amendment): targets 35% (FY2022-23) → 70% (FY2023-24) → 100% (FY2024-25 onwards) of previous year's production/imports.
- **2024 CPCB SOP for advanced batch automated pyrolysis** (post-NGT upgrade) with stricter fugitive-emissions control; import of tyres for pyrolysis oil/char explicitly banned.
- **EPR Certificate prices ₹15,000–35,000/tonne (2024-25)**, often 20–40% of organised plant revenue — strongest revenue architecture in the Waste & Recycling cluster.
- Documented loopholes (Down To Earth, Nov 2025): import diversion to unauthorised pyrolysis + EPR-credit-only escape route; informal-sector dominance via open burning/low-quality pyrolysis.

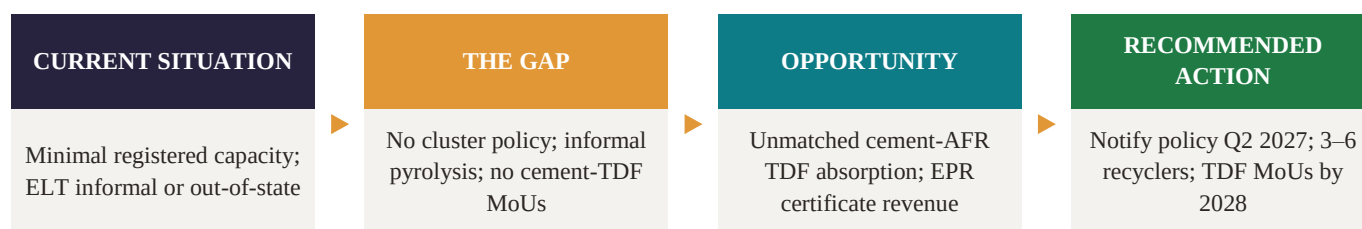
Chhattisgarh Context

- **Greenfield with strong cross-VC alignment** — minimal documented CPCB-EPR-registered organised capacity; most CG waste tyres flow to informal units or out-of-state (Maharashtra, Gujarat, Tamil Nadu).
- Growing vehicle fleet across **Raipur, Bhilai-Durg, Bilaspur, Korba**; substantial industrial/mining off-highway fleets (**SAIL Bhilai, NTPC Korba, NMDC Bailadila, BALCO Korba**) — the most valuable ELT feedstock.
- **CG cement industry** (Ultratech, ACC, Ambuja, Shree around Raipur/Baloda Bazar/Janjgir) provides unmatched **TDF AFR co-processing** absorption density.
- State PWD + PMGSY road network offers **CRM-rubberised-asphalt** demand channel for crumb rubber.
- No notified state Tyre Recycling cluster policy; limited CECB enforcement infrastructure for the 2024 CPCB SOP.

3. Demand & Supply Assessment

- **Supply:** Growing passenger/commercial + off-highway/mining ELT feedstock; industrial-fleet ELT (SAIL/NTPC/NMDC/BALCO) is high-value and easy to channel; currently informal or out-of-state; import-based feedstock discouraged.
- **Demand:** EPR-mandate demand-pull (100% target FY2024-25 onwards) via producers/importers buying EPR Certificates; CG cement-industry TDF AFR absorption; state PWD CRM-rubberised-asphalt roads; crumb-rubber products for sports flooring/playgrounds/footwear.
- **Supply–Demand Gap:** CG generates ELT but has minimal organised processing and no structured cement-TDF MoUs or PWD CRM procurement — value captured out-of-state/informally. Intervention closes the loop in-state via cement-AFR + CRM roads.

Demand → Gap → Opportunity → Action · Tyre Recycling



Source: NITI Aayog, CPCB, Down To Earth

4. Market Ecosystem

CG must build organised recyclers plus cement-AFR and state-PWD demand-pull.

- **Input Suppliers / Feedstock:** Automotive service/retreader workshops; transport yards; industrial/mining fleets (SAIL, NTPC, NMDC, BALCO); informal collectors.
- **Primary Producers & Aggregators:** SHG-cooperative collection (Ambikapur SLW model); transport-and-collection logistics; tyre OEMs holding EPR obligations (Apollo, MRF, JK Tyre, CEAT, Bridgestone, Michelin).
- **Processing & Logistics:** Tier 1 mechanical crumb rubber; Tier 2 advanced batch automated pyrolysis; Tier 3 TDF processing/logistics; national operator templates (Tinna Rubber, Gujarat Reclaim Rubber, Saraf and Sons).
- **Off-takers & Markets:** CG cement plants (TDF AFR); state PWD/Roads & Building (CRM-rubberised asphalt); sports-surface/footwear/moulded-goods buyers; PIBOs buying EPR Certificates.
- **Enablers:** MoEFCC, CPCB (EPR portal + 2024 SOP), CECB, CSIDC + Industries Dept, Transport Dept, PWD, NGT, MoRTH + IRC + BIS (CRM specs), PROs; SHG federations.

Market Ecosystem — Tyre Recycling

Input & Feedstock	Vehicle fleet ELT · Industrial/mining fleets (SAIL/NTPC/NMDC/BALCO) · Retreader workshops
Producers & Aggregators	SHG-cooperative collection · Transport/collection logistics · Tyre OEMs (EPR obligations)
Processing & Logistics	Mechanical crumb rubber · Advanced batch pyrolysis · TDF processing (Tinna/Gujarat Reclaim)

Off-takers & Markets	Cement plants (TDF AFR) · State PWD (CRM roads) · Sports-surface/footwear buyers
Enablers	CPCB (EPR + 2024 SOP) / CECB · CSIDC + Industries Dept · PWD + Transport Dept · IRC/BIS/NHAI + PROs

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Informal waste-tyre collectors	Non-compliant pyrolysis + open burning; migrant/low-income workforce; no traceability	Formalise via SHG-cooperative models (Ambikapur SLW template) under EPR framework
Rural/tribal SHG cooperatives (Berchegondi, Sogda, Luikona)	8 SHG/CLFs + 50 women, 20 SHGs, 9 SHGs; transferable to collection-and-aggregation adjacent to rural transport corridors	Mobilise for small-scale collection near rural transport corridors
Organised MSME recyclers	Minimal CG organised capacity; need technology/partnership	Cluster policy + engage Tinna Rubber/Gujarat Reclaim for technology transfer + partnership
CG industrial-fleet generators (SAIL/NTPC/NMDC/BALCO)	Large off-highway ELT volumes need structured channel	Structured industrial-fleet ELT supply contracts (cross-ref Industrial Waste VC)
CG cement industry (Ultratech/ACC/Ambuja/Shree)	Unmatched AFR-absorption density; needs structured TDF supply	Formal TDF AFR co-processing supply MoUs under CPCB Revised Co-Processing Guidelines
CECB + PWD	Weak SOP enforcement; CRM procurement not mainstreamed	CECB 2024 SOP enforcement + chain-of-custody; PWD CRM Schedule-of-Rates mandate

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Uniquely strong dual revenue — physical products + EPR Certificates (20-40% of organised plant revenue); Tier 1 + Tier 3 first-wave (lower capex, immediately revenue-generating) with Tier 2 pyrolysis scaling as feedstock and SOP-compliance infrastructure mature; aggregator-only operations excluded from EPR-certificate generation.

- **Social Benefits:** Formalises informal waste-tyre collection workforce (often migrant/low-income) into cooperative structures with SHG integration; dignified livelihoods.
- **Environmental & Climate Resilience:** Diverts open-burning/low-quality pyrolysis; TDF substitutes virgin coal/petcoke in cement kilns (scope-1 reduction, pathogen destruction at 2,000°C+); CRM roads extend service life; crumb-rubber circular products.
- **Technical Feasibility:** Proven operator templates (Tinna Rubber CRM-bitumen; Gujarat Reclaim devulcanisation); all CG pyrolysis must meet 2024 CPCB SOP advanced batch automated standard.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Tinna Rubber + Gujarat Reclaim Rubber + CPCB-EPR-registered ecosystem — proven multi-product organised recyclers (crumb rubber/CRM-bitumen for NHAI/state PWD; reclaim rubber/devulcanisation; advanced batch automated pyrolysis) operating the dual-revenue EPR-certificate model — the direct Tier 1 + Tier 2 template for CG's 3-6 organised recyclers by 2028-29. **Cement-industry TDF AFR co-processing** (Ultratech/ACC/Ambuja/Shree) — globally established cement-AFR substitute under CPCB Revised Co-Processing Guidelines; CG's unmatched cement-AFR density makes Tier 3 the natural in-state close-out. **CRM-rubberised-asphalt roads** — IRC/BIS/NHAI specifications with multi-state PWD Schedule-of-Rates precedent (Maharashtra, Gujarat, TN, Karnataka, Kerala) providing the state-procurement demand-pull template for CG PWD.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Minimal organised capacity + no cement-TDF MoUs → notify CG Tyre Recycling Cluster Policy (Q2 2027); build 3-6 CPCB-EPR-registered recyclers by 2028-29; structure cement-TDF AFR supply MoUs by 2028.
- **Financial barriers:** Moderate capex → CPCB-EPR-registration + state PCB authorisation + state tyre/EV-manufacturing incentive convergence; Tier 1 + Tier 3 first-wave (lowest capex, immediate revenue); EPR-certificate revenue layer underpins viability.
- **Knowledge & skill gaps:** 2024 CPCB SOP compliance + regulatory loopholes → CECB enforcement + chain-of-custody discipline; engage national operators (Tinna Rubber, Gujarat Reclaim) for technology transfer; SHG-cooperative collection training.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Virgin raw materials often more cost-competitive than recycled; recycled-product quality-standards gap	Med	State PWD CRM procurement mandates + cement-TDF MoUs + green-procurement preference to close cost gap

Production Feedstock	/	Dispersed passenger-vehicle ELT; informal-sector dominance	Med	Channel high-value industrial/mining off-highway ELT (SAIL/NTPC/NMDC/BALCO); SHG-cooperative collection
Operational Supply Chain	/	Non-compliant pyrolysis; fugitive emissions; import diversion to unauthorised units	High	Strict adherence to 2024 CPCB SOP advanced batch automated pyrolysis; CECB + CPCB chain-of-custody; prioritise domestic ELT over imports
Policy Governance	/	No state cluster policy; EPR-credit-only escape route; weak enforcement	High	Notify cluster policy Q2 2027; CPCB-EPR-portal traceability; CECB enforcement discipline over credit-only route

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (HOWM 2016 + 2022 EPR + 2024 SOP authorisation and enforcement); CSIDC + Industries Dept (cluster industrial-area allocation); Transport Dept (ELT data + retreader mapping); PWD + Roads & Building (CRM-rubberised-asphalt procurement mandate — the key demand-pull).
- **Private Sector & Investors:** Tinna Rubber/Gujarat Reclaim/national recyclers (Tier 1/2 operators); tyre OEMs (EPR obligations); CG cement plants (TDF AFR absorption); industrial-fleet operators (ELT supply); PROs.
- **Development Agencies & NGOs:** SHG-cooperative formalisation of informal collectors (Ambikapur SLW model); collection-and-aggregation near rural transport corridors; TA for CPCB-portal compliance.

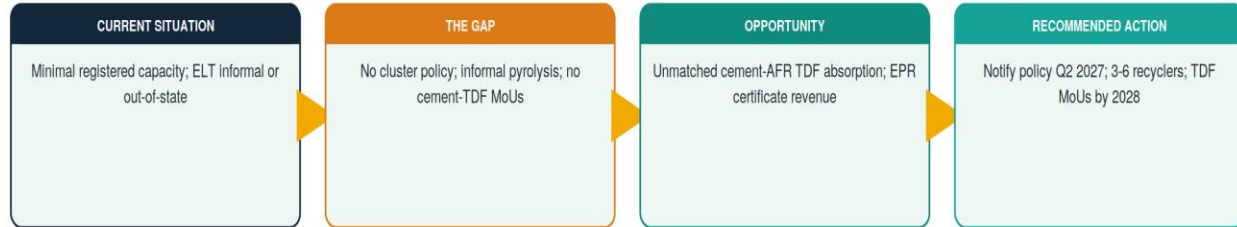
11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies EPR Regulations for Waste Tyres 2022 under HOWM Rules 2016 (2022 Amendment).
- **CPCB:** Operates EPR portal (certificate generation/trading/reporting); issues 2024 SOP for advanced batch automated pyrolysis + permitted-end-product guidelines.
- **CECB (State PCB):** Tyre-recycling facility authorisation + 2024 SOP enforcement + chain-of-custody.
- **CSIDC + Industries Department:** Tyre-recycling cluster industrial-area allocation.
- **CG Transport Department:** State vehicle-fleet ELT data + retreader/workshop ecosystem mapping.
- **CG PWD + Roads & Building Department:** CRM-rubberised-asphalt procurement (state-tier demand-pull).
- **NITI Aayog + NGT:** Circular-economy roadmap and judicial oversight (NGT case drove the 2024 SOP).

- **MoRTH + IRC + BIS:** CRM-rubberised-bitumen specifications for road construction.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Tyre Recycling



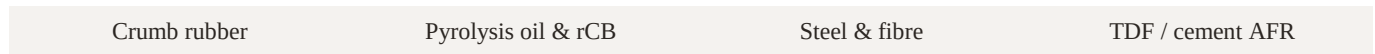
Source: NITI Aayog, CPCB, Down To Earth

Input / Output Flow

INPUTS



OUTPUTS



Source: NITI Aayog, CPCB, Down To Earth

C05 Construction & Demolition Waste Recycling

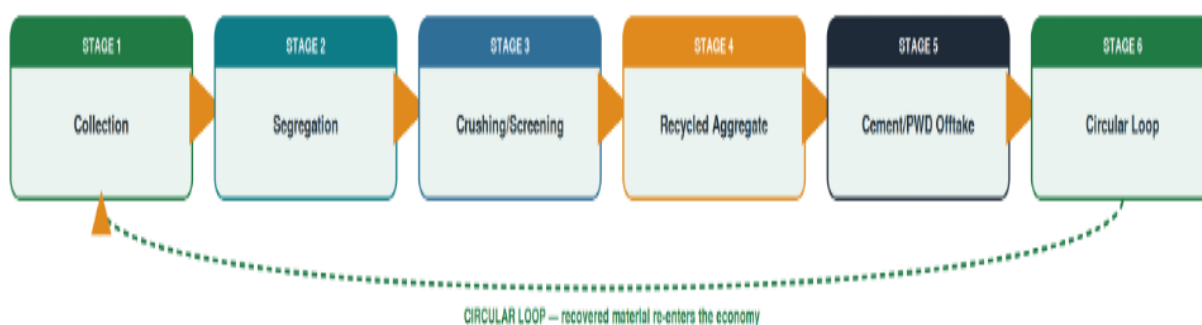
CE · CIRCULAR ECONOMY

The recovery and processing of building materials, debris, and rubble (concrete, brick, mortar, tile, ceramics, wood, glass, plastic, and metal) from construction, remodelling, repair, and demolition into recycled aggregates, manufactured sand, paver blocks, and other recycled-content construction products, with cement-industry co-processing for non-recoverable residuals.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
8,000–18,000 direct jobs (collection, processing, recycled-product manufacturing, transport, cement co-processing logistics)		₹1,500–4,000 Cr opportunity envelope (GETM 2026–32). Capex tiers — Tier 1 centralised recycling plants ₹15–100 Cr/facility (80–200 FTE); Tier 2 collection-and-aggregation + transport ₹50 lakh–5 Cr/node (20–50 FTE + 10–30 FTE/transport unit); Tier 3 cement co-processing + recycled-content offtake ₹2–15 Cr/unit (40–100 FTE)	Cr	CEEW Odisha-benchmark ambitious scenario USD 21–27 million cumulative market opportunity (2024–30); three convergent revenue streams — EPR tipping fees, recycled-product sales (aggregates/M-sand/paver blocks), cement co-processing revenue

Value Chain / Circular Flow — Construction & Demolition Waste Recycling



Metric	2024–26 Baseline	2030–36 Target
National industry size	India C&D generation 150–500 MT/yr (MoHUA 2024); >500 MT/yr by 2025 (3rd-largest construction market); 16 (2019) → 34 (2024) plants + 36 proposed	Approaching 100% recycling (Delhi trajectory); Japan-style 90%+ recycling rate by 2030–32; circular construction sector
Regulatory mandate	C&D Waste Management Rules 2025 (effective 1 April 2026); EPR for producers ≥20,000 sqm; CPCB portal; 2016 Rules superseded	EPR recycling 25% (FY2025–26) → 100% (FY2028–29); recycled-content utilisation 5% (FY2026–27) → 25% (FY2030–31); SPCB enforcement infrastructure

Metric	2024–26 Baseline	2030–36 Target
CG position	Rapidly growing urban construction (Raipur/Bhilai-Durg/Bilaspur/Korba) + tier-2; ZERO documented large-scale plant; informal dumping prevalent	3–6 in-state recycling plants; recycled-aggregate offtake to cement industry + Sustainable Housing + PMAY; cement co-processing for residuals
Cross-VC anchor	CG cement industry (co-processing + aggregate offtake); Sustainable Housing demand-pull; SBM Urban 2.0 priority	Integrated C&D + Sustainable Housing + cement co-processing + SBM Urban 2.0 + PMAY cluster
Job potential (CG)	Informal dumping + small-scale brick reuse; minimal formal recycling workforce	8,000–18,000 direct jobs

2. Contextual Overview

National Context

- **Largest waste stream by volume:** BMTPC estimated 100 MT/yr (2018); MoHUA projected 150–500 MT/yr by 2024; CFlo estimates >500 MT/yr by 2025 as India becomes the world's third-largest construction market.
- **Regulatory transformation:** Environment (C&D) Waste Management Rules 2025 (notified MoEFCC, effective 1 April 2026) introduce mandatory EPR for producers with built-up area $\geq 20,000$ sqm, superseding the 2016 Rules.
- **Steep EPR curve:** Recycling targets rise 25% (FY2025-26) $\rightarrow$ 50% $\rightarrow$ 75% $\rightarrow$ 100% (FY2028-29 onwards); recycled-content utilisation mandated 5% (FY2026-27) $\rightarrow$ 25% (FY2030-31).
- **Underbuilt infrastructure:** Processing plants grew 16 (2019) $\rightarrow$ 34 (2024), with 36 more proposed across 10 states; geographical distribution misaligned with waste generation.
- **Global template:** Japan's Construction Material Recycling Law lifted recycling from ~60% (1990s) to 90% (2024) — the mandate-driven benchmark the 2025 Rules emulate.

Chhattisgarh Context

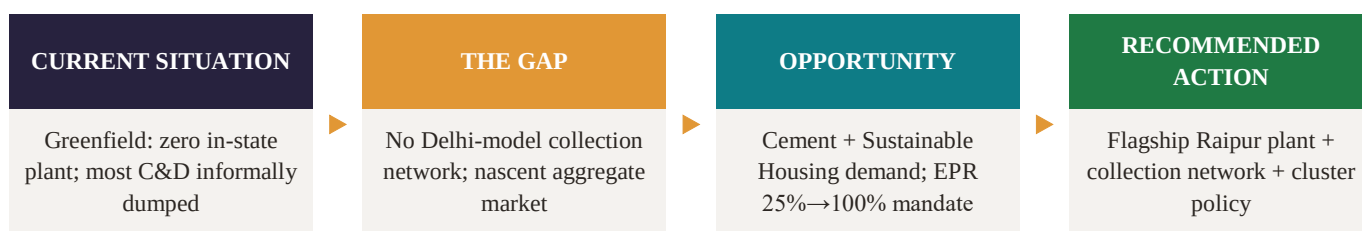
- **Greenfield position:** No documented MCD-Jahangirpuri-scale or Burari-scale C&D recycling plant; no notified state C&D cluster policy; most urban C&D waste dumped in low-lying areas, informal dumpsites, or used for unscientific filling.
- **Dual-anchor cement advantage:** Large CG cement industry (Ultratech, ACC, Ambuja, Shree Cement around Raipur/Baloda Bazar/Janjgir) provides both AFR co-processing for residuals AND captive offtake for recycled aggregates — density no other Indian state matches.
- **Sustainable Housing demand-pull:** PMAY-G/U 2.0 + AVEI + Bhavya Srishti Udyog provide the most directly aligned recycled-content-product offtake of any GETM value chain.
- **SBM Urban 2.0 convergence:** The ₹1,41,678 Cr outlay (2021–26) explicitly includes C&D waste in its six-pronged focus.

- **Growing feedstock:** Rapidly expanding urban construction in Raipur, Bhilai-Durg, Bilaspur, Korba and tier-2 cities generates regulation-mandated recycling feedstock under the 2025 Rules.

3. Demand & Supply Assessment

- **Supply:** C&D waste generated at urban construction/demolition sites across Raipur, Bhilai-Durg, Bilaspur, Korba and tier-2 cities; currently informally dumped. National benchmark plants MCD Jahangirpuri (2,000 TPD, 7 acres) and EverEnviro Burari (2,000 TPD); Delhi 6,500 TPD debris daily served by 106 public collection points + 4 bulk-generator points. Bulk generators ($\geq 20,000$ sqm) become the regulated aggregation base under the 2025 Rules.
- **Demand:** EPR-driven mandatory recycling (25%→100% by FY2028-29) plus recycled-content utilisation mandate (5%→25% by FY2030-31); buyer segments — CG cement/RMC operations, Sustainable Housing/PMAY, state PWD public works, private developers.
- **Supply–Demand Gap:** No in-state processing capacity converting a regulation-mandated feedstock stream into recycled aggregates/M-sand/paver blocks; nascent demand-pull with contractor preference for virgin material until the utilisation mandate matures. The intervention builds in-state plants + collection network + demand-pull contracts to close this gap.

Demand → Gap → Opportunity → Action · C&D Waste Recycling



Source: MoHUA, CPCB, CEEW, BMTPC

4. Market Ecosystem

The C&D ecosystem links urban bulk generators, industrial-area recyclers, and CG's cement-and-housing offtake anchors.

- **Input Suppliers:** Bulk-generator real-estate developers + commercial/industrial construction firms ($\geq 20,000$ sqm); ULB collection yards; MGNREGA (now VBGRAM-G) (now VBGRAM-G)/PMAY rural construction streams.
- **Primary Producers & Aggregators:** ULB collection-and-transfer points (Delhi 106-point model); GPS-tracked transport fleets meeting CPCB standards; municipal corporations across Raipur, Bhilai, Bilaspur, Durg, Korba, Raigarh, Rajnandgaon, Jagdalpur, Ambikapur, Dhamtari, Mahasamund.
- **Processing & Logistics:** C&D recyclers on MCD Jahangirpuri / EverEnviro Resource Management templates; CFlo Industries as equipment-and-technology partner; mobile + stationary crushing/screening/washing lines.
- **Off-takers & Retail:** CG cement industry (Ultratech, ACC, Ambuja, Shree Cement) for cement/RMC + AFR co-processing; Sustainable Housing (PMAY-G/U 2.0); state PWD + Roads & Building Dept public works.

- **Enablers:** MoEFCC/CPCB (portal, EPR certificates); CECB (SPCB authority); UADD, CSIDC + Industries Dept; SBM Urban 2.0 + 15th Finance Commission grants + state capital subsidy; BIS, Indian Roads Congress, IGBC.

Market Ecosystem — C&D Waste Recycling

Input & Feedstock	Bulk generators ≥20,000 sqm · ULB collection yards · MGNREGA/PMAY streams
Producers & Aggregators	ULB collection-transfer points · GPS-tracked transport fleet · Municipal corporations
Processing & Logistics	C&D recyclers (MCD/EverEnviro) · CFlo equipment partner · Mobile crushing units
Off-takers & Markets	CG cement/RMC industry · Sustainable Housing/PMAY · State PWD public works
Enablers	MoEFCC/CPCB EPR portal · CECB SPCB · SBM Urban 2.0 + state subsidy

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CG Cement Industry (Ultratech/ACC/Ambuja/Shree)	Dual-anchor role (residual co-processing + recycled-aggregate market); needs structured supply MoUs	Facilitate cement-and-RMC recycled-aggregate supply contracts + AFR co-processing agreements
Sustainable Housing / PMAY offtakers	Most directly aligned demand-pull; needs recycled-content product specs + reliable supply	Mandate recycled-content in PMAY-G/U + AVEI + Bhavya Srishti procurement
National C&D Recyclers (EverEnviro, MCD-operator, CFlo)	Proven operator/equipment templates; seek anchor sites + offtake certainty	Engage on operator-plus-equipment-partner model for flagship Raipur plant
Bulk Producers (developers ≥20,000 sqm)	Limited EPR registration and compliance preparedness	Early CPCB-portal registration outreach + producer waste-management-plan support
CECB + UADD + CSIDC + CG PWD	No cluster policy, no portal-tracked EPR infrastructure	Notify CG C&D Cluster Policy by Q1 2027; build SPCB infrastructure within 1-year window
Rural PMAY + MGNREGA (now VBGRAM-G) (now VBGRAM-G) construction (FGD geographies)	Small-scale rural C&D streams + downstream recycled-product demand	Integrate rural construction into cluster demand + collection design

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Uniquely strong due to three convergent revenue streams — mandatory EPR tipping fees, recycled-product sales (Delhi PWD schedule-of-

rates + Indiamart price anchors), and cement co-processing revenue. Capex ₹15–100 Cr (Tier 1), ₹50 lakh–5 Cr (Tier 2), ₹2–15 Cr (Tier 3); build periods 6–24 months; CEEW Odisha benchmark USD 21–27 million (2024–30).

- **Social Benefits:** Formalises informal dumping/small-scale brick reuse into a structured workforce; 8,000–18,000 direct jobs; institutional capability transfer from CG's Ambikapur SLW leadership.
- **Environmental & Climate Resilience:** Diverts India's single largest waste stream from landfills/informal filling; substitutes virgin aggregate and sand; cement co-processing recovers energy from non-recoverable residuals; targets Japan-benchmark 90%+ recycling trajectory.
- **Technical Feasibility:** Proven at scale — MCD Jahangirpuri (2,000 TPD, 7 acres) and EverEnviro Burari (2,000 TPD); mobile crushing units serve tier-2 cities below stationary-plant threshold; scalable across CG's urban belt.

7. Success Stories & Proven Models

Proven Models & Benchmarks

MCD Jahangirpuri (Delhi, 2024) — India's largest C&D recycling plant (2,000 TPD, ~7 acres) processing debris from across Delhi (6,500 TPD daily) into recycled aggregates, M-sand, paver blocks, kerb stones, RCC/hollow blocks and bedding sand — the direct template for a 1,500–2,000 TPD flagship Raipur plant on 6–8 acres.

EverEnviro Resource Management — market leader in C&D management (Burari, 2,000 TPD) with integrated urban/agro/hazardous waste and Compressed Biogas operations plus CFlo equipment partnership — proves the cross-waste-stream integrated-operator model CG should engage.

Japan's Construction Material Recycling Law (60%→90%, 1990s–2024) is the mandate-driven trajectory benchmark for CG's 75%+ by FY2028-29 and 90%+ by FY2032-33 targets.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Zero in-state MCD-scale plant + no Delhi-equivalent collection architecture → commission flagship Raipur plant by 2028-29 (replicate at Bhilai-Durg, Bilaspur, Korba); deploy 30–60 collection points per major city + 2–5 bulk-generator points; mobile crushing units for tier-2 cities.
- **Financial barriers:** High Tier 1 capex + nascent recycled-aggregate market → channel SBM Urban 2.0 + state capital subsidy + ULB matching + 15th Finance Commission grants + EPR-fee revenue + recycled-aggregate sales.
- **Knowledge & skill gaps:** Limited bulk-generator compliance readiness + operator capability → CPCB-portal registration outreach, producer waste-management-plan support, and operator engagement (EverEnviro/CFlo-type partnerships) with skilling for crushing/screening/logistics roles.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Recycled-aggregate/M-sand demand resistance; utilisation mandate begins gradually at 5% (FY2026-27)	High	Cement/RMC supply contracts + Sustainable Housing offtake + PWD/ULB tender mandates on Delhi PWD schedule-of-rates model + cement co-processing for residuals
Production Feedstock	Waste-aggregation and geographical-distribution misalignment	Medium	District-level facility siting (Raipur first); bulk-generator ($\geq 20,000$ sqm) enforcement to aggregate flow; mobile crushing for tier-2
Operational Supply Chain	EPR compliance + portal-tracking immaturity; 2016 Rules lacked traceability	Medium	Early CPCB-portal registration + SPCB infrastructure build-out within 1-year window + bulk-generator engagement
Policy / Governance	No notified state cluster policy or incentive framework	High	Notify CG C&D Recycling Cluster Policy by Q1 2027 as early-mover state attracting central support

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (SPCB compliance, producer registration, CPCB-portal integration); UADD (ULB collection yards/recycling plants); CSIDC + Industries Dept (industrial-area allocation); CG PWD + Roads & Building Dept (recycled-aggregate utilisation in public works); State Housing Board + RERA (PMAY/Sustainable Housing integration).
- **Private Sector & Investors:** CG cement industry (offtake + AFR); national C&D recyclers (EverEnviro/CFlo) for PPP plant operations; bulk real-estate developers as EPR-obligated producers; recycled-product processing and technology investment.
- **Development Agencies & NGOs:** Capacity building for ULB and producer compliance; SHG/cooperative integration in collection/transport tiers; technical assistance for cluster policy design and CPCB-portal onboarding.

Stakeholder	Role in Scale-Up	Recommended Action / Point for Action
MoEFCC / CPCB	2025 Rules, portal, Steering Committee	Launch and maintain the tracking portal; support CG early-mover cluster; audit compliance
CECB (state SPCB)	2025 Rules implementation and enforcement	Build compliance infrastructure by Q4 2026; register bulk producers; enforce EPR targets
UADD / ULBs	Collection network and reuse supervision	Deploy Delhi-model collection network by 2028; establish collection yards and storage
CSIDC / CG Industries Dept	Cluster policy and land allocation	Notify CG C&D Cluster Policy by Q1 2027; allocate industrial-area sites
CG cement industry (Ultratech/ACC/Ambuja/Shree)	AFR co-processing aggregate offtake +	Sign recycled-aggregate supply and residual co-processing contracts
CG PWD / State Housing Board / RERA	Demand-pull via public works and housing	Mandate recycled-content in public works and PMAY/Sustainable Housing by 2029–30
National recyclers (EverEnviro, CFlo)	Operator and equipment templates	Partner on flagship Raipur plant and cross-waste-stream operations by 2028–29
Bulk producers (developers ≥20,000 sqm)	EPR obligation holders	Register on CPCB portal; submit waste-management plans; pay tipping fees
PRI / rural ULBs (PMAY-G, MGNREGA (now VBGRAM-G) (now VBGRAM-G))	Rural C&D generation and reuse demand	Channel rural construction waste and absorb recycled-content products

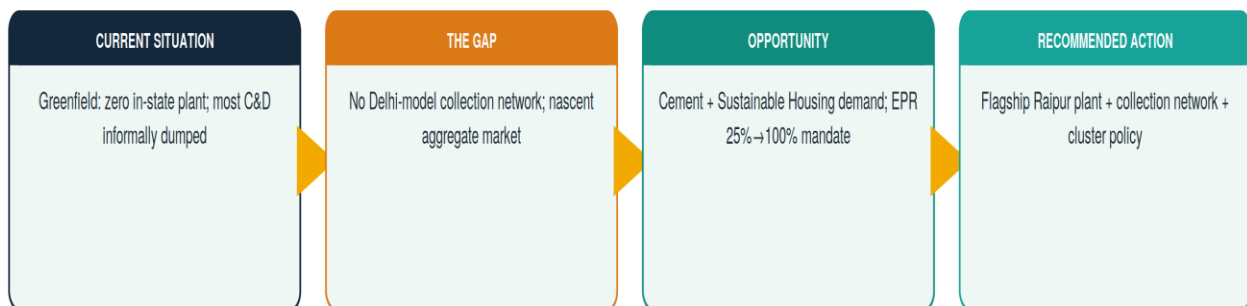
11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies C&D Waste Management Rules 2025; central regulatory authority.
- **CPCB:** Chairs Central Steering Committee; operates tracking portal (6-month launch), EPR certificates, revenue-sharing, annual data, violation audits.
- **MoHUA:** Administers SBM Urban 2.0 (C&D one of six prongs) + PMAY-Urban 2.0 demand integration.
- **Ministry of Rural Development:** PMAY-Gramin demand-side integration.
- **CECB (Chhattisgarh Environment Conservation Board):** SPCB authority — 2025 Rules implementation within 1-year window, producer registration, EPR enforcement.

- **Urban Administration & Development Dept (UADD):** ULB coordination — collection yards, recycling plants, storage, reuse supervision.
- **CSIDC + Industries Dept:** C&D recycling cluster industrial-area allocation.
- **CG PWD + Roads & Building Dept:** Recycled-aggregate utilisation in state public works.
- **BIS + Indian Roads Congress:** Recycled-construction-material and roads-and-bridges specifications.

Demand & Gap Assessment

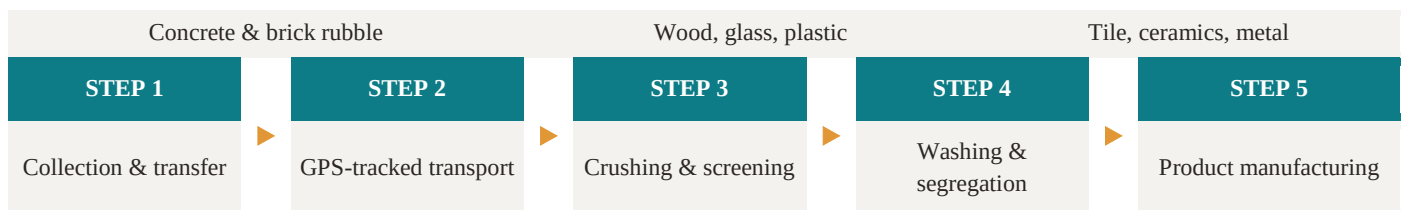
Demand → Gap → Opportunity → Action · Construction & Demolition Waste Recycling



Source: MoHUA, CPCB, CEEW, BMTPC

Input / Output Flow

INPUTS



OUTPUTS

Recycled aggregates M-sand Paver blocks & kerbs RCC/hollow blocks

Source: MoHUA, CPCB, CEEW, BMTPC

C06 Bio-Medical Waste Recycling

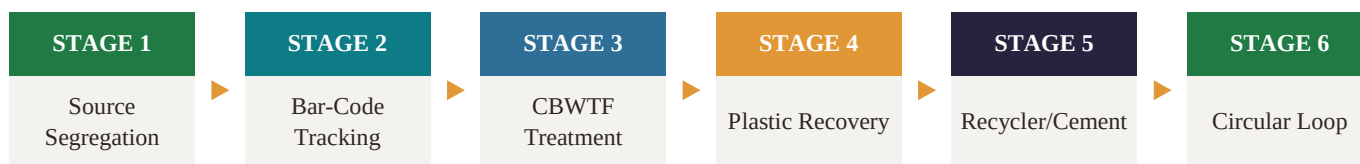
CE · CIRCULAR ECONOMY

The collection, segregation, treatment, and circular recovery of waste generated by healthcare facilities — from source segregation into colour-coded streams through Common Bio-Medical Waste Treatment Facilities (CBWTFs) using incineration, autoclaving, microwaving, and plasma pyrolysis, with downstream plastic-waste circular recovery for disinfected red-category plastics.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
3,000–7,000 direct jobs (CBWTF operations, transport logistics, healthcare-worker BMW training, circular plastic-recovery integration) — a smaller but uniquely high-compliance-intensity workforce		₹400–1,500 Cr opportunity envelope (GETM 2026–32). Capex tiers — Tier 1 CBWTF ₹15–50 Cr/facility (60–150 FTE); Tier 2 HCF handling infrastructure ₹2–25 lakh/facility (5–15 FTE per medium HCF); Tier 3 circular plastic-recovery + transport ₹2–15 Cr/unit (25–60 FTE)		India BMW management market USD 450.91M (2025) → USD 628.29M (2030) at 6.86% CAGR (Mordor) or USD 2.32B (2024) → USD 3.53B (2030) at 7.11% CAGR (TechSci); tipping-fee model ₹15–50/kg plus Tier 3 recycled-plastic revenue

Value Chain / Circular Flow — Bio-Medical Waste Recycling



Metric	2024–26 Baseline	2030–36 Target
National industry size	BMW generation ~619–774 TPD (~743 TPD in 2023); India BMW market USD 450.91M (2025); 218 CBWTFs serving 393,242 HCFs; 8 states/UTs without CBWTF	USD 628.29M by 2030 at 6.86% CAGR (Mordor); USD 3.53B by 2030 at 7.11% CAGR (TechSci); full CBWTF coverage; 165 MT/yr by 2030 (CPCB forecast)
Regulatory mandate	BMW Rules 2016 (amended 2018, 2019); CPCB CBWTF Guidelines 2025 (12 April 2025) — gap analysis, 75 km radius, 48-hour treatment, captive restricted; OCEMS + CBST-BMW	Full statutory compliance + standardised 5-year gap analysis + 100% bar-code tracking + zero-violation enforcement
CG position	Hospital infrastructure (Raipur/Bhilai/Bilaspur/Korba + all district hospitals); rural PHC/CHC network; CBWTF coverage limited vs Ambikapur-grade SLW leadership	Full CBWTF coverage of all districts within 75 km radius; circular plastic-recovery integration; CG bar-coded-tracking exemplar

Metric	2024–26 Baseline	2030–36 Target
Circular recovery	WHO: 85% of healthcare waste non-hazardous if segregated; red-category disinfected plastics permitted for shredding + licensed recycling	Recovered biomedical plastics feed CG Plastic Waste Recycling cluster; cement co-processing for non-recoverable residuals
Job potential (CG)	Concentrated in existing CBWTFs; healthcare-worker training gap; high-compliance-intensity workforce	3,000–7,000 direct jobs

2. Contextual Overview

National Context

- **Generation scale:** India generates ~619–774 TPD of biomedical waste (~743 TPD in 2023); CPCB forecasts growth to 165 MT/year by 2030.
- **Serving infrastructure:** 218 operational CBWTFs covering 393,242 healthcare facilities; 208 of 218 have adopted CBST-BMW bar-code tracking + OCEMS; 8 states/UTs still without any CBWTF.
- **2025 regulatory strengthening:** CPCB CBWTF Guidelines (notified 12 April 2025) introduce standardised 5-year gap analysis (Appendix I), 75 km service radius, 48-hour treatment timeline, captive-treatment restriction to remote/hilly regions, mandatory OCEMS, and CBST-BMW.
- **Compliance intensity:** CPCB found 29,062 HCFs violating BMW provisions and issued 15,355 show-cause notices — the highest-compliance-intensity waste value chain.
- **Circular opportunity:** WHO estimates 85% of healthcare waste is non-hazardous and recoverable if segregated; BMW Rules 2016 permit disinfected red-category plastics to be shredded and dispatched to licensed recyclers.

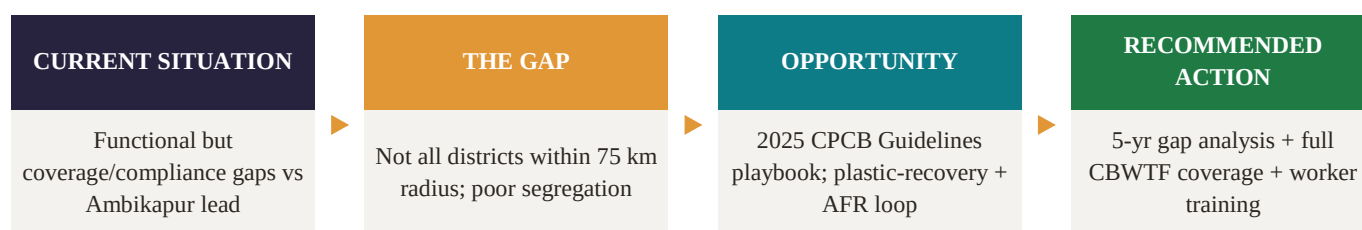
Chhattisgarh Context

- **Functional but lagging:** CG's BMW position mirrors the national-average compliance pattern rather than the Ambikapur-grade leadership it achieves in solid-waste management.
- **Hospital base:** Raipur (AIIMS + Pt. JN Memorial Medical College + Apollo/Ramkrishna CARE/Aurobindo), Bhilai (SAIL hospital), Bilaspur, Korba, all 33 district hospitals, plus expanding private nursing homes.
- **Rural network exposure:** PHCs, CHCs, sub-centres and Ayushman Arogya Mandirs across rural blocks generate BMW requiring compliant handling — the 75 km coverage-radius challenge.
- **Cross-VC integration:** Disinfected red-category plastic can feed the CG Plastic Waste Recycling cluster (GG Wastech Raipur + downstream converters); non-recoverable residuals to cement co-processing (Ultratech/ACC/Ambuja/Shree Cement).
- **Growing feedstock:** Ayushman Bharat/PMJAY-enabled access expansion drives a structurally growing biomedical waste stream needing proportional CBWTF capacity.

3. Demand & Supply Assessment

- **Supply:** BMW generated at HCFs — hospitals, nursing homes, clinics, diagnostic labs, blood banks, pathology/dental clinics, AYUSH and veterinary establishments; segregated into colour-coded streams (yellow/red/white/blue). CBWTF capacity is currently limited relative to the 75 km service radius across CG districts.
- **Demand:** Regulation-mandated — every HCF is legally obligated to use a compliant CBWTF, making BMW recycling among the most demand-secure waste segments in India; downstream demand for disinfected red-category plastic from licensed recyclers.
- **Supply–Demand Gap:** CBWTF coverage gaps in rural-block geographies; healthcare-worker training and segregation-at-source gaps at smaller HCFs; underdeveloped circular plastic-recovery pathway — the intervention closes coverage and captures the 85%-recoverable material stream.

Demand → Gap → Opportunity → Action · Bio-Medical Waste Recycling



Source: Mordor Intelligence, TechSci, CPCB, WHO

4. Market Ecosystem

The BMW ecosystem spans healthcare generators, industrial-area CBWTFs, and cross-VC plastic-and-cement offtake.

- **Input Suppliers:** HCFs (government/private/AYUSH/veterinary); rural PHC/CHC/sub-centre network; colour-coded segregation bin and PPE suppliers.
- **Primary Producers & Aggregators:** HCF waste-management staff; dedicated GPS-tracked BMW transport fleets (sealed/leak-proof, trained handlers) meeting CPCB standards; on-site 48-hour temporary storage.
- **Processing & Logistics:** CBWTF operators (Synergy Waste Management, Mumbai Waste Management, Biotic Waste Solution, SMS Water Graca BMW, GreenTech Environ) — incineration/autoclaving/microwaving/plasma pyrolysis + ETP + OCEMS + CBST-BMW.
- **Off-takers & Markets:** CPCB-licensed plastic recyclers (CG Plastic Waste Recycling cluster; GG Wastech Raipur); cement co-processing partners (Ultratech/ACC/Ambuja/Shree Cement) for residuals; scrap recyclers for sterilised metallic sharps.
- **Enablers:** MoEFCC/CPCB (Guidelines, CBST-BMW, OCEMS); CECB (SPCB authority); CG Health Dept + NHM; DM/CMHO + District Monitoring Committee; NGT judicial oversight.

Market Ecosystem — Bio-Medical Waste Recycling

Input & Feedstock	Hospitals & HCFs · Rural PHC/CHC network · Segregation bin/PPE suppliers
Producers & Aggregators	HCF waste-mgmt staff · GPS-tracked BMW transport · 48-hour on-site storage
Processing & Logistics	CBWTF operators · Incineration/autoclave/OCEMS · CBST-BMW shredding lines
Off-takers & Markets	CPCB-licensed plastic recyclers · Cement co-processing · Metallic-sharps scrap
Enablers	MoEFCC/CPCB CBWTF Guidelines · CECB SPCB · CG Health Dept + NHM

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CG Hospital Infrastructure (waste generators)	Segregation and bar-coded tracking compliance anchors; training gaps	Mandate segregation discipline + CBST-BMW onboarding across all HCFs
CECB + CG Health Dept + DM/CMHO	SPCB authority; no state-wide gap analysis yet	Conduct standardised 5-year gap analysis (Appendix I) by Q2 2026
National CBWTF Operators (Synergy/Mumbai/Biotic/SMS/GreenTech)	Proven CPCB-Guidelines-2025-compliant operator template	Engage operators for CG CBWTF expansion following gap analysis
Upstream Plastic Waste Recycling cluster	Destination for disinfected red-category plastic + residual co-processing	Establish CPCB-licensed-recycler agreements with CBST-BMW chain-of-custody
Rural Healthcare Network (FGD geographies)	Underserved tier outside 75 km compliant coverage	Bring PHC/CHC/sub-centres within 75 km CBWTF service radius
Healthcare Workers (all HCF categories)	BMW-handling training gap — most cited national compliance challenge	Launch state-wide healthcare-worker BMW-handling training by 2027

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Tipping-fee model (~₹15–50/kg by category/location) with regulation-mandated demand security; supplemented by Tier 3 circular plastic-recovery revenue and modest energy-recovery from incineration. Capex ₹15–50 Cr (Tier 1 CBWTF), ₹2–25 lakh (Tier 2 HCF), ₹2–15 Cr (Tier 3); build periods 12–36 months.
- **Social Benefits:** Public-health-critical, high-job-stability, dignified employment; SHG-cooperative integration in non-clinical tiers (transport logistics, recovered-plastic shredding/aggregation); protects HCF and community health through safe handling.

- **Environmental & Climate Resilience:** Closes the WHO 85%-recoverable gap; diverts non-infectious plastics from incineration/dumping; OCEMS controls emissions; cement co-processing safely recovers energy from non-recoverable residuals.
- **Technical Feasibility:** Engineering-intensive but proven — four BMW Rules-recognised treatment technologies (incineration/autoclaving/microwaving/plasma pyrolysis) + ETP + OCEMS + CBST-BMW; 208/218 national CBWTFs already on digital-compliance infrastructure.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Synergy / Mumbai Waste Management operator template — CPCB-Guidelines-2025-compliant CBWTFs combining four treatment technologies, 75 km service radius, tipping-fee revenue, and OCEMS + CBST-BMW digital compliance — the template for CG's gap-analysis-driven district-headquarter CBWTF expansion. **West Bengal bar-coded BMW tracking** (rolled out across all government hospitals, September 2024) provides end-to-end origin-to-disposal chain-of-custody with real-time multi-stakeholder data access — the model for CG state-wide CBST-BMW deployment by 2027. **CSIR-NIIST + circular biomedical-plastic recovery** (BMW Management Conclave, March 2024) plus BMW Rules 2016 disinfected-plastic provisions provide the Tier 3 material-recovery template feeding the CG Plastic Waste Recycling cluster.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** CBWTF coverage gaps vs 75 km radius + inadequate rural transport logistics → build at least one compliant CBWTF per district headquarter (or pooled arrangements) by 2028-29, OCEMS/CBST-BMW-integrated with 48-hour timelines; migrate captive-treatment volumes to compliant CBWTFs.
- **Financial barriers:** High CBWTF capex + small-HCF infrastructure cost → private operator capex via concessional debt + tipping-fee revenue; HCF operating budgets, state health-department grants, and NHM convergence; subsidised infrastructure for government PHCs/CHCs.
- **Knowledge & skill gaps:** Healthcare-worker BMW-handling training gap (most cited nationally) → state-wide training by 2027 across all worker categories and HCF types via CG Health Dept + CECB + medical colleges + private-sector partnership.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Circular plastic-recovery underdeveloped; non-infectious plastics incinerated/dumped foregoing recovery	Medium	Integrate disinfected red-category plastic into CG Plastic cluster under licensed-recycler agreements + bar-coded chain-of-custody

Production Feedstock	/	Segregation-at-source compliance gap; poor segregation undermines the 85% recoverable stream	High	Sustained healthcare-worker training + strict colour-coded segregation enforcement + time-bound HCF authorisation + CBST-BMW traceability
Operational Supply Chain	/	CBWTF coverage gap + captive-treatment overuse (18,015 national captive facilities); 48-hour timeline hard in rural blocks	High	5-year gap analysis (Appendix I) + new/expanded CBWTFs via SPCB + captive-to-CBWTF migration + compliant transport fleet
Policy / Governance		Compliance mirrors national average; weak enforcement	Medium	Strengthen segregation enforcement, District Monitoring Committee, OCEMS oversight, and SPCB show-cause discipline with measurable CG improvement

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (SPCB authority — CBWTF/HCF authorisation, gap analysis, OCEMS monitoring, CBST-BMW state data, show-cause); CG Health & Family Welfare Dept (government HCF compliance + NHM); Directorate of Medical Education (medical-college hospitals); CSIDC + Industries Dept (CBWTF industrial-area allocation); DM + CMHO + District Monitoring Committee.
- **Private Sector & Investors:** National CBWTF operators (Synergy/Mumbai/Biotic/SMS/GreenTech) for capacity build; CPCB-licensed plastic recyclers for Tier 3 offtake; cement-industry co-processing partners; private HCFs investing in segregation and bar-coded tracking.
- **Development Agencies & NGOs:** Healthcare-worker training and capacity building; SHG-cooperative mobilisation in non-clinical handling tiers; technical assistance for gap analysis, CBST-BMW rollout, and circular-recovery pathway design.

11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies/amends BMW Rules 2016 under the Environment (Protection) Act 1986.

- **CPCB:** Issues CBWTF Guidelines 2025; operates CBST-BMW; audits OCEMS; reports annually to MoEFCC and NGT.
- **Ministry of Health & Family Welfare:** Administers NHM and Ayushman Bharat with HCF-compliance responsibility.
- **National Green Tribunal (NGT):** Judicial oversight (12 January 2024 directives).
- **CECB (Chhattisgarh Environment Conservation Board):** SPCB authority — CBWTF/HCF authorisation, 5-year gap analysis, OCEMS monitoring, show-cause issuance.
- **CG Department of Health & Family Welfare:** State hospitals + government HCF compliance + NHM convergence.
- **Directorate of Medical Education:** Medical-college hospital compliance.
- **CSIDC + Industries Dept:** CBWTF industrial-area allocation.
- **District Magistrate + CMHO:** District-level coordination + District Monitoring Committee mandated by BMW Rules.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Medical Waste Recycling



Source: Mordor Intelligence, TechSci, CPCB, WHO

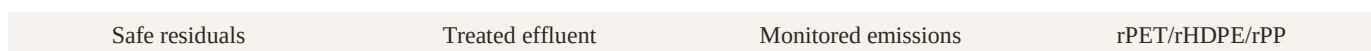
Input / Output Flow

Value Chain Flow · Bio-Medical Waste Recycling

INPUTS



OUTPUTS



Source: Mordor Intelligence, TechSci, CPCB, WHO

C07 Industrial Waste Recycling

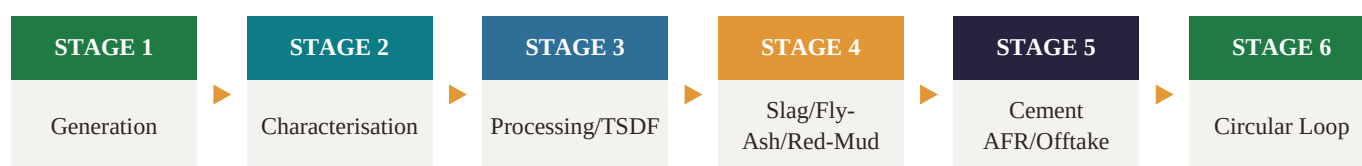
CE · CIRCULAR ECONOMY

The collection, characterisation, treatment, recovery, and circular utilisation of high-volume bulk and hazardous waste streams — steel slag, fly ash, red mud, and hazardous waste — generated by Chhattisgarh's major industrial sectors, routed through Treatment, Storage and Disposal Facilities (TSDFs), cement Alternative Fuels and Raw Materials (AFR) co-processing, recycling, and resource recovery.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
15,000–35,000 direct jobs (slag/fly-ash/red-mud processing, brick/aggregate/cement supply, TSDF operations, transport, AFR co-processing logistics) — the largest in the Waste & Recycling cluster		₹5,000–15,000 Cr opportunity envelope (GETM 2026–32), the largest of any cluster VC. Capex tiers — Tier 1 steel slag ₹25–150 Cr (80–200 FTE); Tier 2 fly ash/bottom ash ₹5–50 Cr (30–150 FTE); Tier 3 TSDF ₹15–100 Cr + AFR logistics ₹5–30 Cr (60–150 FTE + 30–80 FTE); Tier 4 red-mud recovery ₹50–300 Cr (100–300 FTE)		India Industrial Waste Management Market ~USD 13 billion (Ken Research 2025); India Fly Ash Market USD 999.97M by 2035; India Recycling Market USD 0.97B (2026) → USD 1.45B (2031) at 8.44% CAGR (Mordor); three converging revenue layers — tipping fees, recycled-product sales, cement AFR + EPR-certificate revenue

Value Chain / Circular Flow — Industrial Waste Recycling



2. Contextual Overview

National Context

- **Hazardous-waste scale:** ~7.66–7.9 MT/yr from >40,722 industries (CPCB); 44.3% landfillable, 47.2% recyclable, 8.5% incinerable.
- **Market size:** India Industrial Waste Management Market ~USD 13 billion (Ken Research 2025); broader India Waste Management Market USD 22.17B (2023) → USD 54.20B (2030) at 12.5% CAGR (NextMSC).

- **CSE circularity opportunity:** 437 MT fly ash by 2030 → 208–231 MT cement-usable; 52.5 MT steel slag by 2030 → 35.3–41 MT cement-usable; total 750 MT industrial-waste circularity potential by 2030.
- **Mature regulation:** HOWM Rules 2016 + 2nd Amendment 2023 (EPR) + 2024 Amendment; CPCB Framework on Waste-or-By-Products (25 March 2025); Revised Cement Co-Processing Guidelines.
- **Leading states:** CSE identifies Gujarat, Goa and Karnataka as industrial-circularity benchmarks.

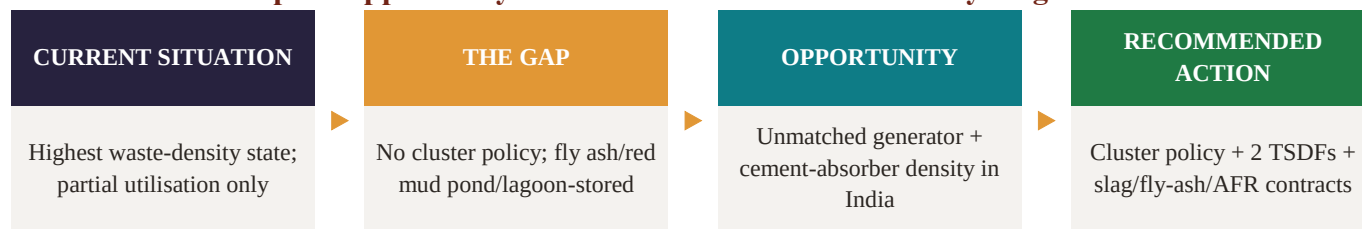
Chhattisgarh Context

- **Highest industrial-waste-density state:** Five national-flagship anchors — SAIL Bhilai (steel slag/mill scale/refractories), NTPC Korba (fly ash/bottom ash), NMDC Bailadila (mining overburden/tailings), BALCO Korba (red mud), and CG cement industry (Ultratech/ACC/Ambuja/Shree Cement).
- **Cement absorption advantage:** Ultra-large kilns around Raipur/Baloda Bazar/Janjgir provide AFR co-processing absorption within ~150 km of SAIL Bhilai and NTPC Korba — among the most favourable circularity-loop geographies in India.
- **Additional base:** Hindalco, Jindal Steel & Power (Raigarh), Adani, Vedanta-Sterlite, sponge-iron/re-rolling plants, and chemicals/pharma/fertiliser units across the Raipur-Bilaspur-Korba belt.
- **Policy gap:** No notified state Industrial Waste Recycling cluster policy; circular utilisation of steel slag, fly ash and red mud operates at a fraction of the CSE 70–80%-of-potential benchmark.
- **Critical Mineral Mission alignment:** BALCO red-mud (alumina/iron/titanium/rare-earth) and NMDC tailings recovery align with the National Critical Mineral Mission.

3. Demand & Supply Assessment

- **Supply:** Massive in-state streams — SAIL Bhilai steel slag (among the largest single-source generators in eastern India), NTPC Korba fly ash/bottom ash (largely pond-stored today), NMDC overburden/tailings, BALCO Korba red mud (lagoon-stored). Most CG hazardous waste currently routed out-of-state or treated captively.
- **Demand:** Cement industry as absorber-of-last-resort (AFR + clinker substitution); fly-ash bricks/blocks for Sustainable Housing + PMAY + state PWD; slag for road base (PWD/NHAI); EPR-mandated tipping under HOWM Rules; LEED/IGBC green-building premium for fly ash.
- **Supply–Demand Gap:** Underdeveloped SAIL-slag-to-cement supply contracts, partial fly-ash utilisation, negligible red-mud recovery, and limited dedicated CG TSDF capacity — the intervention builds structured supply chains, TSDF/AFR infrastructure, and red-mud recovery to close the loop within the state.

Demand → Gap → Opportunity → Action · Industrial Waste Recycling



Source: CSE, CPCB, Ken Research, Mordor Intelligence

4. Market Ecosystem

The ecosystem links flagship industrial generators, cement AFR absorption, dedicated TSDFs, and cross-VC offtake.

- **Input Suppliers:** SAIL Bhilai, NTPC Korba, NMDC Bailadila, BALCO Korba, CG cement plants; plus Hindalco, Jindal Steel & Power, sponge-iron/re-rolling and chemicals/pharma/fertiliser units.
- **Primary Producers & Aggregators:** Slag-cement and fly-ash-brick SMEs; manifest-disciplined transporters (Motor Vehicles Act 1988); CSPGCL for state-power-sector fly ash.
- **Processing & Logistics:** Steel-slag beneficiation lines; fly-ash processing units; TSDF operators (Ramky Enviro / Re Sustainability and others); AFR pre-processing/co-processing logistics.
- **Off-takers & Markets:** CG cement industry (Ultratech/ACC/Ambuja/Shree Cement) for AFR + slag/fly-ash blending; Sustainable Housing brick-and-block markets; state PWD/NHAI road base; recovered-metal secondary value chains.
- **Enablers:** MoEFCC/CPCB (HOWM Rules, Waste-or-By-Products Framework, Co-Processing Guidelines, EPR portal); CECB (SPCB authority); CSIDC + Industries Dept; Ministries of Steel/Power/Mines/Coal; National Critical Mineral Mission; BIS + Indian Roads Congress.

Market Ecosystem — Industrial Waste Recycling

Input & Feedstock	SAIL Bhilai steel slag · NTPC Korba fly ash · BALCO red mud / NMDC tailings
Producers & Aggregators	Slag-cement/fly-ash SMEs · Manifest transporters · CSPGCL power-sector ash
Processing & Logistics	Slag beneficiation lines · TSDF operators (Ramky/Re Sust.) · AFR co-processing logistics
Off-takers & Markets	CG cement industry (AFR) · Sustainable Housing bricks · State PWD/NHAI road base
Enablers	MoEFCC/CPCB HOWM + EPR · CECB SPCB · Critical Mineral Mission

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
CG Industrial Generators (SAIL/NTPC/NMDC/BALCO/Cement)	India's highest waste-density concentration; anchor for all four tracks	Structure supply/MoU frameworks linking generators to cement + PWD offtake
CG Cement Industry (absorber-of-last-resort)	AFR capacity + proximity unmatched; needs regulatory clarity	Formalise AFR co-processing MoUs under CPCB Revised Co-Processing Guidelines by 2027-28
National Operators (Adani Cement, Ramky/Re Sustainability)	Proven AFR + TSDF templates; seek anchor sites	Engage for CG TSDF + AFR logistics infrastructure by 2028-29

CECB + CSIDC + Mines + CSPGCL	No state cluster policy; early-stage EPR/by-product framework	Notify CG Industrial Waste Circularity Cluster Policy by Q2 2027
Industrial-township + surrounding rural communities	Local air/water quality, occupational health, livelihoods	Embed community-benefit and monitoring safeguards in cluster siting
Red-mud technology partners (Norsk Hydro/RUSAL/Vedanta R&D)	Technology-frontier, capital-heavy recovery	Long-horizon technology-transfer partnership + phased pilot-to-scale at BALCO Korba

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Uniquely strong — three converging revenue layers (tipping fees, recycled-product sales of slag cement/aggregate/fly-ash bricks/recovered alumina-iron-titanium, and cement AFR + EPR-certificate revenue). Capex ₹25–150 Cr (Tier 1), ₹5–50 Cr (Tier 2), ₹15–100 Cr TSDF + ₹5–30 Cr AFR (Tier 3), ₹50–300 Cr (Tier 4); build periods 12–36 months; the largest opportunity envelope (₹5,000–15,000 Cr) in the cluster.
- **Social Benefits:** 15,000–35,000 direct jobs (largest in cluster); surrounding-community livelihoods from processing operations; improved local air/water quality and occupational health.
- **Environmental & Climate Resilience:** Diverts steel slag, fly ash and red mud from pond/lagoon storage into circular use; AFR co-processing substitutes virgin fuel/raw material; targets CSE 70–80% utilisation benchmark by 2030; carbon-emissions reduction and natural-resource conservation.
- **Technical Feasibility:** Slag beneficiation and fly-ash utilisation are mature; TSDF + AFR co-processing proven (Ramky/Re Sustainability, Adani Cement); red-mud recovery is technology-frontier (global pilots only recently scaling) requiring partnership.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Adani Cement + ultra-large cement kiln AFR co-processing (CSE-endorsed, CPCB-Revised-Co-Processing-Guidelines-compliant) proves cement kilns as the absorber-of-last-resort for hazardous/plastic/BMW/C&D/biomass residuals, converting waste absorption into a feedstock-volatility hedge and cost advantage — the template for CG's AFR hub. **Ramky Enviro / Re Sustainability** provide the multi-state TSDF + integrated waste-management operator template (incineration + secured landfill + treatment, cross-portfolio expertise, Rule 23 compliance) for CG's two proposed TSDFs (Bhilai-Durg and Korba regions). **Gujarat, Goa and Karnataka** — CSE-identified leading states — provide the integrated-cluster, high-density-geography, and technology-intensive templates CG should benchmark against and surpass given its denser industrial-asset concentration.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Limited dedicated CG TSDF capacity + partial fly-ash utilisation → build two new TSDFs (Bhilai-Durg + Korba) on the Ramky/Re Sustainability template by 2028-29; dedicated fly-ash brick units serving Sustainable Housing/PMAY; reduce out-of-state hazardous-waste routing.
- **Financial barriers:** High Tier 1/3/4 capex → concessional debt + cement-industry MoUs + EPR-certificate revenue + LEED/IGBC green-building premium offtake; National Critical Mineral Mission support for red-mud/tailings recovery.
- **Knowledge & skill gaps:** Early-stage EPR + 2025 By-Products Framework + red-mud technology → CECB leadership on producer registration and by-product categorisation; technology-transfer partnerships (Norsk Hydro/RUSAL/Vedanta R&D/IIT Bombay/IIT Kharagpur); skilling for slag/fly-ash/TSDF operations.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Cement-industry absorption/offtake coordination — kilns prioritise own cost-optimisation	High	Structured supply contracts under CPCB Co-Processing Guidelines + state PCB facilitation + cement-industry MoU framework incentivising absorption
Production Feedstock	/ Partial fly-ash utilisation (pond-stored); underdeveloped slag-to-cement contracts	Medium	Build SAIL-slag-to-cement and NTPC-fly-ash-to-cement-bricks supply chains by 2028 targeting CSE 70–80% utilisation
Operational Supply Chain	/ Technology + capital intensity for red-mud/high-value recovery; global pilots only recently scaling	High	Long-horizon technology-transfer partnership + phased pilot-to-scale at BALCO Korba
Policy / Governance	EPR + By-Products Framework + portal-compliance immaturity; no state cluster policy	Medium	Early CECB adoption + industry registration + by-product categorisation; notify CG Industrial Waste Circularity Cluster Policy by Q2 2027

10. Stakeholder Matrix & Action Domains

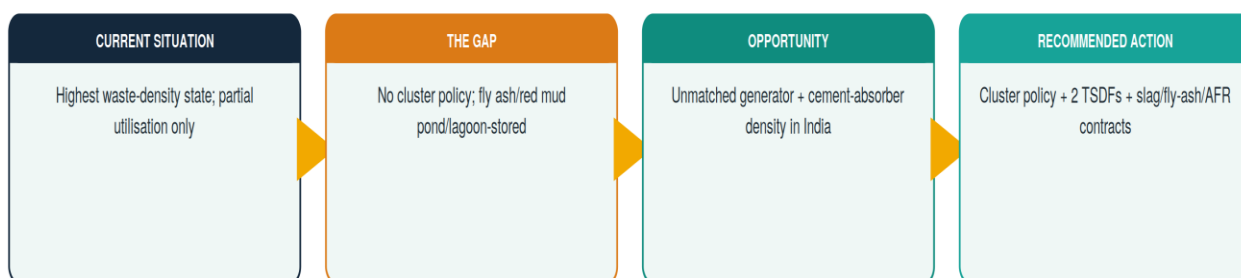
- **State Government / Public Sector:** CECB (SPCB authority — TSDF authorisations, transporter registration, manifest discipline, by-product categorisation, EPR enforcement, AFR oversight); CSIDC + Industries Dept (industrial-cluster allocation); CG Dept of Mines (NMDC/BALCO/Coal coordination); CSPGCL (state-power fly ash); CG PWD + Roads & Building (slag road-base utilisation).
- **Private Sector & Investors:** Five flagship generators (SAIL/NTPC/NMDC/BALCO/cement); cement industry as AFR co-processor; national recyclers (Ramky, Pure Earth, Hanjer Biotech, Veolia India, SUEZ India, Synergy); TSDF operators (Re Sustainability); red-mud technology partners.
- **Development Agencies & NGOs:** Community-benefit safeguards around industrial complexes; capacity building for by-product categorisation and EPR compliance; cross-VC integration facilitation and CSE-benchmark circularity reporting.

11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies HOWM Rules 2016 + Amendments under the Environment (Protection) Act 1986.
- **CPCB:** Issues Waste-or-By-Products Framework (25 March 2025), Revised Cement Co-Processing Guidelines, Incineration/TSDF-audit/Inventory Guidelines; operates the national EPR portal.
- **Ministries of Steel / Power / Mines / Coal:** Sectoral programmes for steel slag, fly ash and mining-waste utilisation.
- **National Critical Mineral Mission:** Underpins red-mud and rare-earth recovery.
- **CECB (Chhattisgarh Environment Conservation Board):** SPCB authority — TSDF authorisations, by-product categorisation, EPR enforcement, AFR oversight.
- **CSIDC + Industries Dept:** Industrial-cluster allocation.
- **CG Department of Mines:** NMDC + BALCO + Coal India + mining-waste coordination.
- **CSPGCL:** State-power-sector fly-ash coordination.
- **CG PWD + Roads & Building / BIS + Indian Roads Congress:** Recycled-aggregate and slag road-base utilisation specifications.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Industrial Waste Recycling

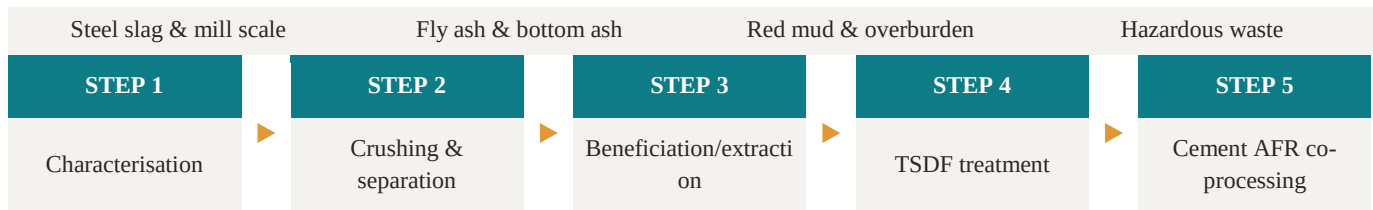


Source: CSE, CPCB, Ken Research, Mordor Intelligence

Input / Output Flow

Value Chain Flow · Industrial Waste Recycling

INPUTS



OUTPUTS

Slag cement & aggregate	Road base	Fly-ash bricks/blocks	Recovered metals
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Source: CSE, CPCB, Ken Research, Mordor Intelligence

C08 Household Goods and Fast-Moving Consumer Goods (FMCG) Products Recycling CE · CIRCULAR ECONOMY

The brand-owner-led collection, sortation, treatment, and circular recovery of post-consumer Fast-Moving Consumer Goods (FMCG) packaging from Indian households — rigid PET, HDPE and PP containers, flexible films, Multi-Layered Plastic (MLP) and sachets — operating under the Extended Producer Responsibility (EPR) framework.

Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
25,000–55,000 direct jobs (50–65% women) across decentralised collection, SHG-cooperative sortation, EPR-portal compliance, brand-owner aggregator partnerships, and recycled-content product manufacturing — the most directly women-led value chain in the GETM portfolio.		₹2,500–7,000 opportunity envelope (GETM 2026–32). Tier 1 (Ambikapur-model collection-and-sortation) ₹5–25 Cr per ULB cluster; Tier 2 (EPR-aggregator + brand-owner hub) ₹2–15 Cr per hub; Tier 3 (MLP co-processing + recycled-content manufacturing) ₹5–30 Cr per integrated unit.	Cr	B2B rPET market ₹15,000 Cr (Burman Capital, EPR-created); India Recycling Market USD 0.97B (2026) → USD 1.45B (2031) at 8.44% CAGR (Mordor Intelligence).

Value Chain / Circular Flow — Household & FMCG Products Recycling



2. Contextual Overview

National Context

- **Exceptional demand-side scale:** FMCG companies spend on average 5–8% of revenue on packaging (Kotak Institutional Equities); India Plastics Pact member brands placed ~788,027 tonnes of plastic packaging on the market in 2024 — 71% technically recyclable but only 1% with recycled content (the binding gap).
- **Transformed regulatory architecture:** PWM Rules 2016 + 2022 EPR Amendment + 2024 + 2025 Amendment; CPCB EPR Portal PIBO registration; recycled-content mandates 30% rigid (FY2025-26) → 60% (FY2028-29), 10% flexible, 5% MLP; recycling targets 30% (2024-25) → 80% (FY2027-28) for rigid; QR/barcode traceability from 1 July 2025.
- **National circularity goal:** 100% recyclable or compostable packaging + 50% average recycled content by 2030.
- **Market scale:** Burman Capital B2B rPET market ₹15,000 Cr; India Recycling Market USD 0.97B (2026) → USD 1.45B (2031) at 8.44% CAGR; PIBO EPR registration covers 44,659 plastic intermediaries (Mordor Intelligence).
- **EPR obligation vs capacity gap:** PIBOs must recycle 8.4 MT plastic packaging by March 2025 (35% of total introduced) against India's recycling capacity of 9.82 MT — a structural mismatch.

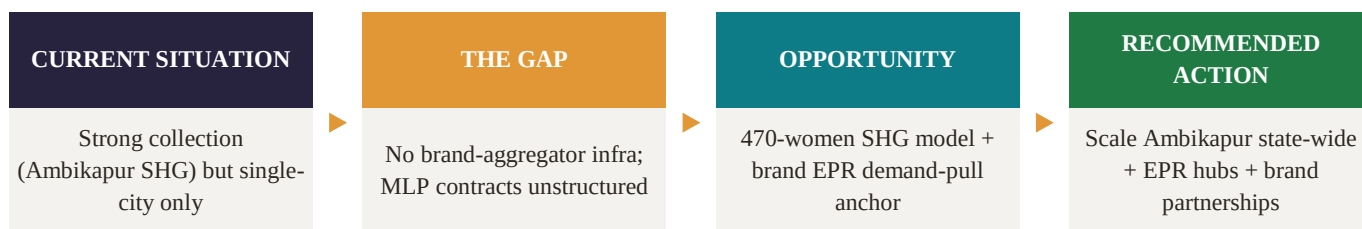
Chhattisgarh Context

- **India's most distinctive collection-and-sortation asset:** the Ambikapur 470-women-SHG SLRM model — 17 SLRM centres, 156 waste categories, 100% zero-landfill — precisely the infrastructure brand-owner-led EPR collection requires at state scale.
- **Deep SHG ecosystem:** FGD-documented Sogda 20 SHGs (highest density), Berchegondi 8 SHG/CLFs + 50 women interested in enterprise, Luikona 9 SHGs with explicit branding-and-packaging interest; ~250,000 SHGs statewide under CG SRLM (Bihar).
- **Growing urban FMCG demand:** Raipur, Bhilai-Durg, Bilaspur, Korba and tier-2 cities generate rising post-consumer FMCG packaging streams.
- **Closed-loop cement absorber:** CG cement industry (Ultratech, ACC, Ambuja, Shree Cement around Raipur/Baloda Bazar/Janjgir) provides MLP/sachet co-processing destination for non-mechanically-recyclable residuals.
- **Structural gaps:** Ambikapur is a single-city showcase, not state-scale deployed; limited brand-owner-aggregator infrastructure; underdeveloped in-state recycled-content manufacturing (out-of-state offtake dependence).

3. Demand & Supply Assessment

- **Supply:** Post-consumer FMCG packaging generated at every household — PET bottles, HDPE/PP containers, flexible films, MLP pouches, sachets, laminated wrappers. Feedstock quality hinges on source-segregation; the Ambikapur SLRM 156-category discipline produces the highest feedstock quality in India, but fragmented municipal collection elsewhere limits quality. India's PET bottle recycling already runs at 90%+ (including informal).
- **Demand:** EPR-mandate-driven recycled-content demand — 30% rigid rising to 60%, plus HUL 25% by 2025 and Coca-Cola India 50% by 2030 collectively requiring 150,000–200,000 tons food-grade rPET annually. Buyer segments: brand-owners (HUL, Nestle, ITC, Dabur, Coca-Cola, Tata Consumer, Marico, PepsiCo, Parle); rPET market opening to 4 lakh MTPA (FY26) → 10–12 lakh MTPA (FY30).
- **Supply–Demand Gap:** India's recycling capacity (9.82 MT) lags the 8.4 MT EPR obligation and, more acutely, only 1% of packaging carried recycled content in 2024 despite 71% being recyclable. The intervention closes this by converting the Ambikapur collection-and-sortation backbone into a brand-owner-anchored offtake economy under CPCB EPR Portal compliance.

Demand → Gap → Opportunity → Action · Household & FMCG Products Recycling



Source: India Plastics Pact, Burman Capital, Kotak, CPCB

4. Market Ecosystem

CG's Household/FMCG Recycling ecosystem links a women-led collection backbone to a brand-owner demand-pull anchor.

- **Input Suppliers / Feedstock:** Households across CG urban centres and rural collection frontier; informal ragpickers; post-consumer FMCG packaging streams (PET, HDPE, PP, MLP, sachets).
- **Primary Producers & Aggregators:** Ambikapur 470-women-SHG SLRM cooperatives; CG SHG networks (Sogda, Berchegondi, Luikona) under Bihan/NRLM; EPR-aggregators and PROs (Saahas Zero Waste, Re Sustainability, Go Rewrite).
- **Processing & Logistics:** CG plastic/packaging recyclers (GG Wastech Raipur + downstream converters); Lucro Plastecycle-template flexible-packaging conversion; MLP pre-processing and cement-AFR co-processing logistics.
- **Off-takers & Retail:** FMCG brand-owners (HUL, Nestle, ITC, Dabur, Coca-Cola India, Tata Consumer, Marico, Mondelez, Godrej, PepsiCo, Parle); cement plants (Ultratech, ACC, Ambuja, Shree Cement) as MLP co-processing offtakers.
- **Enablers (finance / extension / regulatory):** MoEFCC, CPCB (EPR Portal), MoHUA (SBM Urban 2.0 ₹1,41,678 Cr), FSSAI (food-grade rPET), BIS; CECB, UADD, CG Bihan (SRLM), CSIDC; India Plastics Pact (WWF + CII + UNDP).

Market Ecosystem — Household & FMCG Products Recycling

Input & Feedstock	Households (PET/HDPE/MLP) · Informal ragpickers · Post-consumer FMCG packaging
Producers & Aggregators	Ambikapur 470-women-SHG SLRM · CG SHG cooperatives (Bihan) · EPR-aggregators/PROs
Processing & Logistics	CG plastic recyclers (GG Wastech) · Lucro-template converters · MLP cement co-processing
Off-takers & Markets	FMCG brand-owners (HUL, Nestle, ITC, Dabur, Coca-Cola) · Cement plants (Ultratech, ACC, Ambuja)
Enablers	CPCB EPR Portal, MoEFCC · CECB, UADD, CSIDC · MoHUA SBM 2.0, FSSAI, India Plastics Pact

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Action	Policy
Informal Waste-pickers / SHGs	Ambikapur 470-women SHGs retain recyclable-sale revenue but rural collection (e.g. Cha Tolagaon Swachhata-Didi) stalls on unpaid honoraria	Formalise informal workforce under SHG cooperatives; finance collection via EPR producer fees + recyclable sales, not fragile honoraria	

CG SHG Cooperatives / Bihan	Sogda 20 SHGs, Luikona 9 SHGs with branding interest; organisational capability exists but Ambikapur model not yet replicated statewide	Scale Ambikapur SLRM 17-centre + 156-category architecture across CG ULBs via UADD + Bihan by 2028
MSME Recyclers / Converters	In-state rPET/rHDPE/rPP converter base underdeveloped; out-of-state offtake dependence	Build in-state recycled-content manufacturing (FSSAI-grade rPET; Lucro-template flexible) with CSIDC cluster siting
Institutional / Brand-owner Buyers	EPR framework permits discharging obligation by buying CPCB certificates without real collection (greenwashing risk)	Structure brand-owner–Ambikapur-cooperative partnerships linking physical collection to certificate generation; CECB chain-of-custody enforcement
Cement / Industry Off-takers	MLP cannot be mechanically recycled; needs co-processing absorber; supply contracts not yet structured	Structure MLP/sachet co-processing MoUs with CG cement plants under CPCB Co-Processing Guidelines by 2028
CG Regulators (CECB/UADD)	CPCB EPR Portal compliance preparedness limited for CG-headquartered distributors and tier-2 brand-owners	CECB-led EPR Portal onboarding + QR/barcode traceability capacity building

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Modest per-unit capex (Tier 1 ₹5–25 Cr, Tier 2 ₹2–15 Cr, Tier 3 ₹5–30 Cr) with the cluster's largest workforce-generation potential. Three converging revenue layers: brand-owner EPR fees (~₹15,000–35,000/tonne), recycled-content product sales (mechanical recyclers ₹40–60/kg for non-food polymers; chemical recyclers ₹80–120/kg for virgin-quality FSSAI-grade resin), and cement co-processing revenue for MLP/sachet residuals. Build periods 6–18 months for SHG-cooperative infrastructure.
- **Social Benefits:** 50–65% women workforce given the Ambikapur 470-women-SHG benchmark; formalisation of informal ragpicker livelihoods under SHG cooperatives; dignified, revenue-retaining SHG enterprise; displaces public-health harm from open burning of MLP packaging in villages.
- **Environmental & Climate Resilience:** Closes the recycled-content loop (target 50% average by 2030); diverts single-use FMCG packaging (84.2% of mountain-area plastic waste per 2024 Himalayan Cleanup) from landfill and open burning; cement-AFR co-processing absorbs non-recyclable MLP; QR/barcode traceability curbs greenwashing.
- **Technical Feasibility:** Rigid PET/HDPE recycling is mature; MLP remains the hard residual (5% recycled-content mandate) requiring co-processing or energy recovery.

Ambikapur SLRM template is proven and scalable; FSSAI food-grade rPET certification (effective 10 September 2024) enables bottle-to-bottle circularity.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Brand-owner plastic-neutrality cohort — HUL achieved 100% plastic-waste-collection in 2021 (1 lakh tonnes/yr EPR), Dabur plastic neutrality March 2022 (22,000 tpa), Nestle India and ITC by 2024 (ITC 28,000+ tpa MLP) — proving brand-owner-led collection at FMCG scale is operationally and financially viable; read-across: CG should route post-consumer FMCG packaging through Ambikapur-model cooperatives under structured brand-owner partnerships. **Coca-Cola India + Go Rewise** recycles 25% of India's PET bottle waste toward 50% recycled content by 2030 under FSSAI food-grade certification — the highest-value bottle-to-bottle template for CG's Tier 3 in-state rPET manufacturing. **Lucro Plastecycle** (17,000 MT/yr; 30–80% recycled content supplied to Coca-Cola, Dabur, Nestle, Mondelez, HUL, Marico, incl. HUL Surf Excel primary packaging) demonstrates the recycler-to-brand-owner flexible-packaging model with local raw-material sourcing — the template for a CG-anchored 5,000–15,000 MT/yr conversion operation.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Ambikapur remains a single-city showcase and in-state converter capacity is thin → scale the 17-SLRM-centre + 470-women-SHG + 156-category architecture across Raipur, Bhilai-Durg, Bilaspur, Korba, Raigarh, Rajnandgaon and tier-2 cities by 2028; build in-state rPET/rHDPE/flexible converters by 2029-30.
- **Financial barriers:** SHG-cooperative and converter capex/working-capital gaps → finance Tier 1 via SBM Urban 2.0 + 15th Finance Commission grants + state matching + brand-owner EPR-fee aggregation; Tier 2 via CPCB authorisation + brand-owner contract revenue; Tier 3 via CPCB licensing + FSSAI certification + brand-owner supply contracts.
- **Knowledge & skill gaps:** CPCB EPR Portal compliance preparedness limited; MLP design-for-recyclability nascent → CECB-led EPR Portal onboarding + QR/barcode traceability training; accelerate brand-owner investment in MLP mono-material substitution and design-for-recyclability.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Cost gap between virgin and recycled polymers constrains competitiveness	High	Enforce recycled-content mandates as demand floor; anchor brand-owner off-take contracts; leverage EPR-fee revenue layer

Production Feedstock	/	MLP/sachets non-mechanically-recyclable; 84.2% of mountain-area waste is single-use FMCG (71% non-recyclable)	High	Structured MLP supply to CG cement-AFR co-processing; enforce 5% MLP recycled-content target; brand-owner design-for-recyclability
Operational Supply Chain	/	Fragmented municipal collection limits feedstock quality; capacity (9.82 MT) vs obligation (8.4 MT) mismatch	High	Ambikapur SLRM-grade 156-category source-segregation; formalise informal ragpickers under SHG cooperatives
Policy / Governance		Brand-owners discharge EPR by buying CPCB certificates without real collection (greenwashing)	High	Structured brand-owner–Ambikapur-cooperative partnerships linking physical collection to certificate generation; CECB chain-of-custody enforcement

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (SPCB authority for PWM compliance + CPCB EPR Portal coordination + aggregator authorisation); UADD (ULB Ambikapur-model replication + SBM Urban 2.0); CG State Rural Livelihoods Mission (Bihar) for SHG-cooperative scaling; CSIDC + Industries Dept for recycled-content manufacturing cluster allocation.
- **Private Sector & Investors:** Brand-owner EPR partnerships (HUL, Nestle, ITC, Dabur, Coca-Cola, Tata Consumer, Marico, Mondelez, Godrej, PepsiCo); EPR-aggregators/PROs (Saahas Zero Waste, Re Sustainability, Go Rewise); recycler-converters (Lucro Plastecycle template, GG Wastech Raipur); cement plants for MLP co-processing.
- **Development Agencies & NGOs:** India Plastics Pact (WWF + CII + UNDP) roadmap platform; SHG mobilisation and capacity building under Bihar/NRLM; technical assistance transferring Ambikapur SLRM know-how to new ULBs.

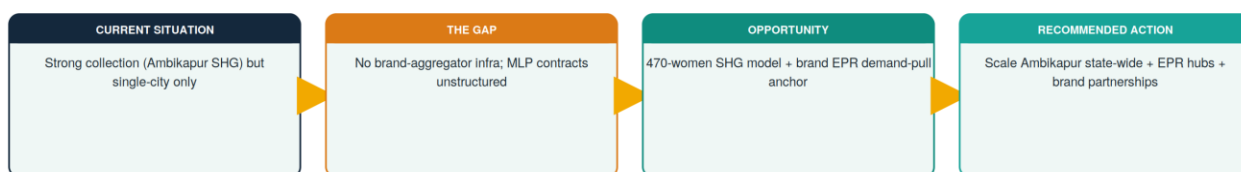
11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies PWM Rules 2016 + 2022/2024/2025 Amendments — the brand-owner accountability framework.
- **CPCB:** Operates the EPR Portal — PIBO registration, EPR Certificate generation, QR/barcode traceability, EC ₹4,000/tonne enforcement.
- **MoHUA:** Administers SBM Urban 2.0 (₹1,41,678 Cr) funding source-segregation and decentralised processing.

- **FSSAI / BIS:** FSSAI food-grade rPET certification (effective 10 September 2024); BIS rPET and recycled-content packaging standards.
- **CECB (Chhattisgarh Environment Conservation Board):** SPCB authority for PWM compliance, CPCB EPR Portal coordination, brand-owner-aggregator authorisation.
- **Urban Administration & Development Department (UADD):** ULB-level Ambikapur-model replication and SBM Urban 2.0 deployment.
- **CG State Rural Livelihoods Mission (Bihar):** SHG-cooperative scaling under NRLM (~250,000 SHGs).
- **CSIDC + Industries Department:** Recycled-content product manufacturing cluster allocation and industrial-zone siting.
- **India Plastics Pact (WWF + CII + UNDP):** Multi-stakeholder roadmap and brand-owner commitment platform.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Household & FMCG Products Recycling

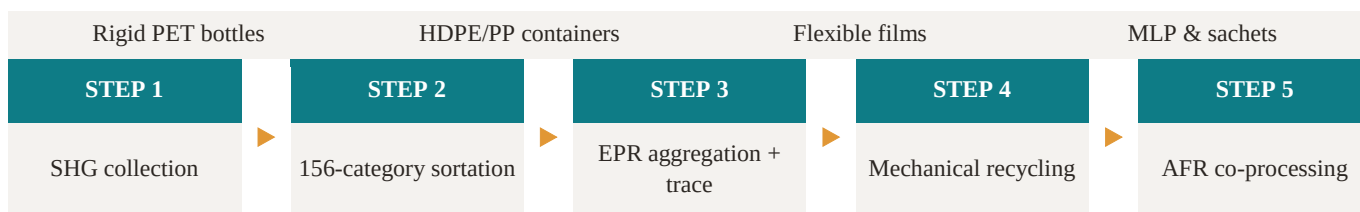


Source: India Plastics Pact, Burman Capital, Kotak, CPCB

Input / Output Flow

Value Chain Flow · Household & FMCG Recycling

INPUTS



OUTPUTS

Food-grade rPET bottles	rHDPE/rPP containers	Flexible packaging	Cement fuel substitute
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Source: India Plastics Pact, Burman Capital, Kotak, CPCB

C09 Packaging using Recycled Materials

CE · CIRCULAR ECONOMY

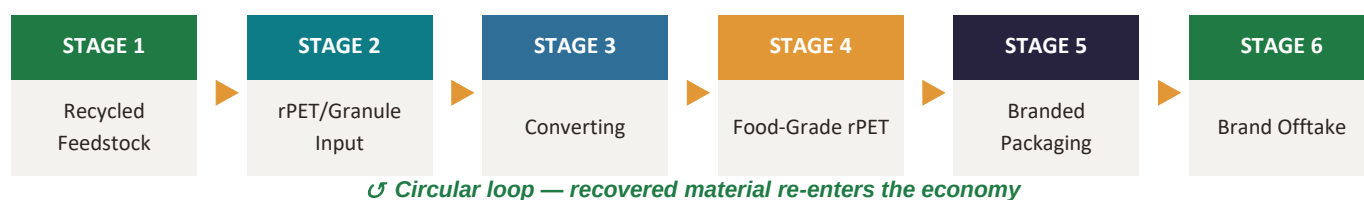
The manufacture of rigid and flexible packaging incorporating post-consumer recycled (PCR) content — principally food-grade recycled PET (rPET), recycled polyolefins, and recycled paper/moulded-fibre — that converts Chhattisgarh's plastic and paper recycling output into compliant, branded, value-added consumer packaging.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
10,000–25,000 direct jobs across rPET converting, recycled-content packaging manufacturing, fibre-based packaging, and design/branding		₹2,000–6,000 Cr opportunity envelope over GETM 2026–32. Tier 1 recycled-content converting ₹2–30 Cr; Tier 2 food-grade rPET production ₹30–300 Cr; Tier 3 fibre-based/compostable ₹1–20 Cr per unit		Brand-facing highest-margin tier of the circular-plastics chain; INR 15,000 Cr B2B rPET market created by EPR norms; B2B rPET commands significantly higher margins than textile-grade RPSF

Methodology: The 10,000–25,000 job range applies typical recycled-content converting unit (30–120 FTE), food-grade rPET facility (80–250 FTE), and fibre-based packaging unit (20–80 FTE) coefficients to a deployment of converting MSMEs + food-grade rPET production + fibre-based packaging clusters over 2026–32. Market figures are drawn from Burman Capital (INR 15,000 Cr B2B rPET market) and Indian Chemical News/MoEFCC (₹9,000–10,000 Cr invested in 15–18 advanced facilities, ~3 lakh MT capacity) at conservative national benchmarks; the ₹2,000–6,000 Cr envelope reflects CG's realistic share of the recycled-packaging opportunity.

Value Chain / Circular Flow — Packaging using Recycled Materials



2. Contextual Overview

National Context

- MoEFCC directive mandates 40% recycled content in food-grade packaging effective 1 April 2026 — the single most demand-accelerating mandate.
- PWM recycled-content trajectory: rigid 30% (FY2025-26) → 60% (FY2028-29); flexible 10%; multi-layer 5%; national 2030 goal of 100% recyclable/compostable packaging with 50% average recycled content.
- Mandate-driven demand created an estimated INR 15,000 Cr B2B rPET market; companies have invested ₹9,000–10,000 Cr in 15–18 advanced recycling facilities (~3 lakh MT) meeting EFSA/USFDA benchmarks.
- India's PET-bottle collection rate of 90–95% — among the world's highest — provides world-class feedstock; only rPET is currently FSSAI-approved for food-contact.
- Structural gap: of 788,027 tonnes of packaging placed on market in 2023-24, 71% recyclable but only 1% contained recycled content.

Chhattisgarh Context

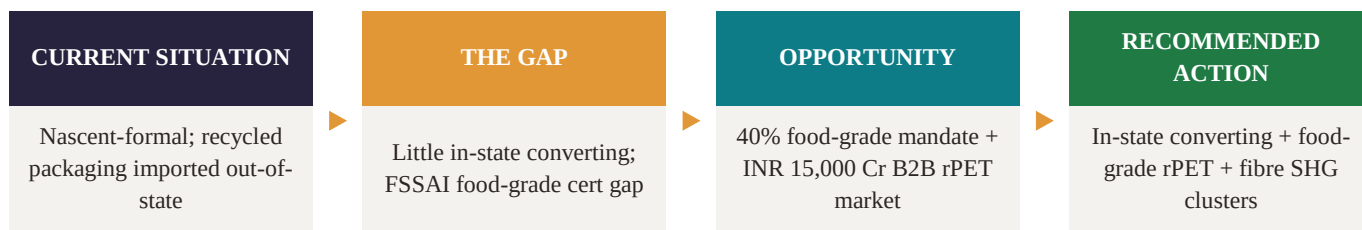
- Position is nascent-formal with a converter-import structure; recycled-content and FSSAI-certified food-grade rPET packaging largely imported from Maharashtra, Gujarat, Tamil Nadu, NCR.

- Direct downstream of the CG Plastic Waste Recycling cluster (GG Wastech, Raipur) — upstream rPET/granule feedstock can close the loop in-state.
- Large in-state packaging-consumption base: FMCG, food-processing, cement (bags/sacks), steel (industrial packaging), e-commerce, agri-produce packaging.
- Fibre-based packaging convergence with CG's Bamboo, Agri-Residue, and Bio-Fibre value chains for moulded-fibre/bagasse/compostable packaging.
- SHG enterprise readiness: Luikona FGD explicit "branding & packaging unit: YES"; Sogda 20 SHGs; Berchegondi 50 women interested in enterprise.

3. Demand & Supply Assessment

- **Supply:** Upstream rPET + recycled granules from the CG Plastic Waste Recycling cluster; India's 90–95% PET-bottle collection provides world-class feedstock; fibre feedstock (bagasse, paddy straw, bamboo) from Bamboo/Agri-Residue/Bio-Fibre VCs. Feedstock quality constrained by fragmented municipal collection.
- **Demand:** Regulation-underwritten and escalating — recycled-content mandate (rigid 30%→60%; food-grade 40% from April 2026; 50% avg by 2030); INR 15,000 Cr B2B rPET market; FMCG/beverage anchor offtake (Tetra Pak India, HUL) under EPR pressure; "Made-in-India rPET" export potential.
- **Supply–Demand Gap:** The 1% recycled-content vs 71% recyclability gap is the precise deficit the mandates close; CG currently captures none of the recycled-content converting value or brand-facing margin, importing packaging from out-of-state converters.

Demand → Gap → Opportunity → Action · Packaging using Recycled Materials



Source: Burman Capital, MoEFCC, FSSAI, India Plastics Pact

4. Market Ecosystem

The value chain converts upstream recycled feedstock into compliant, branded packaging spanning urban-industrial converting and rural fibre-based SHG clusters.

- **Input Suppliers:** Upstream Plastic Waste Recycling cluster (GG Wastech — rPET/granules); PET-bottle collectors (90–95% rate); Bamboo/Agri-Residue/Bio-Fibre VCs (fibre feedstock).
- **Primary Producers & Aggregators:** Food-grade rPET producers (JB Ecotex, Go Rewise, the 15–18 national facilities); recycled-content converters; fibre-based packaging SHG/MSME clusters.
- **Processing & Logistics:** Blow-moulding, injection-moulding, thermoforming, film/pouch extrusion; bottle-to-bottle rPET resin (super-clean decontamination); moulded-fibre/bagasse units.
- **Off-takers & Retail:** FMCG/beverage/food brand-owners (Tetra Pak India, Hindustan Unilever); e-commerce, food-service; domestic + "Made-in-India rPET" export.

- **Enablers:** MoEFCC + CPCB (EPR portal, recycled-content verification); FSSAI (food-grade approval); CECB + state FSSAI + CSIDC; BIS (IS 14534:2023); PMFME + AIF + SFURTI + state capital subsidy.

Market Ecosystem — Packaging using Recycled Materials

Input & Feedstock	Plastic Recycling cluster (rPET) · PET-bottle collection · Bamboo/Agri-Residue fibre
Producers & Aggregators	Food-grade rPET producers · Recycled-content converters · Fibre-packaging SHG clusters
Processing & Logistics	Blow/injection moulding · Film/pouch extrusion · Moulded-fibre/bagasse units
Off-takers & Markets	FMCG/beverage brands (Tetra Pak, HUL) · E-commerce & food-service · Made-in-India rPET export
Enablers	MoEFCC/CPCB + FSSAI · CECB + state FSSAI + CSIDC · PMFME + AIF + SFURTI

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
SHG Fibre-Packaging Enterprises	Luikona explicit "branding & packaging unit: YES"; Sogda 20 SHGs; Berchegondi 50 women — need capital + branding	Develop fibre-based/compostable packaging SHG clusters (2027-28) via SFURTI/PMFME; integrate Bamboo/Agri-Residue/Bio-Fibre VCs
Recycled-Content Converters (MSMEs)	Limited in-state converting capacity; compliance cost for smaller firms	Channel PMFME + AIF + state capital subsidy; SHG/MSME cluster aggregation for shared certification/traceability
Food-Grade rPET Producers	FSSAI food-grade certification gap; only rPET approved for food-contact; India lacks clear FSSAI guidelines	Build FSSAI certification capability (2029-30) on EFSA/USFDA-benchmark model; pursue certification proactively
Upstream Plastic Recyclers (GG Wastech)	Feedstock quality dependent on collection/segregation maturity; B2B rPET tightening bottle supply	Integrate with upstream Plastic Waste Recycling cluster for clean segregated feedstock; leverage 90-95% PET collection
FMCG / Brand Off-takers	Under EPR + recycled-content pressure; need compliant, traceable supply	Secure FMCG/beverage anchor offtake; QR/barcode traceability; "CG circular packaging" identity

CG Regulators (CECB, state FSSAI, CSIDC)	No notified state recycled-packaging cluster policy; converter-import structure	Notify CG Recycled-Packaging Cluster Policy by Q4 2026; food-grade rPET certification support
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6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Rare combination of regulation-underwritten demand + brand-facing value-addition; recycled-content mandate guarantees escalating demand through 2030. B2B rPET higher-margin than RPSF. Working capital moderate at Tier 1 (₹50 lakh–5 Cr) and Tier 3 (₹30 lakh–3 Cr), substantial at Tier 2 (₹10–50 Cr). Viability favours Tier 1 + Tier 3 first-wave. Build periods 3–24 months.
- **Social Benefits:** Fibre-based/compostable tier is the strongest community-anchored tier — women-SHG enterprise (Luikona, Sogda, Berchegondi) via SFURTI/PMFME clusters; brand-facing value-addition retained in-state.
- **Environmental & Climate Resilience:** Converts recycled feedstock into circular packaging, closing CG's circular-packaging loop; compostable fibre-based packaging serves the plastic-free segment of the 2030 goal; diverts plastic via recycled-content substitution for virgin.
- **Technical Feasibility:** Tier 1 converting uses India's existing competency (moderate capex); Tier 2 food-grade rPET requires EFSA/USFDA-benchmark super-clean decontamination + FSSAI certification; Tier 3 fibre-based is lower-technology, SHG/MSME-viable.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Food-grade rPET resin pioneers (JB Ecotex, Go Rewise + the 15–18 advanced facilities, ₹9,000–10,000 Cr invested) — FSSAI-certified bottle-to-bottle rPET at EFSA/USFDA benchmarks, serving the 40%-food-grade mandate and INR 15,000 Cr B2B market; the Tier 2 template. **Integrated rPET-to-packaging converters (Chemco Group)** — PCR-content PET/rPET packaging with design-for-circularity and brand-owner partnerships, closing the loop on plastic; the Tier 1 converting template for CG. **Fibre-based & compostable packaging (moulded-fibre/bagasse/bamboo/agri-residue)** — SHG/MSME-scale (₹1–20 Cr), compostable segment of the 2030 goal, converging with CG's bio-fibre VCs and the Luikona "branding & packaging: YES" SHG readiness — the strongest community-anchored tier.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Limited in-state converting capacity, especially FSSAI food-grade rPET. Solution: notify CG Recycled-Packaging Cluster Policy by Q4 2026; launch Tier 1 converting MSMEs integrated with upstream Plastic Recycling cluster.
- **Financial barriers:** Compliance cost for smaller converters; substantial Tier 2 working capital. Solution: PMFME + AIF + state capital subsidy through converter MSMEs; SFURTI/PMFME SHG-cluster funding for fibre-based tier; concessional debt + FMCG anchor offtake for food-grade rPET.

- **Knowledge & skill gaps:** FSSAI food-grade certification gap (no clear India guidelines vs USFDA/EFSA). Solution: shared FSSAI/food-grade certification + QR-traceability infrastructure for MSME clusters; proactive certification; design + branding studios.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Virgin-recycled cost gap; B2B rPET demand tightening bottle feedstock supply (away from RPSF)	Medium	Integrate upstream for clean feedstock; leverage 90-95% PET collection; rising recycled-content mandate stabilises recycled-resin demand/pricing
Production Feedstock	/ Feedstock quality dependent on upstream collection/segregation; fragmented municipal collection	High	Integrate with CG Plastic Waste Recycling cluster (GG Wastech) for segregated feedstock, closing the loop
Operational Supply Chain	/ FSSAI food-grade certification gap — only rPET approved; no clear India guidelines	High	Invest in EFSA/USFDA-benchmark food-grade rPET tech; pursue FSSAI certification proactively; batch-documented traceable supply
Policy Governance	/ No notified state recycled-packaging cluster policy; compliance cost + reclassification risk for smaller converters	Medium	Notify CG Recycled-Packaging Cluster Policy by Q4 2026; SHG/MSME cluster aggregation for shared certification/traceability

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** CECB (recycled-content compliance, converter consents); CSIDC + Industries Department (packaging-cluster industrial-zone allocation + capital subsidy); Directorate of Food Safety / state FSSAI (food-grade certification); SFURTI/PMFME (fibre-based SHG clusters). Bind: cluster notification + food-grade rPET certification support.
- **Private Sector & Investors:** Food-grade rPET producers (JB Ecotex, Go Rewrite, Chemco Group), recycled-content converters, FMCG/beverage brand-owners (Tetra Pak India, HUL) as anchor offtakers; upstream Plastic Recycling cluster integration.

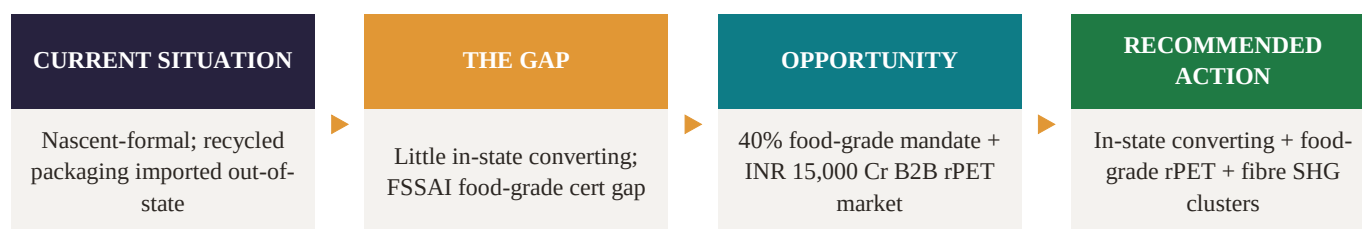
- **Development Agencies & NGOs:** SHG/MSME cluster mobilisation for fibre-based packaging (Luikona, Sogda, Berchegondi); TA for design, branding, and shared certification/traceability; bio-fibre VC convergence.

11. Key Departments & Institutional Alignment

- **MoEFCC:** Administers PWM Rules and recycled-content mandates (incl. 40%-food-grade directive).
- **CPCB:** Operates EPR portal, recycled-content compliance verification, EPR-certificate trading.
- **FSSAI:** Governs food-grade recycled-plastic approval under Food Safety and Standards Act 2006 (currently rPET-only — the framework most needing development).
- **Bureau of Indian Standards:** IS 14534:2023 (recycled-plastic labelling) + packaging standards.
- **DPIIT + Ministry of Food Processing Industries:** Shape packaging-sector and food-processing-linked demand.
- **CECB (Chhattisgarh Environment Conservation Board):** Recycled-content compliance + converter consents.
- **CSIDC + Industries Department:** Packaging-cluster industrial-zone allocation + capital subsidy.
- **Directorate of Food Safety (state FSSAI):** Food-grade rPET certification.
- **SFURTI / PMFME (via state):** Fibre-based packaging SHG cluster support.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Packaging using Recycled Materials



Source: Burman Capital, MoEFCC, FSSAI, India Plastics Pact

Input / Output Flow

Value Chain Flow · Packaging & Recycled Materials

INPUTS



C10 Solid & Liquid Waste Recycling

CE · CIRCULAR ECONOMY

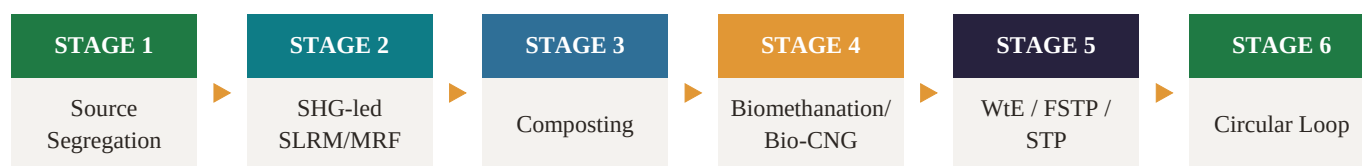
The integrated collection, segregation, processing, treatment, and resource recovery from municipal solid waste, faecal sludge, wastewater, and rural solid-and-liquid resource streams — spanning source segregation through Material Recovery Facilities, composting, biomethanation, waste-to-energy, and faecal-sludge and sewage treatment.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
40,000–80,000 jobs (60–70% women per Ambikapur benchmark) across MRFs, composting, biomethanation, FSTPs, STPs, and SHG-led decentralised SLRM centres	direct	₹3,000–8,000 Cr opportunity over GETM 2026–32. Tier 1 SHG-led SLRM centres/MRFs ₹10 lakh–3 Cr; Tier 2 composting ₹50 lakh–5 Cr, biomethanation/Bio-CNG ₹5–50 Cr, FSTPs ₹2–25 Cr; Tier 3 WtE ₹100–500 Cr, RDF ₹10–50 Cr, STPs ₹25–300 Cr	envelope	Dual-rationale — recovered-material/compost/biogas/electricity sales + SBM Urban 2.0 (₹1,41,678 Cr, 2021–26) + AMRUT + 15th Finance Commission grants + National Bioenergy Programme + EPR convergence

Methodology: The 40,000–80,000 job range — the highest of any Waste & Recycling VC — applies the Ambikapur 470-women-SHG coefficient (25–80 FTE per SLRM centre, 60–70% women) to a deployment of decentralised SLRM centres across CG cities + district HQs + rural blocks, plus composting/biomethanation/FSTP/STP/WtE facility coefficients, over 2026–32. National figures (MSW ~1.45 lakh TPD, 165 MT/yr by 2030, SBM 2.0 outlay) are drawn from NITI Aayog, Invest India/MoHUA, and Swachh Survekshan 2023 at conservative benchmarks; the ₹3,000–8,000 Cr envelope leverages the Ambikapur baseline.

Value Chain / Circular Flow — Solid & Liquid Waste Recycling



2. Contextual Overview

National Context

- India generates ~1.45 lakh TPD MSW (~53 MT/yr), projected to reach 165 MT/yr by 2030 (NITI Aayog 2024).

- SBM Urban dashboard reports ~76% processing, but Swachh Survekshan 2023 shows only 5 states (CG, Gujarat, Kerala, Maharashtra, Odisha) at genuine 50%+ processing; 90% segregation claim often not matched on ground.
- SBM Urban 2.0 (₹1,41,678 Cr, 2021-26) targets garbage-free cities by 2026 — faecal sludge, wastewater, source segregation, single-use plastic, air pollution, C&D, legacy-dump bioremediation.
- SWM Rules 2016 — strengthened by the Solid Waste Management Bill 2025 (introduced Rajya Sabha 5 December 2025) — mandate wet/dry/hazardous segregation, EPR, and rural extension to Gram Panchayats.
- National Bioenergy Programme (2021-22 to 2025-26) supports biogas/BioCNG/power/syngas; WtE/biomethanation operational in Delhi, Hyderabad, Pune, Vishakhapatnam, Tirupati, Indore.

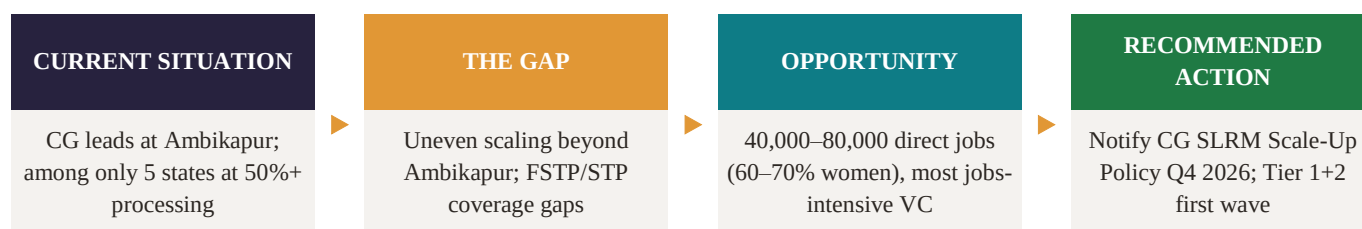
Chhattisgarh Context

- Uniquely advantaged — CG hosts the national champion Ambikapur SLRM model and is among only 5 states at 50%+ processing (Swachh Survekshan 2023); the only cluster VC where CG exports the operational template.
- Ambikapur: 470 women SHGs operate 17 SLRM centres sorting waste into 156 categories, 100% zero-landfill, 16-acre former dump remediated into a public Sanitation Park.
- SHG ecosystem readiness across FGDs (Sogda 20 SHGs, Berchegondi 8 SHG/CLFs + 50 women, Luikona 9 SHGs) for rural SLRM extension under SBM Gramin.
- Anchor and feedstock-aggregator of the entire Waste & Recycling cluster + bioeconomy (Plastic, E-Waste, Bio-medical, C&D, Bio-Inputs, Biochar, Agri-Residue).
- Gaps: uneven scaling beyond Ambikapur; segregation-quality gap; underdeveloped biomethanation/Bio-CNG; FSTP/STP coverage gaps; legacy-dump remediation not yet state-wide.

3. Demand & Supply Assessment

- **Supply:** ~1.45 lakh TPD national MSW; CG feedstock from urban ULBs (Raipur, Bilaspur, Durg, Korba, Raigarh) + rural streams under SBM Gramin; organic waste from markets/hostels/institutions for biomethanation; segregation quality the binding constraint (90% claimed vs ground reality).
- **Demand:** Garbage-free-cities mandate (SBM 2.0, 100% processing by 2026 target); compost offtake to Bio-Inputs/horticulture (FCO-certified); Bio-CNG offtake to public transport (Indore 150+ buses model) + cooking gas; WtE electricity; RDF to cement co-processing (GG Wastech AFR); treated-water reuse.
- **Supply–Demand Gap:** The processing-rate gap (~76% claimed vs only 5 states at 50%+ actual) and uneven scaling beyond Ambikapur are the structural deficits; compost utilisation/marketing and biomethanation/FSTP/STP coverage gaps limit by-product economics.

Demand → Gap → Opportunity → Action · Solid & Liquid Waste Recycling



Source: Swachh Survekshan 2023, NITI Aayog, CSE, Earth5R

4. Market Ecosystem

The broadest, most institutionally mature cluster VC — spanning decentralised SHG-led SLRM through large WtE, anchored on the home-grown Ambikapur model.

- **Input Suppliers:** Households (source segregation); informal waste-pickers; SHG federations; Gram Panchayats (rural streams).
- **Primary Producers & Aggregators:** SHG-led SLRM centres (Ambikapur 17-centre model); MRFs; municipal corporations + councils; nagar panchayats.
- **Processing & Logistics:** Composting plants; biomethanation/Bio-CNG plants (Indore model); FSTPs; STPs; WtE + RDF units; GPS-tracked door-to-door collection.
- **Off-takers & Markets:** Bio-Inputs/horticulture (FCO compost); public transport + cooking-gas (Bio-CNG); electricity grid (WtE); cement co-processors (RDF via GG Wastech AFR); industry/agriculture (treated water).
- **Enablers:** MoHUA (SBM Urban 2.0, AMRUT, Swachh Survekshan); Ministry of Jal Shakti (SBM Gramin); MNRE (National Bioenergy Programme); NITI Aayog (Waste-to-Wealth); UADD + Panchayati Raj + CECB + CREDA; 15th Finance Commission grants.

Market Ecosystem — Solid & Liquid Waste Recycling

Input & Feedstock	Household source segregation · Informal waste-pickers · Gram Panchayat rural streams
Producers & Aggregators	SHG-led SLRM centres (Ambikapur) · MRFs · Municipal corporations
Processing & Logistics	Composting plants · Biomethanation/Bio-CNG (Indore) · FSTPs / STPs / WtE / RDF
Off-takers & Markets	Bio-Inputs/horticulture (compost) · Public transport + cooking gas (Bio-CNG) · Cement co-processing (RDF); grid (WtE)
Enablers	MoHUA SBM 2.0 + AMRUT · UADD + Panchayati Raj + CECB · National Bioenergy + 15th FC grants

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Women SHGs (Ambikapur benchmark)	470 women operate 17 centres, 156-category sorting — the 60-70% women-workforce benchmark; rural readiness (Sogda 20,	Notify CG State SLRM Scale-Up Policy by Q4 2026; designate Ambikapur as state-wide replication training centre

	Berchegondi 50 women, Luikona 9 SHGs)	
Informal Waste-pickers	Unaccounted, low-income; Indore proves formalisation raises system efficiency	Integrate into formal SHG/cooperative SLRM structures with dignified employment
Urban Local Bodies (UADD)	Segregation-quality gap (90% claimed vs mixed-waste reality); uneven replication beyond Ambikapur	Multi-bin enforcement (Ambikapur 156-category / Indore 6-bin) + penalty enforcement + ULB capacity-building
Rural Gram Panchayats	Plastic newly arrived in villages; Cha Tolagaon collection stopped when Swachhata Didi honorarium unpaid — a finance/governance failure	Extend SLRM to large GPs under SBM Gramin with dependable honorarium/user-fee finance + SHG continuity
Bio-Inputs / Cement Off-takers	Compost utilisation/marketing challenge; under-leveraged RDF co-processing	FCO-certified compost offtake to Bio-Inputs/horticulture; RDF to cement AFR (GG Wastech model)
CG Regulators (CECB)	Underdeveloped biomethanation/Bio-CNG; FSTP/STP coverage gaps	WtE/STP/landfill standards; deploy Indore/Pune/Tirupati-model biomethanation + close FSTP/STP gaps under SBM 2.0 + AMRUT

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Unique financial architecture — substantial central + state grant funding flows directly through SBM Urban 2.0, SBM Gramin, AMRUT, National Bioenergy Programme, and 15th Finance Commission grants, reducing capex burden materially below other waste-recycling VCs. Tier 1 SLRM centres (₹10 lakh–3 Cr) are the most capital-efficient and jobs-intensive; viability favours Tier 1 + Tier 2 first-wave. Build periods 3–30 months.
- **Social Benefits:** By a substantial margin the most jobs-intensive and most women-led VC in the cluster — 40,000–80,000 jobs at 60–70% women per Ambikapur; converts informal waste-pickers into sustained SHG enterprise; strongest community anchoring.
- **Environmental & Climate Resilience:** 100% zero-landfill (Ambikapur); legacy-dumpsite bioremediation (16-acre Sanitation Park model); diverts organics to compost/Bio-CNG; displaces open plastic burning (linked to respiratory illness in FGD villages); treated-water reuse.

- **Technical Feasibility:** Ambikapur (decentralised) + Indore (centralised 6-bin, Bio-CNG) + Pune/Vishakhapatnam/Tirupati (biological treatment + WtE) provide proven, home-grown and national templates; the binding constraint is ULB capacity + reliable SHG/honorarium finance, not technology.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Ambikapur SLRM (Surguja, CG) — 470 women SHGs, 17 centres, 156-category sorting, 100% zero-landfill, 16-acre Sanitation Park; the single most strategically important CG asset and the only cluster VC where CG exports (rather than imports) the template; the Tier 1 state-wide scaling blueprint.

Indore (7-year Swachh Survekshan #1) — 100% processing of 1,900 TPD, 6-bin segregation, GPS door-to-door, biomethanation Bio-CNG powering 150+ city buses, informal-waste-picker integration; the centralised Tier 2/3 template for Raipur and Bhilai-Durg.

Pune/Vishakhapatnam/Tirupati — compressed biogas, WtE, and biomethanation templates for CG's larger urban centres and pilgrimage catchments.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** Uneven scaling beyond Ambikapur; underdeveloped biomethanation/Bio-CNG; FSTP/STP coverage gaps. Solution: state-wide Ambikapur replication by 2028 (Ambikapur as training centre); Indore-model Bio-CNG in Raipur/Bhilai-Durg; close FSTP/STP gaps under SBM 2.0 + AMRUT by 2030.
- **Financial barriers:** Rural collection fails on unreliable honorarium finance (Cha Tolagaon lesson). Solution: dependable honorarium/user-fee mechanism + SHG continuity; grant funding via SBM Urban 2.0/Gramin + AMRUT + National Bioenergy Programme + 15th Finance Commission + state matching.
- **Knowledge & skill gaps:** Segregation-quality gap; ULB capacity to replicate decentralised SHG models. Solution: ULB official + SHG-operator capacity-building; multi-bin enforcement (156-category/6-bin); statutory backing under SWM Bill 2025.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Compost quality/marketing + by-product economics; long-standing compost-utilisation challenge	Medium	Cross-VC compost offtake to Bio-Inputs/horticulture; Bio-CNG offtake to transport/cooking gas; FCO compost certification

Production Feedstock	/ Segregation-quality gap (90% claimed vs mixed-waste ground reality)	High	Rigorous segregation-at-source enforcement; multi-bin (156-category/6-bin); ULB penalty enforcement; SHG manual sorting
Operational Supply Chain	/ Decentralised-model replication + ULB capacity risk; rural honorarium-finance failure	High	Ambikapur as state-wide training centre; ULB + SHG capacity-building; dependable honorarium/user-fee finance
Policy / Governance	Uneven scaling beyond Ambikapur; Survekshan methodology historically favoured centralised systems	Medium	Notify CG State SLRM Scale-Up Policy by Q4 2026; statutory backing under SWM Bill 2025

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** UADD (ULB-level SBM Urban 2.0 across municipal corporations); Panchayati Raj & Rural Development (SBM Gramin, village SLWM via Gram Panchayats); CECB (WtE/STP/landfill standards); Agriculture + Horticulture Departments (compost offtake); CREDA (Bio-CNG + WtE-electricity offtake); state SBM cells. Bind: State SLRM Scale-Up Policy + Ambikapur as training centre.
- **Private Sector & Investors:** Private operators for Tier 3 WtE/STP on PPP/concession; cement co-processors (Ultratech, ACC, Ambuja, Shree Cement) for RDF AFR offtake; Bio-CNG offtake to public transport.
- **Development Agencies & NGOs:** Ambikapur model partners + CSE for TA; SHG federation mobilisation for Tier 1 SLRM centres; informal-waste-picker formalisation.

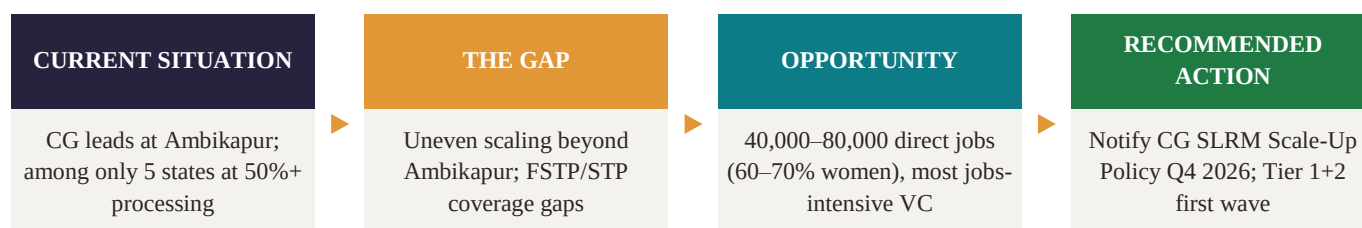
11. Key Departments & Institutional Alignment

- **MoEFCC:** Notifies SWM Rules 2016 + SWM Bill 2025; administers Central Monitoring Committee (headed by Environment Secretary).
- **MoHUA:** Administers SBM Urban 2.0 (₹1,41,678 Cr) + AMRUT + MSW Management Manual + Swachh Survekshan rankings.
- **Ministry of Jal Shakti:** Administers SBM Gramin (rural sanitation + village SLWM).
- **MNRE / MoP:** National Bioenergy Programme + Bio-CNG support.
- **NITI Aayog:** Waste-to-Wealth Mission + strategic SWM roadmap; CPCB (landfill/WtE/STP standards); CPHEEO (technical guidelines); BIS (SWM standards).
- **Urban Administration & Development Department (UADD):** Coordinates ULB-level SWM across CG municipal corporations, councils, nagar panchayats.

- **Panchayati Raj & Rural Development Department:** SBM Gramin + village SLWM through Gram Panchayats.
- **CECB (Chhattisgarh Environment Conservation Board):** WtE/STP/landfill environmental standards.
- **CG Agriculture + Horticulture Departments + CREDA:** Compost offtake (FCO) + Bio-CNG/WtE-electricity offtake.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Solid & Liquid Waste Recycling

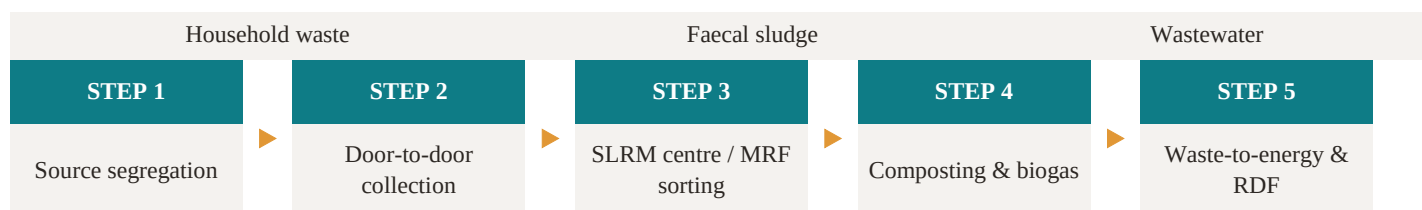


Source: Swachh Survekshan 2023, NITI Aayog, CSE, Earth5R

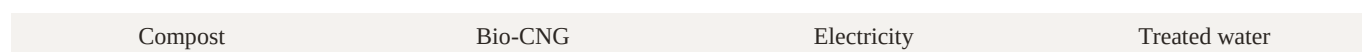
Input / Output Flow

Value Chain Flow · Solid & Liquid Waste Recycling

INPUTS



OUTPUTS



Source: Swachh Survekshan 2023, NITI Aayog, CSE, Earth5R

C11 Agri-Residue Circular Economy

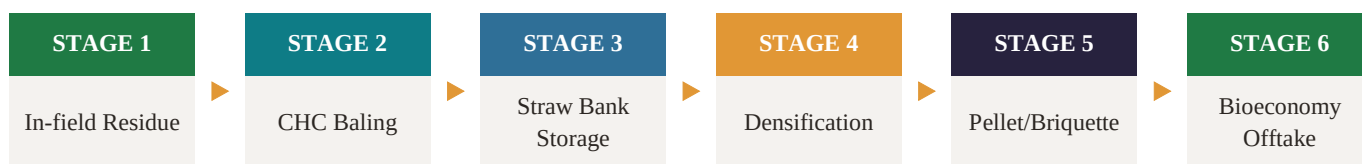
CE · CIRCULAR ECONOMY

The aggregation, baling, transport, storage, primary processing, and densification of crop biomass — paddy straw, wheat straw, maize stover, mustard straw, pulse husk, millet straw and oilseed residues — into bales, briquettes, pellets and torrefied biomass that feed the entire Chhattisgarh bioeconomy.

1. Executive Dashboard

DIRECT EMPLOYMENT	FTE	MARKET INVESTMENT	&	REVENUE POTENTIAL
20,000–40,000 direct rural jobs across Custom Hiring Centres (CHCs), straw banks, aggregation, transport, and pelletisation; women 50–80% of the cluster-tier workforce (PRESPL gender-parity benchmark).		₹400–1,000 Cr addressable investment envelope (GETM horizon). Tier 1 (CHC cluster) ₹15–40 lakh per CHC; Tier 2 (straw bank + primary aggregation) ₹50 lakh–₹3 Cr per cluster; Tier 3 (industrial briquette/pellet + integrated processing) ₹5–50 Cr per unit.		India biomass market ₹15,000 Cr (current) → ₹32,000 Cr by FY2030-31; foundational aggregation unlocks ₹2,500–5,500 Cr of downstream bioeconomy value (RE Manufacturing + Bio-Feed + Bio-Fibre + Biochar + Bio-Inputs).

Value Chain / Circular Flow — Agri-Residue Circular Economy



2. Contextual Overview

National Context

- **Vast unutilised residue burden:** India produces ~750 MMT biomass/yr with ~250 MMT surplus; ~178 MMT of crop residue remains unutilised annually, driving soil degradation and severe air pollution.
- **Growing biomass market:** ~₹15,000 Cr currently, projected to ₹32,000 Cr by FY2030-31; daily briquette/pellet demand of 95,000 tons vs 8,000–10,000 tons production — a ~10x demand-supply gap.
- **National priority / policy stack:** ₹3,500 Cr+ Crop Residue Management (CRM) Scheme, GOBAR-Dhan, SATAT, National Bio-Energy Programme, Agri Infrastructure Fund; CRM Operational Guidelines (March 2024) provide 50–80% machinery subsidy.
- **Punjab reference model:** 19.52 MMT paddy straw (2024); 1,48,451 CRM units distributed cumulatively to 2024-25; ₹395 Cr disbursal in 2025; 70% decline in stubble burning 2024 followed by 53% further decline in Kharif 2025.
- **Downstream demand pathways:** biomass power (Punjab 11 plants, 97.5 MW, 0.88 MMT/yr), thermal co-firing, CBG under SATAT, bio-ethanol (EBP 20%), and carbon/ESG credits.

Chhattisgarh Context

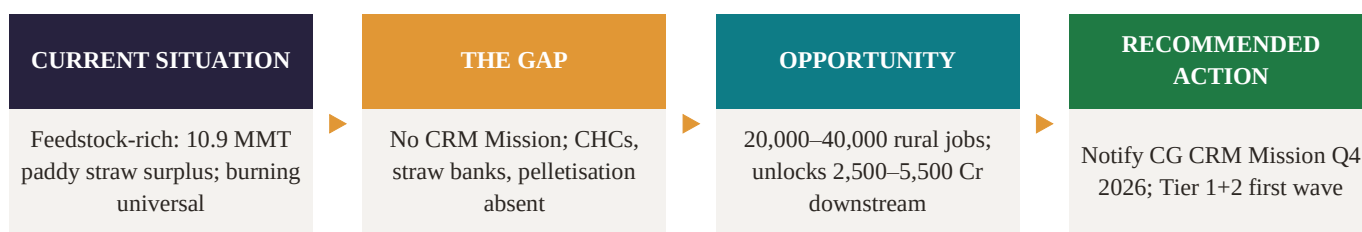
- **Large feedstock endowment:** ~10.9 MMT surplus paddy straw annually plus pulse, millet, oilseed (niger/jatangi), maize, mustard and wheat residues — volume comparable to Punjab but with ~60% lower current monetisation.

- **Universal residue burning:** every Agriculture FGD (Sonesarar, Sideswar, Sogda, Sarudih) records "Burning of crop residue: Common" — establishing intervention opportunity at universal scale and 60–70% destruction of theoretical residue value.
- **Institutional capacity in place:** 130+ operational FPOs statewide; active SHG networks (Sonesarar 6–7 tonnes/yr bio-input; Sideswar 2 SHGs, 10 quintals, 100% women); Sonesarar cooperative paddy procurement at ₹31/kg — a directly extendable aggregation precedent.
- **Aggregation-poor:** no notified state CRM Mission; CHC deployment lags Punjab by an order of magnitude; no straw bank network; sub-scale industrial pelletisation.
- **Coal-transition convergence:** major paddy districts (Korba, Surguja, Raigarh) overlap coal-transition geographies, aligning Just Transition workforce needs with agri-residue cluster deployment.

3. Demand & Supply Assessment

- **Supply:** 10.9 MMT surplus paddy straw plus multi-crop residue (pulse husk, millet straw, niger straw, maize stover, mustard/wheat straw). Highly seasonal — paddy generated in a narrow 30–45 day post-harvest window (Nov–Dec kharif), requiring rapid baling, transport and storage before monsoon degrades quality. Quality/aggregation depend on dense straw banks within 15–25 km of cropping areas.
- **Demand:** Biomass power and 10% thermal co-firing (CG's 14+ GW capacity implies 4–5 MMT/yr, absorbing 40–50% of surplus); briquette/pellet industrial boilers (~10x national demand-supply gap); CBG under SATAT; bio-ethanol; and five downstream bioeconomy VCs (RE Manufacturing, Bio-Food, Bio-Fibre, Biochar, Bio-Inputs).
- **Supply–Demand Gap:** Residue is abundant but stranded — burned in-field for lack of CHC machinery, straw banks, and pre-committed offtake. The intervention builds the missing aggregation layer (CHCs + straw banks + pelletisation) that converts stranded residue into feedstock for the entire CG bioeconomy.

Demand → Gap → Opportunity → Action · Agri-Residue Circular Economy



Source: PRESPL, Punjab CRM Programme, Verbio India

4. Market Ecosystem

Agri-residue is a logistics-and-aggregation value chain with value concentrated at the cluster-tier baling, storage and primary-processing stage.

- **Input Suppliers / Feedstock:** Paddy, pulse, millet, oilseed (niger), maize, mustard and wheat farmers across the six major paddy districts and four Agriculture FGD villages; forest-residue (Sal, Mahua, Tendu, bamboo) cross-supply.
- **Primary Producers & Aggregators:** 130+ FPOs; SHGs and federated SHGs (Sonesarar, Sideswar, Sogda); Custom Hiring Centres (CHCs) as machinery-pool hubs; FPO-SHG-CHC tripartite consortia.

- **Processing & Logistics:** Straw banks (5,000–15,000 tonne capacity, 15–25 km radius); briquette/pellet plants (2–10 TPH); torrefaction units; PRESPL-template vertically integrated operators; regional manufacturers (Brilliant Industries, Buyofuel-listed).
- **Off-takers & Markets:** Biomass power plants and thermal co-firing operators (CREDA/Energy Dept); CBG plants under SATAT (Verbio Tonk template, IOCL/BPCL/HPCL); bio-ethanol plants; brick kilns; Bio-Food/Bio-Fibre/Biochar processors.
- **Enablers (finance / extension / regulatory):** Min. of Agriculture (CRM Guidelines), MoPNG (SATAT), MNRE (Bio-Energy Programme), MoFPI (PMFME), ICAR-IARI (Pusa Bio-decomposer), NABARD (FPO + RIDF), AIF; CG Agriculture Dept, CREDA, CSIDC, KVKs/IGKV, Dept of Cooperation.

Market Ecosystem — Agri-Residue Circular Economy

Input & Feedstock	Paddy/pulse/millet farmers · Niger/maize/mustard residue · Forest residue (Sal, bamboo)
Producers & Aggregators	130+ FPOs · Women SHGs (Sonesarar, Sideswar) · Custom Hiring Centres (CHCs)
Processing & Logistics	Straw banks (5-15K tonne) · Briquette/pellet plants (2-10 TPH) · PRESPL-template operators
Off-takers & Markets	Biomass power + thermal co-firing · CBG under SATAT (Verbio) · Bio-Food/Fibre/Biochar processors
Enablers	Min. Agriculture (CRM), MoPNG (SATAT) · MNRE, MoFPI (PMFME), NABARD, AIF · CG Agriculture Dept, CREDA, KVKs

5. Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Farmers (paddy + multi-crop)	Residue burning "Common" in every Agriculture FGD; residue is stranded cost, not revenue	Notify CG CRM Mission; deploy CHC machinery + Pusa Bio-decomposer to make ex-situ aggregation viable
FPOs (130+ statewide)	Sideswar FPO shareholder-addition model works but lacks CRM machinery access	Channel CRM + AIF + PMFME subsidies through FPO-SHG-CHC tripartite consortia, not direct-to-farmer
Women SHGs	Sonesarar 6-7 tonnes/yr, Sideswar 2 SHGs (100% women); strong enterprise interest ("compost unit: YES")	Anchor residue-processing enterprise on women SHGs; leverage Lakhpatri Didi + NRLM; PRESPL gender-parity template
CHC operators	Punjab has 1,48,451 CRM units; CG counterpart absent — binding infrastructure gap	Deploy 200–400 CHCs with 50–80% central subsidy

		across six paddy districts + Jashpur-Kanker cluster
Straw bank / aggregators	Transit cost ~₹1,330/tonne at 15 km rising to ₹2,500–3,000/tonne at 50 km erodes economics	Build 50–100 straw banks at 15–25 km radius, co-located with FPO/cooperative procurement (₹31/kg society precedent)
Downstream off-takers	CG offtake (biomass power, CBG, Bio-Feed/Fibre) sub-scale vs Punjab's 97.5 MW	Pre-commit offtake MoUs at aggregation establishment via shared-cluster thesis

6. Triple-Bottom-Line & Feasibility

- **Economic Feasibility & ROI:** Moderate, seasonally-cyclic capex — Tier 1 ₹15–40 lakh/CHC, Tier 2 ₹50 lakh–₹3 Cr/straw bank, Tier 3 ₹5–50 Cr/unit; 50–80% CRM subsidy plus AIF 3% interest subvention and PMFME 35% credit-linked subsidy sharply improve viability. Pricing tiers: bales ₹2,500–3,000/tonne delivered, pellets ₹4,000–5,000/tonne, briquettes ₹5,000–8,000/tonne (paddy-straw ₹5–8/kg). A 2 TPH pellet plant processing 7,500 tonnes/yr supports 70 FTE.
- **Social Benefits:** 20,000–40,000 rural jobs concentrated in the harvest-season aggregation window; 50–80% women workforce; SHG-FPO income diversification; addresses public-health harm from open residue burning; convergence with coal-transition Just Transition districts.
- **Environmental & Climate Resilience:** Targets 30–50% reduction in residue burning by 2030; displaces open-field burning (soil degradation + severe air pollution); generates verified carbon credits (VCS, Gold Standard, India CCTS) and Scope 3 reductions; Pusa Bio-decomposer enables in-situ soil enrichment.
- **Technical Feasibility:** Mature, transferable technology stack — balers, rakes, super seeders, mulchers, briquette presses, pellet plants (2–10 TPH), torrefaction; PRESPL's vertically integrated model (USD 10M DFC credit guarantee, BEE ESCO Grade 2+) is the proven industrial template.

7. Success Stories & Proven Models

Proven Models & Benchmarks

Punjab CRM Programme — 1,48,451 subsidised CRM units distributed cumulatively, ₹395 Cr disbursed in 2025, and a 70% (2024) → 53% (Kharif 2025) multi-year decline in stubble burning — proves that a state CRM Mission with CHC machinery subsidy plus ex-situ industrial offtake delivers measurable results; direct read-across: CG needs Mission notification, ₹200–400 Cr cumulative machinery deployment, and downstream offtake pre-commitments. **PRESPL** (India's most vertically integrated biomass-energy enterprise — residue collection to briquetting, pelletisation, logistics and BOOT/O&M steam supply; USD 10M DFC credit guarantee; BEE ESCO Grade 2+; gender-parity workforce) is the Tier 3 industrial template for CG's coal-transition districts, with a women-workforce model that matches FGD-documented SHG enterprise interest.

8. Overcoming Implementation Bottlenecks

- **Infrastructure gaps:** No CHC network, no straw banks, sub-scale pelletisation → deploy 200–400 CHCs + 50–100 straw banks (15–25 km radius, co-located with FPO procurement) + 50–100 industrial pellet/briquette units by 2030.
- **Financial barriers:** FPO-SHG-CHC working-capital and capex gaps, acute in the 30–45 day harvest window → channel CRM 50–80% subsidy + AIF 3% interest subvention + PMFME 35% credit-linked subsidy + NABARD RIDF through tripartite consortia, plus NABARD/SIDBI/SBI concessional debt.
- **Knowledge & skill gaps:** Perception that CRM is only a "Punjab-Haryana issue"; limited machinery/decomposer know-how → KVK + IGKV last-mile extension for CHC operator training and Pusa Bio-decomposer adoption (~₹20–30/acre), integrated with existing NPM/IPM training cycles.

9. Perceived Risks & Mitigation

Risk Category	Identified Risk	Severity	Mitigation Strategy
Market / Price	Delivered cost rises to ₹2,500–3,000/tonne (bales) / ₹4,000–5,000/tonne (pellets) at 50 km — upper end of buyer willingness-to-pay	High	Dense straw-bank network within 15–25 km paired with CHC machinery clusters to compress transit cost
Production Feedstock	Narrow 30–45 day post-harvest window; monsoon degrades uncollected residue; single-crop seasonality	High	Rapid baling + storage sheds; multi-crop feedstock (Sarudih 450 acres, Sideswar pulses/millet) to spread the operating cycle
Operational Supply Chain	Downstream offtake (biomass power, CBG, Bio-Feed/Fibre) sub-scale; aggregated residue lacks structural buyers	High	Pre-commit offtake at aggregation establishment; shared-cluster thesis across five downstream bioeconomy VCs
Policy Governance	CG not a priority state in CRM Guidelines 2024 (targets Punjab/Haryana/UP/MP/Delhi); minimal subsidy uptake	High	Notify CG CRM Mission by Q4 2026; position 10.9 MMT volume for priority extension; route subsidies via FPO-SHG-CHC consortia

10. Stakeholder Matrix & Action Domains

- **State Government / Public Sector:** Agriculture Department (proposed state nodal for CG CRM Mission; CHC + straw bank architecture; FPO-SHG subsidy delivery); CREDA + Energy Dept (biomass power/co-firing/CBG policy); CSIDC + Industries Dept (Tier 3 industrial-zone access; CG Industrial Policy 2024-30 bio-economy subsegment); KVKs + IGKV (last-mile extension); Dept of Cooperation (FPO operations); Tribal Welfare Dept (Bastar-Jashpur-Kanker participation).
- **Private Sector & Investors:** PRESPL and vertically integrated operators; regional briquette/pellet manufacturers (Brilliant Industries, Buyofuel-listed); Verbio India (CBG); biomass power developers; PSU oil-marketing off-takers (IOCL, BPCL, HPCL) under SATAT.
- **Development Agencies & NGOs:** NABARD (FPO Promotion under 10,000 FPO scheme + RIDF); FPO-SHG mobilisation via Bihan/NRLM; ICAR-IARI/KVK capacity building for Pusa Bio-decomposer and CHC operations.

11. Key Departments & Institutional Alignment

- **Ministry of Agriculture & Farmers Welfare:** CRM Operational Guidelines 2024 (50–80% machinery subsidy; CHC + individual-farmer access); Agri Infrastructure Fund (3% interest subsidy on loans up to ₹2 Cr).
- **Ministry of Petroleum & Natural Gas:** SATAT — assured-offtake compressed bio-gas (CBG) at notified price.
- **Department of Drinking Water & Sanitation:** GOBAR-Dhan — rural CBG and bio-fertiliser.
- **MNRE:** National Bio-Energy Programme — briquette/pellet capex and biomass-to-power support.
- **MoFPI:** PMFME — 35% credit-linked subsidy for residue-processing micro-enterprises.
- **ICAR-IARI:** Pusa Bio-decomposer microbial consortium for in-situ decomposition (KVK delivery).
- **NABARD:** FPO Promotion (10,000 FPO scheme) + Rural Infrastructure Development Fund (RIDF).
- **Agriculture Department, Govt of CG:** State nodal for the proposed CG CRM Mission; CHC + straw bank deployment; FPO-SHG subsidy delivery.
- **CREDA + CSIDC + KVKs/IGKV:** Biomass power/co-firing convergence; Tier 3 industrial-zone siting; last-mile CRM extension and operator training.

Part III — Bio-economy & Nature-based Solutions

Land, forest, water and livestock value chains that regenerate natural capital while building rural livelihoods.

Bio-economy & Nature-based Solutions

Creating value from living resources and healthy ecosystems — the inclusion engine of the green economy.

This cluster pairs two related ideas. The **bio-economy** converts biological resources into economic goods — bio-inputs, biogas, bio-fibre, bio-textiles, biochar and bio-based packaging. **Nature-based solutions (NbS)** protect, restore and sustainably manage ecosystems to generate income and jobs — agroforestry, sustainable forest management, pasture and water-security work, and sustainable tourism. Together they are, in CEEW's words, the most innovative way to create economic value from a green transition by sustainably leveraging natural resources.

It is the cluster where Chhattisgarh's endowments are deepest. As one of India's most forested states, with a large **tribal and forest-dependent population** and a substantial agricultural base, it holds strong potential across **non-timber forest produce**, bamboo, agroforestry, bio-inputs and biochar (using the same paddy-straw surplus that feeds bioenergy), inland fisheries, small livestock and nutraceuticals. These value chains reach precisely the rural and tribal households that stand to gain most from a green economy.

They are also highly **job-intensive** — CEEW's Odisha analysis estimated around **9 direct jobs per ₹ crore** for bio-economy and NbS, second only to the circular economy — though employment is often **seasonal** (many bio-economy and NbS roles run roughly 100–180 days a year rather than year-round). Realising this potential therefore depends on aggregation, market linkage and value addition within the state so that primary producers capture more of the final value.

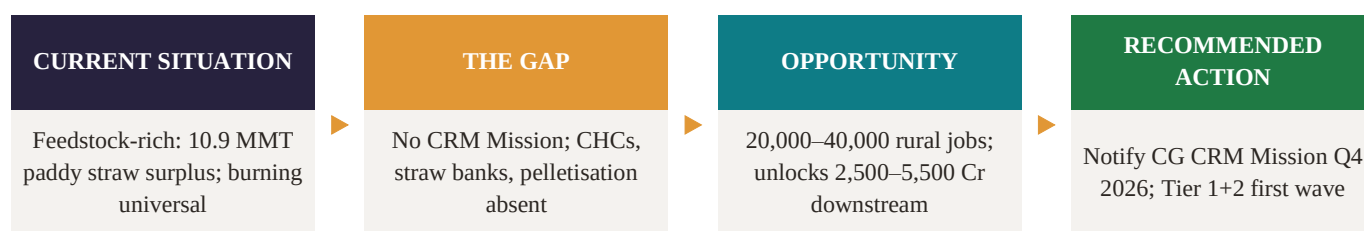
Value chains in this cluster (Chhattisgarh's GETM portfolio)

NTFP · Agroforestry · Bamboo-based Products · Bio-Inputs · Biochar · Bio-Fibre · Bio-Textiles · Bio-Feed · Sustainable Forest Management · Sustainable Agriculture / IPM · Inland Fishery · Small Livestock · Pasture Management · Nutraceuticals · Sustainable Housing · Water Security · Eco-Tourism

Chhattisgarh anchor: *extensive forests and a large tribal and rural workforce make this the cluster with the widest livelihood reach — the paradigm's clearest bridge between natural capital and inclusive incomes.*

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Agri-Residue Circular Economy

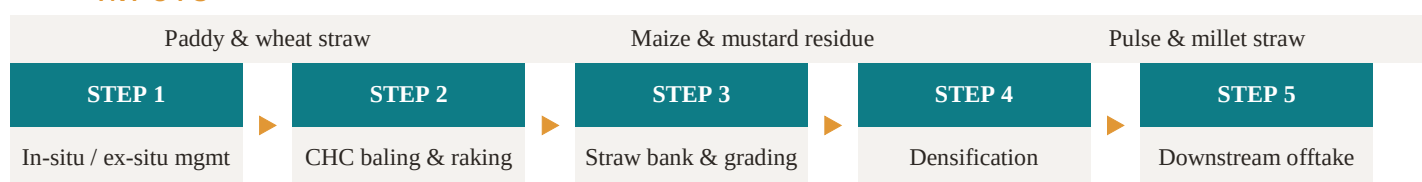


Source: PRESPL, Punjab CRM Programme, Verbio India

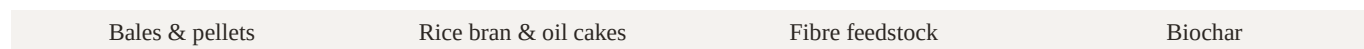
Input / Output Flow

Value Chain Flow · Agri-Residue Circular Economy

INPUTS



OUTPUTS



Source: PRESPL, Punjab CRM Programme, Verbio India

N01 Agroforestry

NbS · NATURE-BASED SOLUTIONS

A precision-designed, market-oriented land-use system that converts degraded and underutilised land into integrated plantations blending high-value horticulture with industrial timber, aggregation and processing infrastructure.

1 Executive Dashboard

Executive dashboard — agroforestry at a glance (Chhattisgarh · GETM 2026–2030 & beyond)

Direct FTE employment. ~31,948 FTE jobs by 2030 from 12.19 million person-days at ~450 person-days/ha/yr — land preparation and pitting (7,200 FTE), 8,000 farm ponds (8,000 FTE), plantation maintenance (5,600 FTE), women-led SHG nursery hardening (528 FTE) and harvesting/value-addition (3,100 FTE), with convergence.

Market & investment opportunity. ₹1,458.5 Cr five-year CapEx for 40,000 ha of integrated plantations plus Village Aggregation Centres (₹39 lakh/unit) and Primary Processing Units (₹1.30–1.50 Cr/unit), supported by CG Industrial Policy incentives (30–45% FCI subsidy; 40–60% interest subvention up to ₹5 Cr/yr).

Revenue potential & ROI. Projected IRR 21.4% and BCR 1.62 across a 40:60 fruit:timber mix — Clonal Eucalyptus ₹1,200 Cr at first harvest (2030), Litchi ₹192 Cr/yr, Mango ₹125 Cr/yr,

Guava ₹80 Cr/yr, Bamboo ₹35 Cr/yr, with bamboo processing lifting value from ₹4,000/MT to ₹35,000/MT.

Climate outcome & carbon monetisation. ~0.66 Mt CO₂e/yr sequestered (biomass + soil organic carbon), Green-Credit-eligible at a 90% survival benchmark — with a second, already-operating monetisation route demonstrated by BHGY through the voluntary carbon market (§4).

Institutional pathway — the addition in this revision. Birsa Harit Gram Yojana (Jharkhand) is treated here not as a comparator but as the delivery instrument: an MGNREGA (now VBGRAM-G) (now VBGRAM-G)-anchored, women-cadre-monitored, carbon-endowed plantation model already operating at ~1.82 lakh acres and over 2 lakh families, whose five-layer stack is directly transferable to Chhattisgarh (§3).

Methodology & assumptions.[1] *All Chhattisgarh headline metrics are derived from the source value-chain diagnostic; all BHGY metrics from the Government of Jharkhand deck and standee brief. Formulas, coefficients and data gaps are detailed in the footnote.*

Executive Dashboard · Agroforestry · Chhattisgarh 2026–30 & Beyond

DIRECT FTE JOBS	5-YEAR CAPEX	PROJECTED IRR	CARBON
31,948	₹1,458.5 Cr	21.4%	0.66 Mt CO₂e/yr
by 2030 (12.19 million person-days; 450 person-days/ha/yr)	40,000 ha integrated plantations + infrastructure	BCR 1.62 · peak revenue Litchi ₹192 Cr, Mango ₹125 Cr	biomass + soil organic carbon; Green Credit-eligible

Metric	2024–26 Baseline	2030–36 Target
Employment	Avg. household income ₹9,677/mo; 1.25 ha fragmented holdings	~31,948 FTE jobs; 12.19 million person-days
Raw Material Base / Market	9.6 lakh ha underutilised fallow; wood imports for furniture demand	789,000 MT RMB (233K horticulture + 556K forestry)
Revenue / Returns	40–60% survival; high price volatility	IRR 21.4%; BCR 1.62; peak revenue Litchi ₹192 Cr, Mango ₹125 Cr
Carbon	373.54 sq. km wasteland added (2008–2016)	0.66 Mt CO ₂ e/year (440,400 biomass + 220,200 SOC)

2 The Opportunity — and the Delivery Gap

Chhattisgarh has the raw ingredients for an agroforestry-led green industry: fragmented smallholdings (average 1.25 ha; household income ~₹9,677/month), large degraded and wasteland tracts (373.54 sq km added between 2008 and 2016), a layered subsidy stack (AIF, PMKSY-PDMC, MMVSY, National Bamboo Mission, MIDH, , NRLM), and three agro-climatic zones with proven species fit. What it has lacked is not land, species or scheme money. It has lacked a

delivery instrument capable of holding smallholder plantations alive through the five-to-ten-year gestation between planting and income.

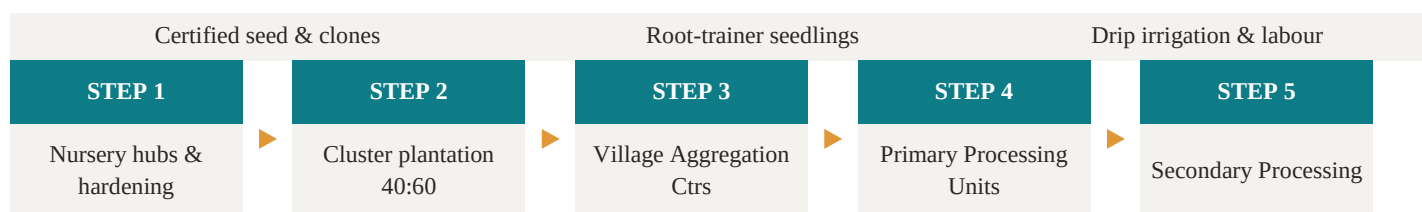
- **The failure mode is institutional, not biophysical.** Past afforestation in the state achieved only 40–60% survival. Species selection was not the binding constraint; sustained maintenance, water access and farmer confidence during the pre-revenue years were. The redesign therefore enforces a non-negotiable 90% survival benchmark — but a benchmark is a target, not a mechanism.
- **The disconnection gap.** Land, farmers and industry currently operate in silos. Aggregation and processing capacity is thin, and raw material leaves the state unprocessed — bamboo at ₹4,000/MT against a ₹35,000/MT processed value.
- **The maintenance cliff.** Every plantation programme faces the same question at the end of its support window: who pays for orchard upkeep once project funds stop? Unanswered, this is where survival rates collapse. [analyst]

Sections 3 to 5 argue that all three gaps have already been closed, at scale and in a comparable agro-ecological and administrative setting, by **Birsa Harit Gram Yojana** (BHGY) in Jharkhand — and that Chhattisgarh's fastest, lowest-risk route to 40,000 ha is to adopt that instrument rather than design a new one.

Input / Output Flow

Value Chain Flow · Agroforestry

INPUTS



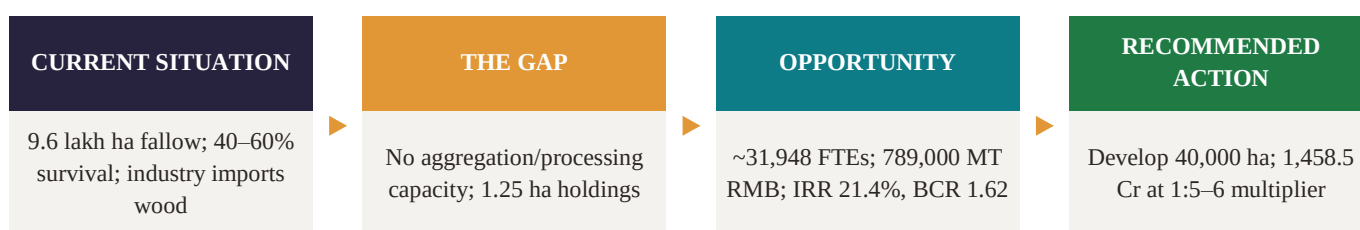
OUTPUTS

Horticultural produce	Industrial timber	Bamboo round sticks	Fruit pulp
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Source: Berchegondi FGD (TRI, Billion Next), CG Industrial Policy 2024–30, National Agroforestry Policy 2014

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Agroforestry



Source: Berchegondi FGD (TRI, Billion Next), CG Industrial Policy 2024–30, National Agroforestry Policy 2014

3 BHGY as the Institutional Instrument for Scale-Up

BHGY is a plantation scheme of the Rural Development Department, Government of Jharkhand, implemented as block plantation on individual land under MGNREGA (now VBGRAM-G) (now VBGRAM-G), targeting underprivileged and marginalised rural families. It runs on a SAMAJ–SARKAR–BAZAR architecture: decentralised planning through women's collectives (VPRP-GPDP) and a community cadre; public-system delivery of funds, monitoring and irrigation support; and market linkage for produce and carbon. From a 500-farmer pilot across 9 blocks of 4 districts in 2015, it became a state-wide flagship in 2020–21 with five-year support and inter-cropping, and now operates across 24 districts and 264 blocks.

The standard unit and what it buys

- **One acre, 192 trees, five years.** 112 fruit plants plus 80 timber plants per acre, at a unit cost of ~₹4.7 lakh/acre inclusive of five years of maintenance support — the same 112+80 configuration now cited externally as a reference smallholder agroforestry model.
- **A wage instrument, not a subsidy.** ~73% of the unit cost is wage component (72.80% labour : 27.20% material on the departmental estimate at an unskilled wage of ₹282/person-day), paid through MGNREGA (now VBGRAM-G) (now VBGRAM-G). Each unit supports the beneficiary family plus roughly four to five nearby families.
- **Survival delivered, not merely targeted.** Cumulative plant mortality across the full 2016-17 to 2024-25 portfolio is 6.5% — i.e. ~93.5% survival — against Chhattisgarh's 40–60% historical baseline and its 90% benchmark. [derived from the source coverage table]

BHGY as Institutional Instrument — the Five-Layer Delivery Stack

Proven in Jharkhand at ~1.82 lakh acres · transferable to the Chhattisgarh agroforestry value chain.

Layer	BHGY mechanism (Jharkhand, evidenced)	Transfer to Chhattisgarh GETM
1 · Financing Rail	MGNREGS wage window carries ~73% of the ~₹4.7 lakh/acre unit cost over 5 years	<i>Converts the CapEx ask into a wage-transfer entitlement</i>
2 · Supply Backbone	Didi Bagiya Yojna — SHG / women-collective nurseries supply quality saplings	<i>5 hi-tech nursery hubs + 80–100 SHG hardening units</i>
3 · Survival Assurance	7,179 Bagwani Sakhis + app-based orchard monitoring → 6.5% cumulative mortality	<i>Delivers the 90% survival benchmark vs a 40–60% baseline</i>
4 · Water & Yield	Irrigation-well convergence (BSKSM), jalkunds, NABARD RIDF lift / drip pipeline	<i>8,000 farm ponds + PMKSY-PDMC drip irrigation</i>
5 · Post-Project Endowment	Voluntary carbon market (ACORN / Rabobank CRUs) — 20-year farmer payment stream	<i>The maintenance answer the Green Credit overlay still needs</i>

Benchmark: BHGY performance against the Chhattisgarh plan

Parameter	BHGY Jharkhand (achieved)	CG Agroforestry plan (projected)	Read-across
Scale	1,82,059 acres (~73,700 ha); 24 districts, 264 blocks	40,000 ha (~98,800 acres) over five years	CG target is ~1.34× BHGY's achieved area — a scale BHGY has already demonstrated is administrable
Households	Over 2 lakh families benefited	Not separately stated in the source diagnostic	BHGY gives CG a per-household unit of account the current plan lacks
Unit cost	~₹4.7 lakh/acre (~₹11.6 lakh/ha) with 5-year support [derived]	~₹1.48 lakh/acre (~₹3.65 lakh/ha) [derived: ₹1,458.5 Cr ÷ 40,000 ha]	A ~3.2× gap. Most likely the CG figure is a materials-and-infrastructure provision excluding the wage rail — this must be reconciled before the CapEx is fixed [analyst]
Wage share	~73% of unit cost through MGNREGA (now VBGRAM-G) (now VBGRAM-G)	~₹94 Cr stimulus ≈ 6% of ₹1,458.5 Cr [derived]	The single largest financing lever available to CG and currently the least used [analyst]
Survival	6.5% cumulative mortality (~93.5% survival)	90% survival benchmark vs 40–60% historical	BHGY already clears the CG benchmark — the cadre-plus-app model is why
Public investment	More than ₹5,000 Cr to date (~₹2.75 lakh/acre spent, cycles still running) [derived]	₹1,458.5 Cr five-year CapEx	Confirms the scale of fiscal commitment a genuine 40,000 ha programme implies
Carbon route	Voluntary carbon market — ACORN (Rabobank) CRUs, 20-year horizon, operating	Green Credit Programme, 5-year verification threshold, not yet activated	Two distinct routes. CG can pursue either or both; BHGY proves the voluntary route is bankable at smallholder scale [analyst]

4 Case Study 1 — BHGY and the Global Carbon Market

Case study · linking 1 lakh+ smallholder orchards to the voluntary carbon market

The problem it solves. BHGY's support window closes after five years. At that point the orchard is biologically established but not yet at peak yield, and the household has no external reason to keep investing labour in it. This is the maintenance cliff that has historically destroyed plantation survival rates. The carbon linkage converts orchard upkeep from a cost into an income stream for a further two decades.

The instrument. Transform Rural India, with Intellectap and ACORN (Rabobank), and with the Rural Development Department, Government of Jharkhand, registers willing BHGY farmers whose orchards were established after 2018 onto the ACORN platform, which issues Carbon Removal Units (CRUs) for smallholder agroforestry. The programme is designed to require no investment and carry no downside risk for either the farmer or the state; RDD, GoJ has recorded no additional financial burden on its part.

The architecture — four things Chhattisgarh should note. (i) Measurement is remote-sensed: geo-tagged plots are monitored by satellite (Satelligence), so verification does not depend on field self-reporting. (ii) Payment is direct: benefits are transferred to farmers' bank accounts, with the great majority of CRU sale value contractually flowing to the smallholder. (iii) The horizon is 20 years, matching the durability period of the credit rather than the project cycle. (iv) Aggregation makes one-acre plots viable: fixed verification and registration costs are pooled across tens of thousands of farmers, which no individual smallholder could carry alone.

Status. Over 15 districts have issued authorisation for farmer survey; survey completed in 4 districts and ongoing in 10+. The programme deck records more than 45,000 farmers registered with farmer agreements, and the standee brief 50,000+ — with CRU calculation initiated and payouts indicated from late 2025 onwards. Independent reporting places the ambition at 1 lakh+ women farmers and around ₹500 Cr of carbon-removal benefit over 20 years. Current disbursement status could not be verified for this revision and must be confirmed before external citation (§8).

Order of magnitude for the farmer. The programme deck indicates an average of roughly ₹60,000 per one-acre orchard over 20 years — around ₹3,000/acre/year. This is not a livelihood on its own; it is a maintenance retainer, and that is precisely its design function. Read alongside the same programme's horticultural income — a Khunti beneficiary earning ₹60,000–70,000 from one acre in two years — the carbon stream is the floor that protects the asset generating the larger return. [analyst]

Why this is the scale-up unlock for Chhattisgarh. The CG diagnostic already assumes a carbon overlay via the Green Credit Programme at a five-year verification threshold. BHGY demonstrates a second, complementary and already-transacting route — the voluntary market — with the MRV discipline, aggregation structure and farmer-agreement machinery built and tested in an adjacent state under the same central schemes. Adopting it would give the CG programme a post-2030 maintenance endowment that its current design does not have. [analyst]

Design caution. Voluntary-market CRU prices fluctuate and are not guaranteed; carbon commitments restrict tree felling for the full crediting period, which interacts directly with the CG plan's timber-harvest revenue lines (Clonal Eucalyptus at 2030, Gamhar at 10 years). Carbon-encumbered and harvest-destined blocks should be planned as separate estates, not the same trees counted twice. [analyst]

Other Case studies

Clonal Eucalyptus for the Nava Raipur Furniture Cluster — Industrial timber planted under the 60 percent timber allocation reaches first harvest in 2030, projected to generate ₹1,200 Crores in phased revenue and establishing a reliable local Raw Material Base for the furniture hub. Environmentally it contributes to the 0.66 Mt CO₂e annual sequestration and reclaims degraded land; economically it substitutes out-of-state wood imports. Read-across for Chhattisgarh: it demonstrates how the 40:60 mix's long-horizon asset directly answers the industrial supply gap.

Bamboo value-addition (round sticks) — Converting raw bamboo (₹4,000/MT) into industrial round sticks (₹35,000/MT) shows a near-nine-fold value uplift captured locally, with bamboo plantations targeted at ₹35 Crores annually. The model illustrates how PPU/SPE processing retains margin in the state rather than exporting raw feedstock — a template for block-level processing enterprises.

Berchegondi community nursery pathway (Kanker) — Although agroforestry is not yet practised, Berchegondi's 8 SHGs, 92 IFR titles and 50 women interested in nursery raising provide the institutional scaffolding for SHG-managed nurseries and farm-boundary agroforestry (Mahua, Amla, Bamboo) on FRA-titled land, with an estimated 20–30 jobs. It exemplifies the "start with nursery and boundary planting, de-risk with demonstration plots" approach for high-readiness tribal clusters.

Community & Stakeholder Insights

Field evidence comes from a Focus Group Discussion in **Berchegondi village (Albera Gram Panchayat, Kanker Block, Kanker district), March 2026**, conducted under GETM by Transform Rural India and Billion Next BoP Solutions. Berchegondi is a fully forest-dependent community — all 120 households rely on forest resources — with an active Van Samiti (since 2006), 8 SHGs, and 92 Individual Forest Rights (IFR) titles. Institutionally it is among the strongest FGD sites, but **agroforestry is not yet practised by any farmer** — the FGD captures aspirational potential and enabling conditions.

Constraints voiced: felling-permission and transit-pass complexity deters on-farm tree planting; long gestation (5–15 years) is incompatible with short-term credit; no bank loan or insurance product for tree crops is known; there are no demonstration plots or extension advisory; and — the single largest deterrent — no assured buy-back or village-level buyer for tree produce. Enablers: 92 IFR titles provide secure land rights for on-farm planting; 40 youth interested in forest-based enterprise and 50 women in nursery raising; women SHG interest in fruit processing creates demand pull; and estimated employment of 20–30 persons from nursery and agroforestry-adjacent activities. The Forest Management FGD scored **21.5/25 (High Readiness)**, driven by Institutional Enablement (5/5) and Environmental Impact (5/5); however, agroforestry-specific readiness alone — zero current practice, zero scheme uptake, missing market linkages — sits in the Moderate-Emerging range, indicating the intervention must lead with de-risking and market linkage.

6 Adapting the Model to Chhattisgarh's Agro-Climatic Zones

The BHGY programme material includes a Chhattisgarh-specific annexure mapping plantation models to the state's three agro-climatic zones — Northern Hills (8.3 lakh ha, 5 districts, 11% of net sown area irrigated), Central Plains (32.95 lakh ha, 15 districts, 43% irrigated) and the Plateau Region (6.4 lakh ha, 7 districts, 5% irrigated). This is the bridge between the Jharkhand instrument and Chhattisgarh's own species and soil conditions, and it should anchor cluster planning.

Plantation model	Zone	Livelihood generated (₹/ha)	C sequestration (t/ha)
Mango (250 plants) + intercrops + Albizia procera fence	Northern Plateau; Central Plains	₹95,000 from 3rd year + ₹25,000/yr intercrops	23.5 (17 + 6.5)
Gamhar (Gmelina arborea) clonal block + intercrops	Central Plains	₹20,00,000 after 10 years + ₹15,000/yr intercrops	19.5
Guava (Psidium guajava) + intercrops + Albizia fence	Northern Plateau; Central Plains; Plateau	₹1,50,000/yr from 2nd year + ₹25,000/yr intercrops	16.5 (10 + 6.5)
Arjuna (Terminalia arjuna) + Tasar silk rearing	Northern Plateau; Plateau	₹1,50,000/yr from Tasar cocoons	11.03
Dwarf coconut + intercrops + Albizia fence	Plateau Region	₹1,50,000/yr green coconuts + ₹25,000/yr intercrops	13.5 (7 + 6.5)
Coffee (Coffea arabica) + Red Cedar / silver oak (100 trees)	Plateau Region	₹2,00,000 from coffee beans	198 — figure inconsistent with all other rows; verify
Litchi (Litchi chinensis) + intercrops + Albizia fence	Northern Plateau; Central Plains	₹95,000 from 3rd year + ₹25,000/yr intercrops	23.5 (17 + 6.5)
Citrus / custard apple + intercrops + Albizia fence	Central Plains	₹1,00,000/yr from 2nd year + ₹25,000/yr intercrops	16.5 (10 + 6.5)

Source: Chhattisgarh annexure to the BHGY programme deck, which cites published horticulture and carbon-sequestration literature. The annexure labels the northern zone "Northern Hills" in the map and "Northern Plateau" in the model table; the two are read here as the same zone. The coffee sequestration value (198 t/ha) is an order of magnitude above every other model in the same table and should be treated as an error or a different basis until verified against the underlying reference. [analyst]

7 Scale-Up Pathway, Institutional Alignment and Risk

A three-phase pathway

- **Phase 1 (2026–27) — install the rail.** Constitute the State Agroforestry Cell as convergence SPV; issue a Chhattisgarh plantation protocol on the BHGY template (one-acre unit, 112+80 configuration adapted to zonal models, five-year support); route the wage component through with Gram Sabha beneficiary selection; commission SHG nurseries on the Didi Bagiya model with root-trainer and QR-coded traceability.
- **Phase 2 (2027–29) — install the cadre and the water.** Recruit and certify a Bagwani-Sakhi-equivalent women's cadre with app-based orchard monitoring through CG-AMIS; converge farm ponds and PMKSY-PDMC drip; stand up 65–80 horticulture and 48–50 forestry VACs and block-level PPUs, sequenced to biological maturity rather than built ahead of it.
- **Phase 3 (2029 onwards) — install the endowment.** Register maturing plantations on both monetisation routes — Green Credit at the five-year threshold and a voluntary-market aggregation on the ACORN/BHGY pattern — with milestone-linked DBT, drone and satellite survival audit, and Secondary Processing Enterprises drawing on CG Industrial Policy FCI subsidy and interest subvention.

Principal risks and mitigation

Risk	Severity [analyst]	Mitigation — with the BHGY instrument
Plantation survival collapses, as in the 40–60% historical baseline	High	Adopt the mechanism, not just the benchmark: root-trainer nurseries, five-year maintenance funding, a paid women's monitoring cadre and app-based reporting — the combination that produced 6.5% mortality in Jharkhand
CapEx under-provisioned against real per-acre cost	High	Reconcile the ₹1.48 lakh/acre provision against BHGY's ₹4.7 lakh/acre norm before commitment; expand the wage rail from ~6% to the ~73% BHGY demonstrates is achievable
Maintenance cliff after the support window closes	High	Build the carbon endowment into the design from year one rather than bolting it on, as BHGY did retrospectively for post-2018 orchards
Carbon revenue does not materialise, or conflicts with timber harvest	Medium	Treat carbon as a maintenance retainer, not a revenue pillar; segregate carbon-encumbered blocks from harvest-destined timber estates; pursue Green Credit and voluntary routes in parallel
Market layer stays thin and value leaves the state	Medium	Sequence VAC/PPU/SPE build to maturity; in-state bamboo and fruit processing (AIF 3% subvention, PM-FME, MIDH); FPO aggregation from the outset — the layer BHGY built last

Risk-Proofing the Scale-Up

Policy / Legal / Regulatory: Transit and felling-permission complexity, and uncertainty over farm-forestry classification, deter farmer investment. Mitigation: continued policy liberalisation treating agroforestry species as agricultural crops, simplified e-transit passes and Gram-Panchayat-level single-window felling permission, backed by farmer legal literacy on FRA rights.

Environmental: Climate variability, erratic monsoon and heat stress threaten newly planted trees; land degradation persists. Mitigation: climate-resilient species baskets, drip irrigation, legume intercropping for soil health, and 8,000 farm ponds for water security — with agroforestry itself functioning as an erosion- and microclimate-mitigation strategy.

Socio-economic (CBOs, PRI, Local Administration): Smallholder fragmentation, delayed cash flows and thin market access risk first-mover reluctance. Mitigation: 40:60 mix for mid-term liquidity, FPO aggregation, women-led SHG enterprises, milestone-linked Direct Benefit Transfers via CG-AMIS, and PRI/BATF-led labour mobilisation and grievance redressal to maintain community ownership.

16 Stakeholder Matrix for Scale — Recommendations & Actions

Stakeholder	Role in Scale-Up	Recommended Action / Point for Action
Central (MoEFCC / MoA&FW / TRIFED)	National schemes, carbon rules, market rails	Operationalise Green Credit verification for 2026 plantations; converge SMAF, National Bamboo Mission, MIDH and e-NAM/ONDC.
State Agroforestry Cell (SPV)	Inter-departmental convergence, monitoring	Run Mission Mode with CG-AMIS milestone-linked DBT; enforce the State Agroforestry Protocol and 40:60 mix.
Forest & Horticulture Departments	Clones, silviculture, transit passes, orchards	Supply certified clones and grafts; simplify transit passes; accredit nurseries and drive high-density planting.
Developer / Enterprise (anchor buyers, SPEs)	Demand pull, secondary processing	Sign anchor buyer contracts ahead of maturity; invest in PPUs/SPEs and agroforestry parks under the Thrust Sector subsidy.
Finance (NABARD, banks, AIF)	Long-tenure and working capital	Pilot 7–10 year plantation loans with maturity-matched moratorium; extend AIF interest subvention to VACs/PPUs; blend catalytic capital at 1:5–6.
Community / CBO / PRI (FPOs, SHGs, JFMC)	Aggregation, nursery, execution	Form FPOs to aggregate smallholders; establish SHG hardening units and community nurseries; use FRA-titled land for farm-boundary agroforestry.
Rural Development / Panchayat	Labour, works, social audit	Converge MGNREGS for pitting, fencing and 8,000 farm

Stakeholder	Role in Scale-Up	Recommended Action / Point for Action
		ponds; manage social audits and first-tier grievance redressal.
CG State Power Company	Biomass offtake	Establish plantation residue-based power procurement to monetise by-products.

[1]**Methodology.** Chhattisgarh — Employment: ~31,948 FTE = 12.19 mn person-days at ~450 PD/ha/yr (pitting 7,200 + farm ponds 8,000 + maintenance 5,600 + nursery 528 + harvesting/value-addition 3,100 FTE). Investment: ₹1,458.5 Cr five-year CapEx for 40,000 ha + infrastructure (VAC ₹39 lakh/unit; PPU ₹1.30–1.50 Cr/unit); CG Industrial Policy 30–45% FCI subsidy, 40–60% interest subvention up to ₹5 Cr/yr. Returns: IRR 21.4%, BCR 1.62; 40:60 fruit:timber; peak revenues Eucalyptus ₹1,200 Cr (2030), Litchi ₹192 Cr, Mango ₹125 Cr, Guava ₹80 Cr, Bamboo ₹35 Cr/yr; bamboo ₹4,000→₹35,000/MT. Carbon: 0.66 Mt CO₂e/yr (biomass + SOC), Green-Credit-eligible at 90% survival. BHGY — coverage, mortality, unit cost, labour:material split (72.80:27.20 at ₹282/PD), cadre strength and carbon-finance status are as stated in the Government of Jharkhand programme deck and the RESTORE standee brief; where the two disagree, both figures are shown (§8). Acre–hectare conversions use 1 ha = 2.471 acres. Per-acre and percentage comparisons between the two programmes are computed here and marked [derived]; they are directional and are not like-for-like until plantation density and support duration are reconciled. Fast-moving inputs should be re-verified before external citation.

N02 Sustainable Forest Management

NbS · NATURE-BASED SOLUTIONS

The integrated, community-led management of forests for ecological, economic and social outcomes — protection, regeneration, sustainable harvesting and forest-based enterprise — as the upstream foundation of Chhattisgarh's forest bio-economy.

1 Executive Dashboard

EXECUTIVE DASHBOARD — SFM AT A GLANCE (Chhattisgarh · the upstream foundation of NTFP, Agroforestry & Carbon)

Employment base. Forest-based livelihoods generate ~91 million person-days of employment annually, with tribal residents accounting for ~90% of this workforce — the livelihood foundation of the tribal heartland (~30.6% Scheduled Tribe population, ~41% of the state under forest).

Market & Investment Opportunity. Downstream value-chain investment rather than foundational mobilisation: a Van Dhan-linked primary-processing facility (₹15–30 lakh/Kendra, 100% PMVDY grant), decentralised storage, a buy-back guarantee and a seasonal working-capital line — anchored by CFR funding under PM-JUGA (~₹15 lakh per 100 ha + ₹15,000/ha management).

Revenue & Value Uplift. Chhattisgarh's tendu trade exceeds ₹1,000 Cr, with collection wages alone rising from ₹75 Cr (2001) to ~₹609 Cr (2025). Conservative estimates suggest household forest income can rise from ~15% to 30–35% of total income within 3–5 years while keeping extraction within sustainable limits.

Climate & Strategic Outcome. ~505 Mt carbon stock (3rd in India) and the single-largest 2021–23 gain in forest and tree cover (+684 sq km) make the state a prime candidate for carbon-finance-linked restoration under the Green Credit Programme. SFM is the upstream foundation for NTFP, Agroforestry and Carbon and influences five more value chains.

Methodology & assumptions.^[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Sustainable Forest Management (SFM) · Chhattisgarh

FOREST EMPLOYMENT	FOREST & CARBON	MFP ECONOMY	INCOME UPLIFT
91M person-days/yr	55,812 sq km	tendu >₹1,000 Cr	15% → 30–35%
~90% tribal — the livelihood base of the forest economy	3rd-largest cover · ~505 Mt carbon stock (3rd in India)	collection wages ₹75 Cr (2001) → ₹609 Cr (2025)	household forest income within 3–5 yrs (Berchegondi)

2 Contextual Overview

National Context

- **Forest as a national priority:** FRA 2006 (IFR/CR/CFR rights), CAMPA afforestation finance, PMVDY Van Dhan processing, MSP for minor forest produce and the Green Credit Programme (Green Credit Rules 2023) form the national architecture for community-led forest management and value addition.

- **Carbon-finance frontier:** the Green Credit Programme creates a market mechanism for ecosystem restoration and assisted natural regeneration on degraded forest — an emerging revenue overlay.

Chhattisgarh Context

- **Best-in-class forest endowment:** 55,812 sq km forest cover (3rd in India, ~41% of the state), ~505 Mt carbon stock (3rd), and the largest single 2021–23 gain in forest and tree cover among all states.
- **Deep institutional architecture:** a three-tier system — state (Forest Dept, CG MFP Federation with 31 district unions and ~916 primary societies), district (DFO/FRA committees/MFP unions) and village (JFMCs, FRA committees, SHGs, VDVks); ~20.06 lakh ha CFR area issued to ~4,349 Gram Sabhas; ~139 VDVks operational.
- **Field archetype (Barchegondi):** a high-readiness village (GRI 21.5/25) — active Van Samiti since 2006, 92 IFR titles (~77% coverage), 8 SHGs, smooth Forest-Dept coordination — where the binding constraint has shifted from mobilisation to downstream market and finance.

3 Demand & Supply Assessment

Supply Analysis

- **The forest is the productive asset:** a rich, largely native NTFP-yielding species mix (mahua, tendu, char/chironji, sal seed, imli, amla) under community management; forest cover recovering since Van-Samiti formation.
- **Aggregation & processing:** collection is women-led; primary aggregation runs through SHGs and (partly) direct trader sale; the VDVk cluster (cleaning, drying, grading, storage) is the intended processing spine, with TRIFOOD (Jagdalpur) for tertiary processing.
- **Constraints at source:** trader monopoly, no local storage, quality-grading issues and a certification gap compress community returns to the lowest tier.

Demand Dynamics

- **Price backstops:** for nationalised NTFPs (tendu, sal, harra, gum) MSP and the CG MFP Federation provide a meaningful floor; for non-nationalised items (mahua flower, char, imli) trader margins are structurally larger absent MSP.
- **Branded & institutional demand:** Tribes India, Bastar Se Bazaar Tak and private offtake offer higher-value channels once grading and processing exist.

Supply–Demand Gaps

- **Value leaks at the trader stage:** ‘market monopoly by traders’, ‘lack of storage’, ‘quality-grading issues’, ‘certification gap’ and ‘working-capital shortage’ are the FGD-named constraints — precisely where value exits the community.
- **Income under-realisation:** forest income at ~15% sits below the 20–50% typical of fully forest-dependent villages — signalling large unrealised potential.

Demand → Gap → Opportunity → Action · Sustainable Forest Management

CURRENT SITUATION	THE GAP	OPPORTUNITY	RECOMMENDED ACTION
Best-in-class institutions; forest only ~15% of HH income	Trader monopoly; no storage/processing; working-capital gap	Double forest income to 30–35%; 18–30 lakh/yr per village	Establish VDVK cluster; seasonal working-capital line

Source: FSI ISFR 2023, Berchegondi FGD (Billion Next), CG MFP Federation, Mendha-Lekha

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Sustainable Forest Management

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4 Market Ecosystem for the Value Chain

The SFM value chain runs from community protection and regeneration (JFMCs/Van Samitis, CFR management plans, ANR, fire control), through women-led collection under sustainable-harvest protocols, to primary aggregation and processing at a VDVK cluster, and on to CG MFP Federation/TRIFOOD processing and branded markets — with an optional carbon-credit overlay. It is the cross-cutting institutional and ecological foundation for several downstream GETM value chains.

Sustainable Forest Management Value-Chain Architecture

Protection & Regeneration	Community Collection	Primary Aggregation	Processing & Market	Carbon Overlay
JFMC/Van Samiti · CFR plan · ANR · fire control	Women-led · sustainable harvest protocols	VDVK cluster · weighing · grading · storage	TRIFOOD · CG MFP Federation · Tribes India / offtake	Green Credit · carbon-credit aggregation

Market Ecosystem for the Sustainable Forest Management Value Chain

Inputs & Resource	Community-managed native forest (NTFP-yielding) · nurseries / seed-balls · fire-lines · water structures
Producers / Institutions	Forest households · JFMCs/Van Samitis · FRA Gram Sabhas · 8+ SHGs · primary MFP cooperatives
Processing & Storage	Van Dhan Vikas Kendras (~139 in CG) · decentralised storage · TRIFOOD (Jagdalpur) · tertiary processing

Off-takers & Markets	CG MFP Federation (31 unions, ~916 societies) · MSP backstop · Tribes India / Bastar Se Bazaar · private offtake
Enablers	CAMPA · FRA 2006 · PM-JUGA 2024 · PMVDY · MSP for MFP · Green Credit Rules 2023 · NABARD

5 Community & Stakeholder Insights

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Forest households / gatherers	Forest income is only ~15% of household income; value leaks to traders; readiness to invest given assured buy-back, processing, storage and interest-free finance.	Provide a buy-back guarantee and a seasonal working-capital line to displace trader advances; VDVK-based processing to lift income to 30–35%.
Women's SHGs	8 SHGs active; ~50 women interested in nursery and processing — the collection and processing backbone.	Anchor door-to-door SHG collection with weighing stations and VDVK processing (PMVDY 100% grant); women-led nursery regeneration.
JFMC / Van Samiti / Gram Sabha	Best-in-class institutions (active since 2006, no Forest-Dept conflicts); the bamboo collapse is a harvest-governance warning.	Fund CFR management plans and JFMC-enforced harvest protocols via PM-JUGA (~₹15 lakh/100 ha + ₹15,000/ha), especially for tendu/mahua/sal.
CG MFP Federation / cooperatives	MSP backstop and cooperative structure exist for nationalised items but non-nationalised items lack a floor.	Extend cooperative aggregation and working capital to non-nationalised NTFPs; strengthen grading/certification through the Federation.
Traders (dominant intermediary) / processors	Trader monopoly and absent local processing (nearest TRIFOOD at Jagdalpur) compress returns.	Break the monopoly via VDVK storage/processing and TRIFOOD linkage; branded offtake through Tribes India / private buyers.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Downstream investment, high leverage:** a ₹15–30 lakh VDVK (100% PMVDY grant) plus PM-JUGA CFR funding is largely no-cost to the community; the seasonal working-capital line is the highest-priority gap that unlocks value retention.
- **Value-uplift outcome:** forest income rising from ~15% to 30–35% within 3–5 years — the source states no formal enterprise IRR, so any ROI figure would be an analyst estimate.

2. Social Benefits

- **Tribal livelihood foundation:** ~91 million person-days/yr (~90% tribal); women lead collection and processing — direct, inclusive income for the most forest-dependent households.
- **Governance strength:** active JFMCs and FRA titles provide a rare, conflict-free institutional base for benefit-sharing.

3. Environmental & Climate Resilience

- **Carbon & regeneration:** ~505 Mt carbon stock, recovering cover and ~536 ha of Green-Credit-identified degraded land position SFM for carbon-finance-linked restoration.
- **Sustainability guardrail:** the local bamboo collapse is a flashing signal — harvest protocols for tendu, mahua and sal are essential to avoid repeating over-extraction.

4. Technical Feasibility

- **Low-tech, high-readiness:** the intervention is institutional and market design, not new technology; VDVK processing and grading are field-proven (CG is a national Van Dhan leader).
- **Binding enabler:** storage, working capital and buy-back — not technology — are the decisive prerequisites.

7 Success Stories & Proven Models

CASE STUDY 1 · Berchegondi (Kanker) — The High-Readiness Archetype

Berchegondi scores 21.5/25 on the GVC Readiness Index (High-Readiness band) with best-in-class institutions — active Van Samiti since 2006, 92 IFR titles (~77% coverage), 8 SHGs and conflict-free Forest-Department coordination — yet forest income is only ~15% of household income because processing, storage and buy-back are absent.

Relevance: *the archetype showing that foundational mobilisation is done; a VDVK cluster, storage, buy-back and working capital can lift income to 30–35% while keeping extraction sustainable.*

CASE STUDY 2 · Chhattisgarh's Tendu & Van Dhan System — A Proven MFP Backbone

Chhattisgarh's tendu trade exceeds ₹1,000 Cr with collection wages rising from ₹75 Cr (2001) to ~₹609 Cr (2025); the state is a national Van Dhan leader (~139 VDVKS, ~866 procurement centres, door-to-door MFP procurement) with a three-tier MFP cooperative structure.

Relevance: *proof that the MSP-plus-cooperative backbone works for nationalised items — the priority is extending processing, storage and working capital to non-nationalised NTFPs where trader margins are largest.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no local storage or processing (nearest TRIFOOD at Jagdalpur); quality-grading and certification gaps.
- **Solution:** establish a VDVK cluster (~300 beneficiaries, 15 SHGs) with cleaning/drying/grading/storage, linked to TRIFOOD and branded offtake.

Financial Barriers

- **Barrier:** peak-season working-capital shortage is the highest-priority gap — cooperatives/SHGs cannot advance cash to gatherers, leaving the field to traders; enterprise finance and insurance are weak.
- **Solution:** a seasonal working-capital line and buy-back guarantee; collateral-free enterprise credit; explore price/weather insurance.

Knowledge & Technical Skill Gaps

- **Barrier:** nascent carbon-credit awareness (only 2 interested); latent enterprise interest not yet crystallised.
- **Solution:** CFR management-plan support (PM-JUGA), grading/GMP skilling, and carbon-credit aggregation awareness for FRA-titled villages.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Trader monopoly and certification gaps compress returns; non-nationalised NTFPs lack an MSP floor.	High	Buy-back, working capital and VDVK grading/storage; extend cooperative aggregation to non-nationalised items.	
Production / Climate	Over-harvest (bamboo collapse) and fire risk in climate-driven dry periods threaten the resource base.	High	JFMC-enforced harvest protocols, fire-lines and ANR funded via CAMPA/PM-JUGA.	
Operational / Supply Chain	No local storage/processing; peak-season working-capital shortage forces distress sales.	High	VDVK cluster with storage and a seasonal working-capital line to displace trader advances.	
Policy / Governance	CFR governance in flux (2024–25); enterprise-grade finance underused despite available CAMPA/JFM funds.	Med	Stabilise CFR norms; channel PM-JUGA and enterprise credit; convergence across Forest, Tribal Welfare and Rural Development.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Baseline vs Target

Indicator	Baseline	Target
Household Forest Income (%)	15	32.5
Tendu Collection Wages (₹ Cr)	75 (2001)	609 (2025)
Berchegondi GVC Readiness (/25)	21.5	25

Income uplift is a 3–5-yr projection contingent on VDVK processing, storage, buy-back

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Fund CFR management plans (PM-JUGA) and JFMC harvest protocols; anchor VDVK clusters with storage and working capital; strengthen CG MFP Federation aggregation for non-nationalised NTFPs; enable carbon-finance-linked restoration under the Green Credit Programme.

Private Sector & Investors

- Provide processing technology, grading and branded/export offtake (Tribes India / private buyers); partner on carbon-credit aggregation; co-invest via CSR/PPP in VDVK and storage infrastructure.

Development Agencies & NGOs

- Support SHG-led collection and nursery regeneration, working-capital and buy-back design, grading/certification skilling, and CFR governance — replicating the high-readiness archetype across similar clusters.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the SFM Value Chain
Forest Department		Protection/regeneration, CFR management-plan support, harvest protocols, ANR, fire control, carbon-restoration (CAMPA, Green Credit).
CG MFP Federation		MSP procurement, cooperative aggregation (31 unions, ~916 societies), institutional marketing, working-capital support.
Tribal Welfare Department		VDVK establishment (PMVDY), FRA/CFR facilitation, market linkage, skilling.
Panchayat & Rural Development		SHG strengthening, financial inclusion, working-capital facilitation, rural warehousing.
FRA Gram Sabhas / JFMCs (Van Samitis)		Village governance, sustainable-harvest enforcement, CFR management, benefit-sharing.
Medicinal Plant Board		MAP-adjacent species management and value addition.
TRIFOOD (Jagdalpur) / Tribes India		Tertiary processing and branded market access.
NABARD / Financial institutions		Enterprise credit, AIF, credit guarantee and seasonal working-capital lines.

MoEFCC (Green Credit Programme)	Carbon-finance-linked restoration and green-credit market mechanism.
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[1]**Methodology.** Employment: ~91 million forest-based person-days/yr (~90% tribal); a person-day-to-FTE conversion is not asserted in the source. Revenue: tendu trade >₹1,000 Cr; collection wages ₹75 Cr (2001) → ~₹609 Cr (2025). Income uplift: ~15% → 30–35% of household income over 3–5 years, contingent on VDVK processing, storage, buy-back and working capital. Investment: VDVK ₹15–30 lakh (100% PMVDY grant); PM-JUGA ~₹15 lakh/100 ha + ₹15,000/ha management for CFR. Forest/carbon: 55,812 sq km cover (3rd), ~505 Mt carbon stock (3rd), +684 sq km 2021–23 gain, ~536 ha Green-Credit degraded land; ~20.06 lakh ha CFR to ~4,349 Gram Sabhas. Berchegondi GRI 21.5/25. All figures originate in the source diagnostic (FSI ISFR 2023, MoEFCC, MoTA, CG MFP Federation). Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Sustainable Forest Management

INPUTS



OUTPUTS



Source: FSI ISFR 2023, Berchegondi FGD (Billion Next), CG MFP Federation, Mendha-Lekha

N03 Non-Timber Forest Produce (NTFP)

NbS · NATURE-BASED SOLUTIONS

The integrated forest bio-economy value chain that shifts tribal minor forest produce from raw extraction to community-led collection, primary and high-value processing, and organised marketing.

1 Executive Dashboard

EXECUTIVE DASHBOARD — NTFP AT A GLANCE (Chhattisgarh · GETM 2024–2036 · baseline vs target)

Direct FTE Employment. 240,000 direct FTE jobs by 2036 (from ~45,000 today — a 5.3× rise) across harvesting, processing and marketing, at a calculated 0.48 FTE per household integrated. Phased: 72,000 jobs / 150,000 HHs by 2029 → 168,000 / 350,000 HHs by 2033 → 240,000 / 500,000 HHs by 2036.

Market & Investment Opportunity. A ₹2,700 Cr ten-year capital outlay across Ecological (₹1,250 Cr — SFM over 100,000 ha), Enterprise (₹850 Cr — 500 VDVks + 100 FPOs) and Infrastructure (₹600 Cr — cold storage, 10 district hubs, 20 QC labs) capital, blended via PMVDY/PMFME/CAMPA/DMF for a 45–65% grant component.

Revenue Potential. ₹2,960 Cr annual sector value by 2036 (a 6.6× rise from ₹450 Cr), via a two-tier mix — bulk processed goods (120,000 MT → ₹960 Cr) and high-value oils/extracts/branded goods (80,000 MT → ₹2,000 Cr, 67.6% of value). Producer value capture rises from 15–25% to 45–55%.

Climate & Strategic Outcome. ~5 Mt CO₂ sequestered cumulatively by 2036; the sector anchors inclusive tribal growth toward Chhattisgarh Vision 2047 while advancing India’s Paris commitments through sustainable forest management.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Non-Timber Forest Produce (NTFP) · Chhattisgarh 2024–36

TRIBAL HOUSEHOLDS	DIRECT FTE JOBS	ANNUAL SECTOR VALUE	PRODUCER VALUE CAPTURE
500,000	240,000	₹2,960 Cr	15–25% → 45–55%
integrated into formal value chains by 2036 (from ~150K Phase I)	a 5.3× rise from ~45,000 today (0.48 FTE/household)	a 6.6× rise from ₹450 Cr formal procurement value	threefold rise in tribal value retention

2 Contextual Overview

National Context

- **A national forest-economy priority:** NTFPs underpin tribal livelihoods nationwide; an MSP framework covers 96 minor-forest-produce items, and Van Dhan (PMVDY), PMFME and TRIFED marketing channels form the national support architecture for value addition.
- **Value-erosion problem:** informal trade with four-to-six intermediary layers means producers capture only a fraction of final value — the core inefficiency the strategy targets.

Chhattisgarh Context

- **Disproportionate endowment:** India's 3rd-largest forest cover (55,812 sq km) and 7.82 million tribal population, ~64% NTFP-dependent; NTFPs contribute 20–60% of annual tribal household income.
- **Structural under-capture:** most VDVks run on basic equipment, statewide cold storage is below 5,000 MT, QC labs are urban-confined, and only 30–35% of harvest is formally processed — so producers capture just 15–25% of final value.
- **Field signal (Berchegondi):** an active Van Samiti since 2006 with 92 IFR titles and community appetite (women in nursery raising, youth in forest enterprise) — institutional readiness is high; the binding gap is downstream processing, storage and buy-back.

3 Demand & Supply Assessment

Supply Analysis

- **Resource base:** annual potential of ~150,000 MT oilseeds and ~80,000 MT food items; ~95,000 MT currently under formal procurement, scaling to a 200,000 MT processing target by 2036.
- **Processing spine:** ~500 VDVks (primary — clean/dry/grade/deshell) feeding ~100 tribal FPOs (secondary — oil extraction, herbal, food-grade), backed by 10 district hubs and 20 QC labs.
- **Quality gaps:** grading/certification (FSSAI, organic, Fair Trade) is largely inaccessible to rural producers, compressing realisation.

Demand Dynamics

- **Multi-channel demand:** CGMFPEED institutional procurement sets the floor, but the growth demand sits with private buyers — specialty-fat and CBE processors, ayurvedic and herbal FMCG manufacturers, lac and shellac exporters, bidi leaf purchasers, packaged-food brands, organised retail and quick commerce, alongside GeM and export markets for certified high-value oils and extracts.
- **Value-mix shift:** demand growth concentrates in high-value products (oils, extracts, branded goods) that deliver 67.6% of target value at lower volume.

Supply–Demand Gaps

- **Working-capital-driven distress:** despite MSP on 96 items, working-capital shortages force distress sales ~20% below MSP.
- **Infrastructure & institutional gaps:** sub-5,000 MT cold storage, urban-confined QC labs, and fragmentation across Forest, Tribal Welfare and Rural Livelihood departments compress returns and delivery.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Non-Timber Forest Produce

CURRENT SITUATION	THE GAP	OPPORTUNITY	RECOMMENDED ACTION
Producers capture only 15–25% of market value; informal trade	Cold storage <5,000 MT; only 30–35% processed formally	240,000 FTE jobs by 2036; 2,960 Cr annual sector value	2,700 Cr over 10 yrs; 500 VDVks, 100 FPOs, 10 hubs

Source: Berchegondi FGD, CGMFPFED, ICAR-IINRG, PIB 2024

4 Priority Varieties — Top 5 by Value Potential

Not every item in the forest basket deserves equal capital. Ranking by the combination of resource depth, unit value, demonstrated enterprise economics and the existence of a real private buyer, five varieties account for the bulk of the realisable upside — and each has a different binding constraint, so the intervention package differs by variety rather than being uniform across the sector.

Variety (rank)	Why it ranks — evidence base	Value-added product routes	Demand-side offtake landscape
1 · Mahua (Madhuca longifolia) — flower & seed	The basket's single largest household earner: at Vanusari (Kondagaon) 170 of 180 households depend on it, described as 'second only to rice'. It is also the only variety in the diagnostic with a costed enterprise model — oil unit IRR 19.2%, payback 4.2 years.	Cold-pressed mahua (mowrah) oil and butter for cosmetics and specialty-fat blends; food-grade dried flower into laddoo, syrup and nutra-beverage; de-oiled cake as feed input.	Specialty-fat processors buying tree-borne kernels — Manorama Industries Ltd operates an integrated plant at Birkoni near Raipur and states it sources mowrah from Chhattisgarh and MP forest floors. Beverage route proven by Rusicaa Beverages Pvt Ltd, the TRIFED/FITT technology licensee for Mahua Nutra.
2 · Tendu Patta (Diospyros melanoxylon)	The only produce in the basket with a fully functioning MSP-plus-bonus channel and timely payment, field-confirmed at Berchegondi. Largest formalised volume; the working template for extending discipline to non-MSP items.	Graded and bundled bidi leaf (core); analyst-flagged diversification into leaf-based biodegradable packaging and leaf-fibre applications.	Private bidi manufacturers and leaf traders purchasing through CGMFPFED advance auctions — already the largest organised private buyer group in the state's NTFP trade. Recommend verifying current auction

			volumes and participant list with CGMFPFED.
3 · Sal (Shorea robusta) — seed & leaf	Chhattisgarh sits inside the world's largest sal belt. Seed is an MSP-partial item flowing out raw; the dona/pattal leaf craft is in living memory at Kohkapal, Ulnar, Pharsigaon and Barchegondi, and Ulnar already runs a small unit it wants expanded.	Sal fat and stearine into Cocoa Butter Equivalents (CBE) and cosmetic butters; sal seed meal for animal feed; dona-pattal and moulded leaf tableware for the biodegradable-packaging market.	The strongest existing private pull in the state: Manorama Industries Ltd (Raipur) manufactures and exports sal-derived CBE and butters to international confectionery and personal-care customers. Leaf tableware sells into food-service and quick-commerce packaging buyers.
4 · Lac (Kerria lacca on host trees)	Named repeatedly as a distinctive local capability — notably at Barchegondi (Bastar) — yet almost entirely uncaptured locally. The ICAR-IINRG brood-lac and SHG host-tree model is proven in the Jharkhand-Chhattisgarh belt, making this the largest latent-value gap in the basket.	Sticklac to seedlac to shellac; dewaxed and bleached shellac grades; aleuritic acid; lac dye — end-uses in pharmaceutical coating, food glaze, cosmetics and wood finishes.	An established private processing-and-export industry already sources from this belt: D. Manoharlal (Shellac) Pvt Ltd, Indian Shellac Industries and Thakuria Lac Industries (Dhamtari) among others. India is the world's leading shellac exporter; verify current export values with IBEF or DGCIS before citation.
5 · Chironji / Char (Buchanania lanzan)	The highest unit-value item in the household basket and explicitly outside MSP — so it carries the widest gap between farm-gate and retail realisation. Communities specifically	Cleaned, graded and vacuum-packed kernel; confectionery and premium dry-fruit SKUs; chironji oil for cosmetic use; GI-tagged provenance brand.	Premium dry-fruit and packaged-food brands, organised retail and quick commerce (Reliance Retail, DMart, BigBasket, Amazon, Flipkart, Blinkit/Zepto as

	asked for GI or provenance branding for Char and Mahua.		illustrative channels), plus ayurvedic and nutraceutical formulators.
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Ranking is an analyst judgement built from the source diagnostic's field evidence (household dependence, unit value, enterprise economics) combined with publicly stated buyer profiles; the source document does not itself publish a ranked variety list. Company names are illustrative of who buys these products commercially — they are not confirmed GETM participants and no commitment is implied. Verify current sourcing footprints directly before any outreach.

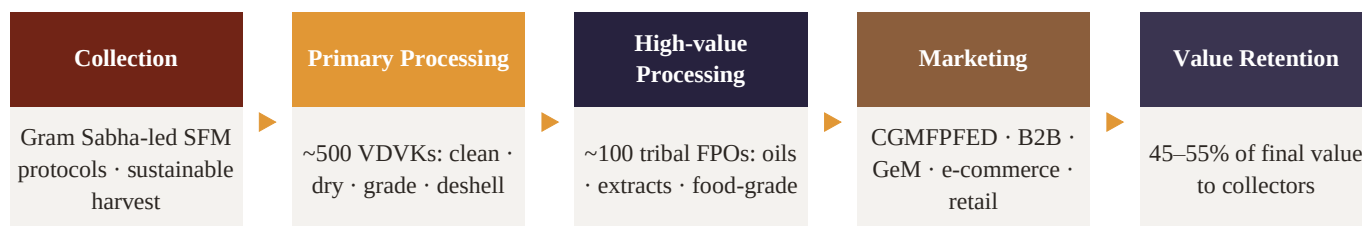
Next tier — worth staging into Phase II

- **Tamarind (Imli):** large volume across all four districts; Vanusari specifically voiced tamarind-chappati processing. Constraint is de-seeding and hygienic block-making capacity, not demand.
- **Amla, Harra & Baheda:** the triphala trio, with steady pull from the ayurvedic and herbal-FMCG industry; the gap is herb-wise traceability and residue testing rather than volume.
- **Honey and Van Tulsi:** CGMFPPED already trades both as non-specified MFP; both are low-capital SHG value-addition entry points suited to early wins.

5 Market Ecosystem for the Value Chain

NTEP is a four-node integrated architecture: Gram Sabha-led community collection under Sustainable Forest Management protocols; primary processing at ~500 Van Dhan Vikas Kendras; secondary and high-value processing at ~100 tribal FPOs; and multi-channel marketing — shifting the sector from raw extraction to value-added processing and organised marketing. The fourth node is where the design has so far been thinnest. CGMFPPED and GeM are necessary as a price floor and a payment guarantee, but a single institutional buyer cannot absorb 200,000 MT or pay the premium that certified, branded, high-value product commands. The offtake map below sets out the private demand that already exists for this basket, and what each segment needs before it will contract with a tribal FPO.

NTEP Four-Node Value-Chain Architecture



Market Ecosystem for the NTFP Value Chain

Inputs & Resource	Forest resource (tendu, mahua, sal, lac) · community nurseries · treatment & processing equipment
Producers / Aggregators	Tribal collectors (7.82M pop, ~64% NTFP-dependent) · Gram Sabhas · SHGs · 500K target HHs
Processing & Logistics	~500 VDVKS · ~100 FPOs · 10 district processing hubs · cold storage · 20 quality-testing labs
Off-takers & Markets	CGMFPPED · B2B contracts · GeM · e-commerce · organised retail · exports (FSSAI/organic/Fair Trade)
Enablers	PMVDY · MSP (96 items) · PMFME · CAMPA · DMF · AIF · SFAC · TRIFED · NABARD · Green Credit Rules 2023

The Private Demand Map — Who Actually Buys This Basket

Private buyer segment	What it pulls from the CG basket	Illustrative firms already active in the category	What GETM must supply to convert it
Specialty fats & CBE manufacturers	Sal seed, mahua/mowrah, kokum, dhupa and other tree-borne kernels.	Manorama Industries Ltd (integrated plant at Birkoni, Raipur — the anchor private processor already inside Chhattisgarh); other tree-borne-oilseed processors and global CBE buyers.	Assured graded seed volumes on a season calendar, moisture-controlled village storage, free-fatty-acid-compliant drying, and multi-year forward contracts.
Ayurveda & herbal FMCG	Amla, harra, baheda, van tulsi, medicinal roots and bark.	Dabur, Himalaya Wellness, Patanjali Ayurved, Baidyanath, Emami (Zandu), Organic India, Sri Sri Tattva; botanical-extract makers such as Natural Remedies.	Herb-wise traceability to collection village, pesticide and heavy-metal residue testing at the 20 QC labs, and good collection-practice SOPs for wild harvest.
Lac & shellac processors and exporters	Sticklac and seedlac from host-tree cultivation.	D. Manoharlal (Shellac) Pvt Ltd, Indian Shellac Industries, Thakuria Lac Industries (Dhamtari), Jagdamba Lac Factory and other Chhattisgarh-Jharkhand belt processors.	Brood-lac supply and host-tree management at village level, scraping and grading skills, and a buy-back price band that survives international resin price swings.

Bidi manufacturing & leaf trade	Graded tendu patta.	Private purchasers bidding in CGMFPFED advance auctions — the largest organised private buyer group in the state's NTFP trade today.	Nothing new — this channel works. The lesson is to port its auction discipline, advance payment and bonus mechanism onto non-MSP items.
Beverages, foods & tribal nutraceuticals	Mahua flower, chironji, amla, honey, millet-NTFP blends.	Rusicaa Beverages Pvt Ltd (TRIFED/FITT licensee for Mahua Nutra); D2C wellness brands such as Kapiva and OZiva; regional food processors.	FSSAI-grade hygienic collection and mechanical drying, cold storage at the 10 district hubs, and a state-backed licensing route for mahua-based food and beverage products.
Organised retail, e-commerce & quick commerce	Packaged, branded NTFP SKUs.	Reliance Retail, DMart, BigBasket, Amazon, Flipkart, Blinkit/Zepto — alongside the state's own Sanjeevani outlets.	Barcoded FSSAI-labelled SKUs, consistent lot sizes and shelf-life data, GST-compliant FPO invoicing, and listing/working-capital support to survive retail payment cycles.
Certification, testing & traceability services	Organic, Fair Trade, FSSAI and provenance verification.	Accredited certifiers and NABL-accredited testing laboratories operating in India; digital traceability providers.	Group-certification structures at FPO level (individual certification is unaffordable), plus subsidised first-cycle audit costs.
Impact capital, NBFCs & FPO lenders	Working capital, term debt and equity for VDVks and FPOs.	Agri-focused NBFCs and impact lenders that already underwrite FPOs, alongside SFAC equity, NABKISAN and commercial banks under CGTMSE.	Audited FPO books, a buy-back contract as the security substitute, and DMF-funded first-loss cover to compress the perceived risk of tribal enterprise lending.

Firms named above are illustrative of companies publicly active in each product category, identified by the analyst from public company disclosures and press reporting. They are not confirmed GETM partners, and inclusion does not imply any commitment or current Chhattisgarh sourcing except where explicitly stated. Company footprints change; verify before outreach or publication.

Rebalancing the channel mix — a working target

A practical de-risking rule for the marketing node: no single channel above roughly half of volume by 2036. Indicatively, CGMFPFED and other institutional procurement holding the MSP floor at

around 40-45% of volume; direct private B2B and contract processing at around 30-35%; branded retail, e-commerce and quick commerce at around 15-20%; and certified export at around 5-10%. These are analyst-proposed planning targets to make the channel-diversification intent measurable — they are not drawn from the source document and are not official GETM targets.

6 Community & Stakeholder Insights

Data note. *NTFP is a genuinely community-anchored value chain. Field evidence draws on forest-community FGDs (Berchegondi, Kanker — active Van Samiti, 92 IFR titles, SHGs) and the sector diagnostic's stakeholder analysis of tribal collectors, women's groups, VDVks/FPOs and institutional buyers.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Tribal collectors / Gram Sabhas	Capture only 15–25% of final value; MSP exists on 96 items but working-capital shortages force distress sales ~20% below MSP.	Provide 3% interest-subvention working capital and buy-back guarantees; route 80% of net enterprise surplus to Gram Sabhas for village development.
Women's SHGs	Strong appetite for nursery-raising and processing enterprise; the social infrastructure for last-mile aggregation.	Anchor VDVk/FPO processing and nursery raising through women's SHGs with PMVDY equipment/training grants and SFAC equity.
VDVks & tribal FPOs	Most VDVks run on basic equipment; only 30–35% of harvest is formally processed; secondary processing capacity thin.	Upgrade 500 VDVks and capitalise 100 FPOs (PMVDY ₹15–20 lakh/unit; SFAC equity up to ₹10 lakh/FPO); shift to high-value oils/extracts.
Institutional buyers (CGMFPPED)	Fragmented marketing and weak branding depress institutional price realisation.	Strengthen CGMFPPED MSP procurement, institutional marketing and brand building; open GeM/e-commerce/B2B channels.
Private sector / processors	Limited PPP and contract-processing presence; certification and QC labs urban-confined.	Mobilise ₹150 Cr CSR + ₹50 Cr private equity via PPP/contract processing; deploy 20 QC labs and 10 district hubs for FSSAI/organic/Fair Trade compliance.

7 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Enterprise viability:** a Mahua oil-extraction unit achieves 19.2% IRR and 4.2-year payback; the blended-finance model (PMVDY, PMFME, CAMPA, DMF) yields a 45–65% grant component, de-risking enterprise scale-up.

- **Value retention:** the two-tier product mix delivers a threefold rise in producer-level value retention (to 45–55%), the core economic outcome.

2. Social Benefits

- **Inclusive tribal livelihoods:** 500,000 tribal households and 240,000 direct FTEs, with women's SHGs central to processing and nursery enterprise — direct income augmentation for the most marginalised.
- **Governance dividend:** Gram Sabhas receive 80% of net surplus for village development, embedding benefit-sharing.

3. Environmental & Climate Resilience

- **Carbon & regeneration:** ~5 Mt CO₂ sequestered cumulatively by 2036 via SFM and assisted natural regeneration over 100,000 ha, eligible under Green Credit Rules 2023.
- **Sustainable-harvest guardrail:** Gram Sabha SFM protocols keep extraction within regeneration limits — the bamboo-collapse warning underscores the need.

4. Technical Feasibility

- **Proven, scalable processing:** cleaning, grading, oil extraction and food-grade processing are field-ready; the constraint is equipment upgrade, QC labs and cold-chain, not technology readiness.
- **Infrastructure need:** cold storage, district hubs and QC labs are the decisive scale enablers.

8 Success Stories & Proven Models

CASE STUDY 1 · Mahua Oil-Extraction Enterprise — Proven Unit Economics

A Mahua oil-extraction unit demonstrates strong enterprise viability — 19.2% IRR and a 4.2-year payback — validating the shift from raw collection to high-value processing at FPO tier under the blended-finance model.

Relevance: *the replicable enterprise template for the 100-FPO high-value processing node; bankable returns make the ₹850 Cr Enterprise Capital pool deployable at scale.*

CASE STUDY 2 · Berchegondi Van Dhan Institutions (Kanker) — Community Readiness Proof

Berchegondi has an active Van Samiti since 2006, 92 Individual Forest Rights titles distributed, 8 SHGs and smooth Forest-Department coordination — with households stating readiness to invest given assured buy-back, processing, storage and interest-free finance.

Relevance: *institutional mobilisation is largely done; the priority is a Van Dhan-linked primary-processing facility, decentralised storage and buy-back to break the trader monopoly and lift forest income from ~15% to 30–35%.*

9 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** statewide cold storage below 5,000 MT; QC labs urban-confined; most VDVKS on basic equipment.
- **Solution:** upgrade 500 VDVKS, build 10 district processing hubs and cold storage (AIF 3% interest subvention), and deploy 20 QC labs for certification access.

Financial Barriers

- **Barrier:** working-capital shortages force distress sales ~20% below MSP; collateral constraints limit enterprise credit.
- **Solution:** 3% interest-subvention working capital, collateral-free credit (CGTMSE/NABSanrakshan up to ₹5 Cr), SFAC equity and DMF viability-gap funding.

Knowledge & Technical Skill Gaps

- **Barrier:** weak grading/certification skills and institutional fragmentation across Forest, Tribal Welfare and Rural Livelihood departments.
- **Solution:** a State NTFP Value Chain Development Authority (Chief-Secretary-chaired) for mission-mode convergence; SHG/FPO skilling in grading, GMP and branding.

10 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Four-to-six intermediary layers and weak branding erode producer value to 15–25%; distress sales ~20% below MSP.	High	Strengthen procurement as the price floor, then contract multi-year private offtake (specialty-fat, shellac, herbal and retail buyers) so price discovery is not single-channel; provide working capital and buy-back to break the trader monopoly.	CGMFPPED
Production / Climate	Over-harvest risk (bamboo collapse at Berchegondi is a warning for tendu/mahua/sal); resource depletion.	High	Enforce Gram Sabha SFM harvesting protocols and assisted natural regeneration across 100,000 ha; community nurseries.	
Operational / Supply Chain	Sub-5,000 MT cold storage, basic VDVK equipment and urban-confined QC labs cap aggregation and quality.	High	Deploy cold storage, 10 district hubs, upgraded VDVKS and 20 QC labs; formalise grading/certification.	

Policy Governance /	Institutional fragmentation across Forest, Tribal Welfare and Rural Livelihood departments delays delivery.	Med	Establish the State NTFP Authority and District Coordination Committees for convergence and localised action plans.
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Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Baseline vs 2036 Target

Indicator	Baseline 2024–25	Target 2036
Direct FTE Jobs (thousands)	45	240
Annual Sector Value (₹ Cr)	450	2,960
Producer Value Capture (%)	20	50

FTE at 0.48 FTE/household across 500,000 HHs; ₹2,960 Cr from a two-tier mix (bulk 120,000 MT → ₹960 Cr; high-value 80,000 MT → ₹2,000 Cr). Source: value-chain document.

11 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish the Chief-Secretary-chaired State NTFP Value Chain Development Authority; converge PMVDY/PMFME/CAMPA/DMF; upgrade 500 VDVks, build 10 hubs, cold storage and 20 QC labs; strengthen CGMFPED MSP procurement and interest-subsidy working capital; enforce SFM harvesting.

Private Sector & Investors

- Anchor processors (specialty fats, shellac):** sign multi-year forward contracts with FPO clusters for sal, mahua and lac at a declared price band; co-invest in village drying and storage so raw-material quality meets export specification. Manorama Industries' Birkoni plant makes this the shortest path to a demonstrable private offtake in Chhattisgarh.
- Herbal & FMCG buyers:** move from spot buying through traders to traceable direct sourcing from VDVks for amla, harra, baheda and van tuls; co-fund good-collection-practice training and residue testing in return for supply-chain traceability the brand can market.
- Consumer brands & retail:** list tribal-origin SKUs, provide category and packaging expertise, and offer shorter payment cycles or supply-chain finance to FPOs — the single most valuable non-cash contribution a retailer can make.
- Contract manufacturing & technology licensing:** license proven product technology to FPOs on the TRIFED-FITT-Rusicaa model rather than building captive capacity, keeping ownership and margin with the tribal enterprise.
- Investors & lenders:** deploy the ₹50 Cr private equity and ₹150 Cr CSR pools alongside SFAC equity and CGTMSE-backed debt; treat the buy-back contract as the security substitute for collateral-poor tribal enterprises.
- The state's side of the bargain:** a single-window offtake registry, transparent auction access extended to non-MSP items, group certification, and enforceable Gram Sabha benefit-sharing so private entry raises producer capture rather than substituting one intermediary layer for another.

Development Agencies & NGOs

- Mobilise SHGs/FPOs, build enterprise and financial-inclusion capacity, facilitate CFR/IFR and buy-back models, and support nursery-raising and sustainable-harvest governance.

12 Institutional Alignment — Public Departments & Market Counterparts

Nodal Institution	Department /	Primary Responsibility in the NTFP Value Chain
Forest Department		Resource assessment, SFM implementation, sustainable-harvesting protocols, biodiversity monitoring, certification support (CAMPA, Green Credit Rules 2023).
Tribal Welfare Department		VDVK establishment, PMVDY convergence, market linkage, CFR/IFR facilitation, skill development.
Panchayat & Rural Development (Bihaan)		SHG strengthening, FPO formation, financial inclusion, working-capital facilitation, rural warehousing.
Industries Department		Quality standards, GMP compliance, product development, branding, QC-lab establishment and export facilitation (PMFME).
Finance Department		Resource allocation, fund-flow monitoring, convergence coordination, viability-gap funding, credit-guarantee facilitation.
CGMFPFED		MSP procurement, institutional marketing, working-capital support, brand development, market stabilisation.
District Collectors / DMF Council		District coordination, localised action plans, DMF viability-gap funding for community enterprises.
Gram Sabhas		Foundational governance; enterprise approval; recipient of 80% of net surplus for village development.
TRIFED / NABARD		National marketing channels; refinance, AIF and credit-guarantee support.

Market Counterparts — the Private Half of the Institutional Map

Departments create the enabling conditions; they do not create demand. The counterparts below are the commercial institutions that must be contracted, not merely consulted, for the value chain to clear its 200,000 MT target.

Market counterpart	Role in the NTFP value chain
Specialty-fat & CBE processors	Anchor offtake for sal and mahua kernels; technical specification-setting; export market access.
Lac & shellac processors/exporters	Offtake for sticklac and seedlac; brood-lac supply; grading standards; access to global resin markets.

Ayurveda, herbal & nutraceutical manufacturers	Volume demand for amla, harra, baheda and medicinal plants; traceability and quality protocols; premium for certified wild-harvest.
Organised retail, e-commerce & quick commerce	Shelf and listing access for branded tribal SKUs; consumer-facing brand building; category and packaging expertise.
Bidi manufacturers & leaf traders	Established competitive bidding for tendu through CGMFPPED auctions — the state's proven private price-discovery mechanism.
Certification bodies & accredited testing labs	Organic, Fair Trade and FSSAI certification; residue and quality testing; group-certification structures for FPOs.
Impact investors, agri-NBFCs & FPO lenders	Working capital and term finance for VDVks and FPOs; equity for enterprise scale-up; first-loss and guarantee structures.
Technology licensors & incubators	Product and process technology transfer to FPOs (the TRIFED-FITT licensing model); enterprise incubation and GMP support.

[1]**Methodology.** Employment: 240,000 direct FTE by 2036 = 500,000 households × 0.48 FTE/household across harvesting/processing/marketing (phased 72,000/150,000 HHs by 2029; 168,000/350,000 by 2033). Revenue: ₹2,960 Cr = bulk 120,000 MT → ₹960 Cr + high-value 80,000 MT → ₹2,000 Cr; Phase-I ₹888 Cr = 60,000 MT × ~₹148/kg weighted realisation. Capital: ₹2,700 Cr = Ecological ₹1,250 Cr (SFM 100,000 ha) + Enterprise ₹850 Cr (500 VDVks, 100 FPOs) + Infrastructure ₹600 Cr (cold storage, 10 hubs, 20 QC labs); 45–65% grant via PMVDY/PMFME/CAMPA/DMF. Enterprise example: Mahua oil unit IRR 19.2%, payback 4.2 yr. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Non-Timber Forest Produce

INPUTS



OUTPUTS

Bulk processed goods	Mahua oil & extracts	Sal-leaf plates	Carbon sequestration
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Source: Berchegondi FGD, CGMFPPED, ICAR-IINRG, PIB 2024

N04 Biochar

Nbs · NATURE-BASED SOLUTIONS

A carbon-rich, porous, stable solid produced by pyrolysing crop residues and biomass in a low-oxygen environment, applied to soil to sequester carbon, cut residue burning, and restore fertility.

1 Executive Dashboard

EXECUTIVE DASHBOARD — BIOCHAR AT A GLANCE (Chhattisgarh · GETM to 2035–36)

Direct FTE Employment. 32,000 jobs by 2035–36 — 13,000 direct FTE (biomass aggregation, kiln operation, biochar application, MRV data collection, FPO aggregation/sales) plus 19,000 indirect — at a ratio of ~1 direct job per ₹3.2 lakh of sector investment (higher than most rural-manufacturing pathways) plus ~1.5 indirect jobs.

Market & Investment Opportunity. ₹820 Cr capital by 2030–31 (₹1,650 Cr cumulative to statewide) via a blended stack — public grants (NMSA, MNRE W2E, CRM, MGNREGS, CAMPA) 25%, concessional debt (NABARD) 20%, carbon-credit forward purchase (Google–Varaha template) 30%, CSR/blended 15%, community co-investment 5%, state budget 5%. External conditions are favourable: CCTS live (2024), Google–Varaha forward purchase signed, BiocharIND ₹150 Cr JV launched.

Revenue Potential — pays three times. ₹2,450 Cr by 2035–36 across three streams: physical biochar (₹15–25/kg vs ₹8–12 production cost), carbon-removal credits (₹100–200/tonne), and downstream farmer savings (~⅓ less urea + ~10% yield gain at 2 t/acre) — among the highest-return green value chains per rupee, with break-even in 2.5–3 years including credits and payback ~4 years at scale.

Climate & Strategic Outcome. 2.1 MT CO₂e removed annually by 2035, locked in soil for 100+ years, by converting 10–15% of the state's surplus residue via 2,800 community kilns + 150 FPO reactors — replacing residue burning, restoring fertility and embedding CG in the fastest-growing soil-climate market without waiting for a Punjab-style crisis.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Biochar · Chhattisgarh

ECONOMIC VALUE	JOBS GENERATED	CARBON REMOVED	CAPITAL NEEDED
₹2,450 Cr	32,000	2.1 MT CO₂e/yr	₹820 Cr
annual value by 2035–36 (3-revenue model)	13,000 FTE + 19,000 indirect at statewide scale	durable removal · CCTS-eligible by 2035–36	2,800 kilns + 150 FPO reactors across rollout

2 Contextual Overview

National Context

- **Large residue-to-carbon opportunity:** India burns ~92 MT of crop residue annually (of 228 MT surplus); converting 30–50% could produce 15–26 MT biochar, remove ~0.1 Gt CO₂e and create up to 5.2 lakh rural jobs; the global biochar market grows from USD 3.1 Bn (2025) to USD 6.5 Bn (2030) at 13.8% CAGR.
- **Live carbon market:** India's CCTS compliance carbon market launched July 2024; in January 2025 Google agreed to buy 100,000 tonnes of biochar carbon credits from Varaha's Indian farms by 2030; BiocharIND (PRESPL, APChemi, Intellectap) is building five aggregation facilities.

Chhattisgarh Context

- **Existing aggregation base:** Chhattisgarh can anchor 10–15% of surplus-residue conversion by 2035, building on its 7,836 Gauthan aggregation network — a rare in-state institutional foundation.
- **Zero village awareness (the gap):** FGDs in Sonesarar and Sideswar show zero baseline awareness and zero carbon-credit literacy, but strongly favourable underlying conditions (abundant biomass, recognised burning and fertility problems, intuitive acceptance) — the gap is greenfield, and that is the opportunity.
- **Orphan-scheme problem:** NMSA treats biochar as a soil intervention, MNRE as bioenergy and CCTS as a carbon asset — no single agency owns it at farmer level, keeping village awareness at zero.

3 Demand & Supply Assessment

Supply Analysis

- **Feedstock & conversion:** abundant crop residue (FGD-confirmed sufficient) converted via low-tech community/SHG kilns (₹8–12/kg production cost) and FPO-level pyrolysis reactors, scaling to 2,800 kilns + 150 reactors statewide.
- **Affordability constraint:** the low household affordability ceiling (₹4–5k/farmer) makes household-scale infeasible — only community-enterprise and FPO-aggregation models work.
- **MRV backbone:** 3,500 Biochar Sakhis as kiln operators and MRV data collectors (built on bio-input SHG cadres), with MRV initially outsourced to BiocharIND/Varaha and progressively internalised.

Demand Dynamics

- **Three demand pulls:** carbon buyers (Google–Varaha forward purchase), soil-amendment demand from farmers (urea savings + ~10% yield gain), and physical biochar sales at ₹15–25/kg.
- **Market timing:** CCTS being live and a signed forward-purchase de-risk offtake — the demand side is favourable now, ahead of village supply.

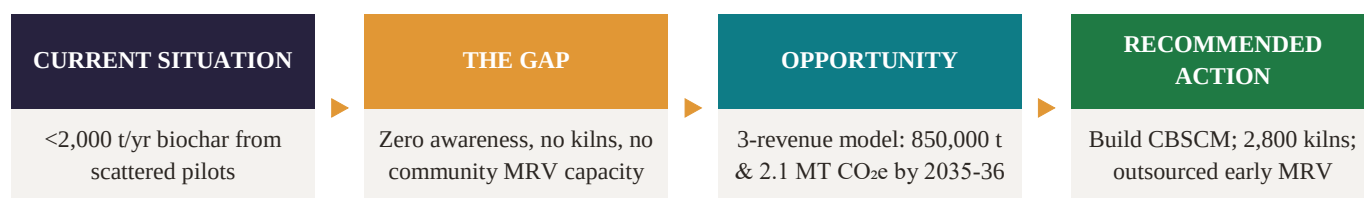
Supply–Demand Gaps

- **Zero awareness & infrastructure:** no peer-to-peer visibility, no production infrastructure and no scheme-facilitation channel at village level — the binding constraints.

- **Scheme orphan-status:** the absence of a single owning agency prevents layered support reaching farmers — resolved by a consolidated state mission.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Biochar

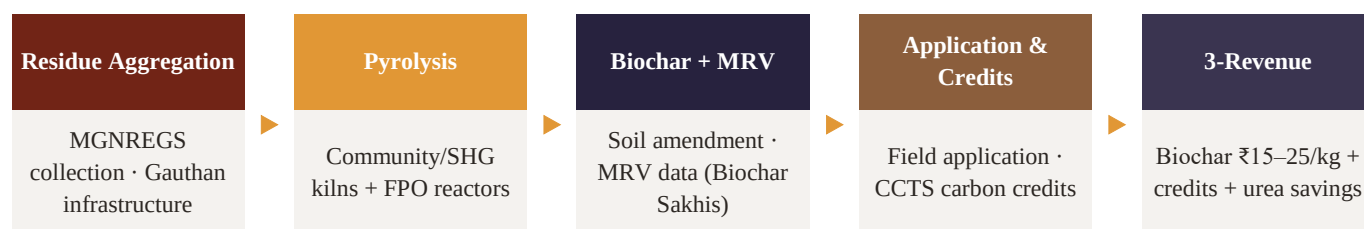


Source: FGDs (Sonesarar, Sideswar, Jashpur); 24-village LCAT synthesis

4 Market Ecosystem for the Value Chain

The biochar value chain aggregates crop residue (MGNREGS collection on Gauthan infrastructure), pyrolyses it in community/SHG kilns and FPO reactors, produces biochar and MRV data (via Biochar Sakhis), and monetises three revenue streams — physical biochar as soil amendment, carbon-removal credits under CCTS, and downstream farmer savings from reduced urea and higher yield. It is unusually cash-positive because it pays producers three times and solves residue burning, soil-carbon loss and fertility decline at once.

Biochar Value-Chain Architecture



Market Ecosystem for the Biochar Value Chain

Inputs & Feedstock	Crop residue (~92 MT India burn) · low-tech kilns · FPO pyrolysis reactors · 7,836 Gauthans
Producers / Operators	Community/SHG kilns · FPO reactors · 3,500 Biochar Sakhis (kiln + MRV cadre)
Aggregation & MRV	BiocharIND (₹150 Cr JV) · Varaha MRV · CCTS registry · warehouse-receipt financing
Off-takers & Markets	Carbon buyers (Google–Varaha 100k t) · soil-amendment farmers · urea-savings + 10% yield
Enablers	CBSCM (proposed) · CCTS 2024 · NMSA / MNRE W2E / CRM · CAMPA · NABARD · Carbon Rights Framework

5 Community & Stakeholder Insights

Data note. Biochar is community-anchored but greenfield on awareness. FGDs in Sonesarar (Rajnandgaon) and Sideswar (Kanker), March 2026, show zero awareness against strongly favourable conditions; Sonesarar is ready for an immediate community-kiln pilot (land available), while Sideswar needs a 12-month awareness-first approach.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Farmers (Sonesarar — kiln-ready)	Abundant biomass, recognised burning/fertility problems, land available, interest in a community kiln; affordability ceiling ₹4–5k/farmer.	Launch an immediate community-kiln pilot; use community-enterprise/FPO models (not household-scale) given the low affordability ceiling.
Farmers (Sidesar — awareness-first)	Same favourable conditions but no kiln interest yet and no land for a unit.	Run a 12-month awareness-first phase before kiln deployment; build peer-to-peer visibility.
Biochar Sakhis / SHG cadres	No carbon-credit literacy; existing bio-input SHG cadres can be re-skilled.	Deploy 3,500 Biochar Sakhis as trained kiln operators and MRV collectors (CGSRLM–KVK–Ithaka partnership).
FPOs / aggregators	Household scale is infeasible; MRV and offtake are the binding needs.	150 FPO pyrolysis reactors with MRV outsourced to BiocharIND/Varaha; NABARD warehouse-receipt financing against forward-purchase contracts unlocks ~₹200 Cr working capital.
State institutions (orphan-scheme problem)	No single agency owns biochar at farmer level.	Establish the Chhattisgarh Biochar and Soil Carbon Mission (CBSCM) as a single-window authority; enact a Carbon Rights Framework (70:30 farmer:MRV benefit-share, rising to 80:20).

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Three-revenue economics:** physical biochar (₹15–25/kg vs ₹8–12 cost), carbon credits (₹100–200/tonne, at the ~USD 24.6/tCO₂e break-even) and farmer savings (~⅓ less urea + ~10% yield) — break-even 2.5–3 years with credits, payback ~4 years at scale.
- **Financing:** a blended capital stack (public grants, NABARD debt, carbon forward purchase, CSR, community and state budget) with warehouse-receipt financing against off-take contracts.

2. Social Benefits

- **Rural, SHG-led jobs:** 32,000 jobs (13,000 direct FTE) in aggregation, kiln operation, application and MRV, with Biochar Sakhis creating a women-led MRV cadre.
- **Benefit-sharing:** a Carbon Rights Framework assigns credits to farmers with 70:30 (rising to 80:20) farmer:MRV benefit-sharing — protecting community value.

3. Environmental & Climate Resilience

- **Durable carbon & air quality:** 2.1 MT CO_{2e}/yr removed and locked in soil for 100+ years while replacing residue burning — a triple win with fertility restoration.
- **Soil health:** biochar improves fertility, reducing urea dependence and lifting yields ~10%.

4. Technical Feasibility

- **Low-tech, proven pyrolysis:** community kilns and FPO reactors are field-ready; the constraint is awareness, MRV and aggregation, not core technology.
- **MRV is the enabler:** credible MRV (BiocharIND/Varaha, then internalised) is the decisive prerequisite for carbon revenue.

7 Success Stories & Proven Models

CASE STUDY 1 · Google–Varaha Forward Purchase & BiocharIND — De-risked Carbon Offtake

With India's CCTS live (2024), Google agreed in January 2025 to buy 100,000 tonnes of biochar carbon credits from Varaha's Indian farms by 2030, and BiocharIND (₹150 Cr JV of PRESPL, APChem, Intellect) is building five aggregation facilities — signed offtake and MRV infrastructure that de-risk the carbon-revenue stream.

Relevance: *the template for CG's Tier-1 pilot MRV outsourcing and NABARD warehouse-receipt financing (~₹200 Cr working capital) against forward-purchase contracts.*

CASE STUDY 2 · Sonesarar Kiln-Ready Village (Rajnandgaon) — Community-Enterprise Pilot

Sonesarar shows abundant biomass, recognised burning and fertility problems, community interest in a kiln and available land — but zero awareness and a ₹4–5k/farmer affordability ceiling that rules out household-scale investment.

Relevance: *the archetype for an immediate community-enterprise/FPO kiln pilot; Sideswar-type villages (no land, no kiln interest) instead get a 12-month awareness-first phase.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no village-level production infrastructure; household scale infeasible at the ₹4–5k affordability ceiling.
- **Solution:** deploy 2,800 community/SHG kilns + 150 FPO reactors on Gauthan infrastructure via community-enterprise/FPO models; MGNREGS residue aggregation.

Financial Barriers

- **Barrier:** high aggregation labour cost and working-capital needs; carbon revenue requires credible MRV.
- **Solution:** blended capital stack + NABARD warehouse-receipt financing against forward-purchase contracts (~₹200 Cr working capital); carbon forward purchase (Google–Varaha template).

Knowledge & Technical Skill Gaps

- **Barrier:** zero village awareness and carbon-credit literacy; scheme orphan-status.
- **Solution:** deploy 3,500 Biochar Sakhis; consolidate schemes under CBSCM; awareness-first sequencing for low-readiness villages.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Carbon revenue depends on MRV integrity and credit prices (₹100–200/tonne); physical biochar demand nascent.	Med	Anchor forward-purchase offtake (Google–Varaha template); credible MRV via BiocharIND/Varaha then internalised.	
Production / Climate	Household scale infeasible (₹4–5k ceiling); seasonal residue supply.	Med	Community-enterprise/FPO kilns and reactors; MGNREGS residue aggregation on Gauthan infrastructure.	
Operational / Supply Chain	Zero village awareness, no infrastructure, no scheme-facilitation channel.	High	Tiered village sequencing (pilot → scale → statewide); 3,500 Biochar Sakhis; awareness-first for low-readiness villages.	
Policy / Governance	Orphan-scheme status — no single agency owns biochar at farmer level.	High	Establish CBSCM single-window authority and a Carbon Rights Framework (70:30 → 80:20 benefit-share).	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three-Tier Village Sequencing (Greenfield → Statewide)

Tier 1 · Pilot (100 villages)	Tier 2 · Scale (500 villages)	Tier 3 · Statewide (~3,000 villages)
Yr 1–2; MRV via BiocharIND/Varaha ramp to 800 kilns break-even ~2.5–3 yr	Yr 3–5; state MRV internalised 45→150 FPO reactors ₹680 Cr value (Ph I)	Yr 6–10; full rollout 2,800 kilns + 150 reactors ₹2,450 Cr · 32,000 jobs

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish the Chhattisgarh Biochar and Soil Carbon Mission (CBSCM) consolidating NMSA/MNRE-W2E/CCTS-liaison/MGNREGS/Gauthan/CAMPA/RKVY; enact a Carbon Rights Framework; sequence 100 → 500 → ~3,000 villages; deploy 3,500 Biochar Sakhis.

Private Sector & Investors

- Provide MRV and carbon-market access (BiocharIND/Varaha), forward-purchase offtake (Google template), pyrolysis technology and aggregation facilities; co-invest via CSR/blended capital.

Development Agencies & NGOs

- Re-skill bio-input SHG cadres into Biochar Sakhis (CGSRLM–KVK–Ithaka); run awareness-first mobilisation; structure NABARD warehouse-receipt working-capital and community-enterprise/FPO models.

11 Key Departments & Institutional Alignment

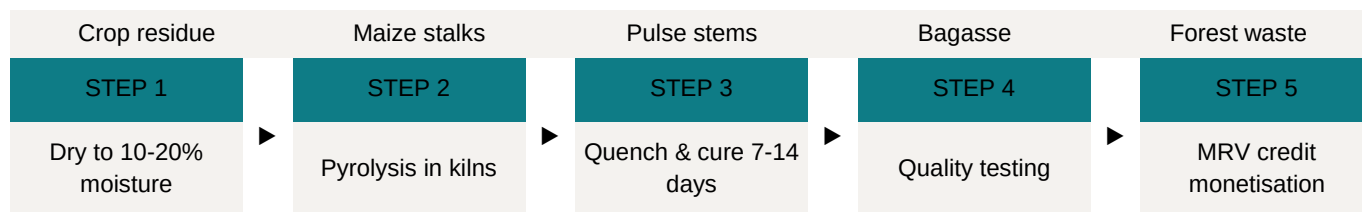
Nodal Institution	Department /	Primary Responsibility in the Biochar Value Chain
Chhattisgarh Biochar & Soil Carbon Mission (CBSCM, proposed)		Single-window authority consolidating NMSA, MNRE W2E, CCTS liaison, MGNREGS, Gauthan, CAMPA and RKVY.
Ministry of Power (CCTS)		Compliance carbon market and credit registry (live 2024).
Agriculture / NMSA		Soil-intervention framing, residue-management and farmer extension.
MNRE (Waste-to-Energy) / CRM		Bioenergy framing and crop-residue-management support.
MGNREGS / Rural Development		Residue aggregation labour and Gauthan infrastructure.
NABARD		Concessional debt and warehouse-receipt financing against forward-purchase contracts.
FPOs / SHGs (Biochar Sakhis)		Kiln operation, biochar application and MRV data collection.
BiocharIND / Varaha (MRV & aggregation)		MRV, aggregation facilities and carbon-market access.

[1]**Methodology.** Employment: 32,000 jobs = 13,000 direct FTE + 19,000 indirect, at ~1 direct job/₹3.2 lakh investment + ~1.5 indirect. Revenue: ₹2,450 Cr across three streams — physical biochar ₹15–25/kg (cost ₹8–12), carbon credits ₹100–200/tonne (break-even ~USD 24.6/tCO₂e), farmer savings (~⅓ less urea + ~10% yield at 2 t/acre). Capital: ₹820 Cr by 2030–31, ₹1,650 Cr cumulative statewide; blended stack (grants 25% / NABARD debt 20% / carbon forward purchase 30% / CSR 15% / community 5% / state 5%); break-even 2.5–3 yr with credits, payback ~4 yr at scale. Deployment: 2,800 community kilns + 150 FPO reactors; 10–15% of surplus residue; 2.1 MT CO₂e/yr. All figures originate in the source diagnostic (CCTS 2024, BiocharIND, Varaha, Global Biochar Market Report 2025). Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Biochar

INPUTS



OUTPUTS



Source: FGDs (Sonesarar, Sideswar, Jashpur); 24-village LCAT synthesis

N05 Bio-Inputs

NbS · NATURE-BASED SOLUTIONS

A decentralised, women-led enterprise chain converting livestock dung, crop residue and microbial cultures into vermicompost, biofertilizers, biopesticides and Jeevamrit that restore soil fertility without chemical dependence.

Executive Dashboard

EXECUTIVE DASHBOARD — BIO-INPUTS AT A GLANCE (Chhattisgarh · GETM to 2035–36)

Direct FTE Employment. 72,000 jobs by 2035–36 — 28,000 direct FTE (production, formulation, quality testing) plus 44,000 indirect (aggregation, logistics, retail, extension) — at a revenue elasticity of ~1 direct job per ₹2.8 lakh of sector revenue plus ~1.6 indirect jobs, positioned across ~20,000 villages with active cattle and SHG networks. Women make up 90–100% of the workforce.

Market & Investment Opportunity. ₹540 Cr capital by 2030–31 (₹780 Cr cumulative) via a blended stack — public grants (PKVY, NMNF, PM-PRANAM, GNY) 35%, concessional debt (NABARD, SIDBI, AIF) 25%, environmental/convergence funds (CAMPA, DMF, MGNREGS) 20%, CSR/blended 12%, SHG/FPO equity 8% — anchoring 4,500 upgraded Bio-Resource Centres (one certified BRC per 50-ha cluster).

Revenue Potential. ₹2,150 Cr by 2035–36 (from ₹260 Cr today) as average value per kg rises ₹10 → ₹28 → ₹45 through a tiered certification model, lifting the producer-community share to ~₹860 Cr — turning bio-inputs from a subsidy beneficiary into a net fiscal contributor by 2031–32.

Climate & Strategic Outcome. 1.4 MT CO₂e avoided annually, building on Chhattisgarh's Godhan Nyay Yojana — the largest publicly-validated bio-inputs enterprise model in India (7,836 Gauthans, ₹147 Cr cow dung procured, 9.79 lakh q vermicompost, ₹27.44 Cr to women SHGs). The task is a certification-and-offtake upgrade on infrastructure that already exists.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Bio-Inputs · Chhattisgarh (Vermicompost · Biofertilizers · Biopesticides · Jeevamrit)

REVENUE POTENTIAL	JOBS GENERATED	CO ₂ e AVOIDED	CAPITAL NEEDED
₹2,150 Cr	72,000	1.4 MT/yr	₹540 Cr
by 2035–36 (from ₹260 Cr today)	28,000 direct FTE + 44,000 indirect by 2035–36	decentralised, women-led production	by 2030–31 (₹780 Cr cumulative)

Metric	2024–26 Baseline	2030–36 Target
Revenue	₹260 Cr	₹1,050 Cr (2030–31) → ₹2,150 Cr (2035–36)
Jobs (direct + indirect)	9,000	32,000 (2030–31) → 72,000 (2035–36)
Production volume	0.25 MT	1.8 MT (2030–31) → 3.8 MT (2035–36)
Avg. value per kg	₹10	₹28 (2030–31) → ₹45 (2035–36)

Metric	2024–26 Baseline	2030–36 Target
Producer-community share	~₹100 Cr	₹420 Cr (2030–31) → ₹860 Cr (2035–36)
Capital required (cumulative)	—	₹540 Cr (2030–31) → ₹780 Cr (2035–36)

2 Contextual Overview

National Context

- **Three converging policy tailwinds:** PM-PRANAM returns 50% of fertiliser-subsidy savings as grants to states reducing chemical use; NMNF funds 10,000 Bio-Input Resource Centres nationally; PKVY delivers ₹31,500/ha over three years (incl. ₹15,000/ha DBT). The India biofertiliser market grows from USD 152.5 M (2025) to USD 395.86 M (2032) at 10–11% CAGR.
- **Waste-to-value:** bio-inputs turn discarded biomass, livestock waste and microbial cultures into a productive stream, against a national chemical-fertiliser subsidy burden exceeding ₹1.75 lakh crore.

Chhattisgarh Context

- **India's validated proof-of-concept:** Godhan Nyay Yojana already delivers the largest publicly-validated bio-inputs enterprise model — 7,836 Gauthans, ₹147 Cr cow dung procured, 9.79 lakh q vermicompost, ₹27.44 Cr to women SHGs — so the model is proven; the challenge is upgrading it.
- **Natural landscape fit:** ~20,000 villages with active cattle populations, SHG networks and paddy-dominant cropping make bio-inputs a decentralised, women-led enterprise fit.
- **The economics gap:** at ₹10/kg and a 3,000 kg/acre dose, vermicompost costs ₹30,000–36,000/acre versus ₹4,000–5,000/acre for chemical fertiliser — the substitution case does not close on price alone.

3 Demand & Supply Assessment

Supply Analysis

- **Production already in place:** FGDs confirm capability — Sonesarar produces 6–7 t/yr jeevamrit/biopesticides (1 SHG + 10 farmers), Sideswar ~10 q/yr vermicompost (2 SHGs + 10 farmers), both at ₹10/kg with 90–100% women participation.
- **Quality-infrastructure gap:** no nearby quality lab and no PMFME/AIF access at either site — the binding constraints are quality infrastructure, assured offtake and working capital, not raw materials or willingness.
- **BRC backbone:** 4,500 upgraded Bio-Resource Centres at existing Gauthan-SHG clusters (one certified BRC per 50-ha cluster) form the scale-up spine.

Demand Dynamics

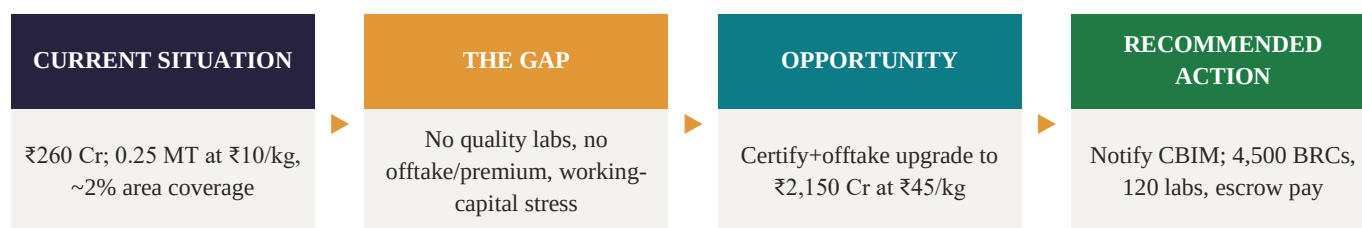
- **Tiered demand:** community-grade (village use, ₹10/kg), FPO-grade (inter-village/institutional, ₹25/kg) and export-grade (national retail/export, ₹50/kg) — built on FCO Schedule-VI compliance and 120 district labs.

- **Institutional pull:** institutional procurement with T+30 payment and premium-crop outlets (organic rice, millets) are decisive demand channels.

Supply–Demand Gaps

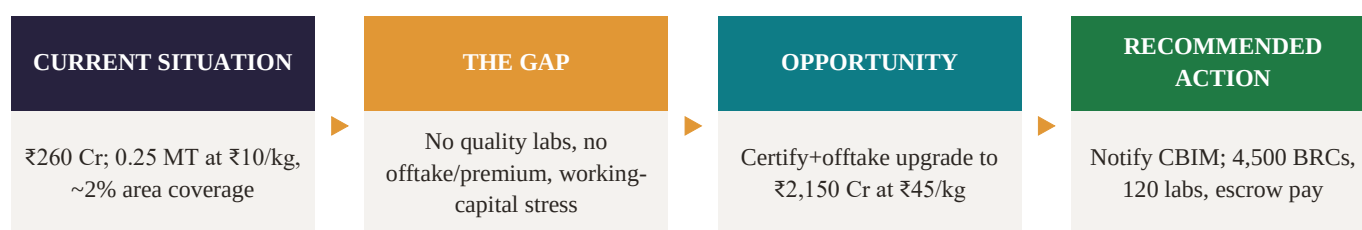
- **Price economics don't close alone:** vermicompost at ₹30,000–36,000/acre vs ₹4,000–5,000/acre chemical requires (a) tiered certification/pricing, (b) premium-crop outlets, (c) institutional procurement (T+30) and (d) monetised ecosystem services (soil-carbon credits).
- **Scheme-silo problem:** SHGs cannot access layered support (PKVY/NMNF/PM-PRANAM/GNY/PMFME/AIF/GOBARDhan) — resolved by a single-window mission.

Demand → Gap → Opportunity → Action · Bio-Inputs



Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Inputs



Source: FGDs (Sonesarar, Sideswar); Jashpur (Sogda, Sarudih); 24-village LCAT

4 Market Ecosystem for the Value Chain

The bio-inputs value chain converts cow dung, agri-residue and microbial cultures (on the Gauthan base) into vermicompost, jeevamrit and biopesticides at women-SHG Bio-Resource Centres; grades and certifies them under FCO Schedule-VI via 120 district labs; aggregates through FPOs with branded packaging; and sells across a tiered market — community, FPO and export grade — with institutional procurement and a soil-carbon-credit overlay.

Bio-Inputs Value-Chain Architecture



Market Ecosystem for the Bio-Inputs Value Chain

Inputs & Feedstock	Cow dung · agri-residue · microbial cultures · 7,836 Gauthans (Godhan Nyay base)
Producers / Aggregators	Women SHGs (90–100%) · 4,500 upgraded Bio-Resource Centres · FPOs
Quality & Logistics	120 district quality labs (FCO Schedule-VI) · cold-chain-light storage · branded packaging
Off-takers & Markets	Farmers · institutional procurement (T+30) · national retail · export · soil-carbon credits
Enablers	CBIM (proposed single-window) · PKVY · NMNF · PM-PRANAM · GNY · GOBARDhan · PMFME · AIF · NABARD

5 Community & Stakeholder Insights

Data note. Bio-inputs is a women-led, community-anchored value chain with a live state proof-of-concept (Godhan Nyay). FGDs in Sonesarar (Rajnandgaon) and Sideswar (Kanker), March 2026, confirm production capability and the binding quality/offtake/finance constraints.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Women's SHGs (Sonesarar)	6–7 t/yr jeevamrit/biopesticides (1 SHG + 10 farmers), ₹10/kg, 90% women — but no PMFME/AIF access and no quality lab nearby.	Upgrade to certified BRCs with FCO Schedule-VI compliance; open PMFME/AIF access and district quality-lab linkage.
Women's SHGs (Sidesar)	~10 q/yr vermicompost (2 SHGs + 10 farmers), ₹10/kg, 100% women; same infrastructure gaps.	Anchor a certified BRC per 50-ha cluster with blended finance for capex, storage and branded packaging.
Farmers / buyers	Vermicompost ₹30,000–36,000/acre vs ₹4,000–5,000 chemical — the price case doesn't close alone.	Enable tiered pricing, premium-crop outlets, institutional procurement (T+30) and soil-carbon-credit monetisation.

FPOs / aggregators	No assured offtake or working capital; certification absent.	FPO-grade certification (₹25/kg) and institutional/export linkage; NABARD/SIDBI/AIF working-capital and equity support.
State institutions (scheme silos)	SHGs cannot access layered PKVY/NMNF/PM-PRANAM/GNY/PMFME/AIF/GOB ARdhan support.	Establish the Chhattisgarh Bio-Inputs Mission (CBIM) as a single-window authority consolidating all schemes.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Value uplift via certification:** average value per kg rising ₹10 → ₹28 → ₹45 lifts revenue from ₹260 Cr to ₹2,150 Cr and the producer-community share to ~₹860 Cr — bio-inputs becoming a net fiscal contributor by 2031–32.
- **Economics close with four levers:** tiered certification, premium-crop outlets, institutional procurement (T+30) and soil-carbon credits — price alone is insufficient (the source states no single project IRR).

2. Social Benefits

- **Women-led enterprise at scale:** 72,000 jobs (28,000 direct FTE) with 90–100% women participation across ~20,000 villages — one of the state's largest decentralised women-led sectors.
- **Proven inclusion base:** Godhan Nyay already channelled ₹27.44 Cr to women SHGs — a validated benefit-sharing foundation.

3. Environmental & Climate Resilience

- **Emissions & soil health:** 1.4 MT CO₂e avoided annually by displacing chemical fertiliser and recycling livestock/crop waste into nutrients.
- **Circularity:** cow dung and residue become on-farm inputs, closing nutrient loops.

4. Technical Feasibility

- **Field-proven, low-tech:** vermicompost, jeevamrit and biopesticide production is already practised; the constraint is quality certification, storage and offtake, not core technology.
- **Quality is the enabler:** FCO Schedule-VI compliance and 120 district labs are the decisive prerequisites for grade-based pricing.

7 Success Stories & Proven Models

CASE STUDY 1 · Godhan Nyay Yojana — India's Largest Validated Bio-Inputs Model

Godhan Nyay Yojana operates 7,836 Gauthans, procured ₹147 Cr of cow dung, produced 9.79 lakh quintals of vermicompost and distributed ₹27.44 Cr to women SHGs — the largest publicly-validated bio-inputs enterprise model in India, with women SHGs as the workforce.

Relevance: *the path from ₹260 Cr to ₹2,150 Cr is not greenfield — it is a certification-and-offtake upgrade on infrastructure that already exists, anchored on 4,500 upgraded BRCs.*

CASE STUDY 2 · Sonesarar & Sideswar SHG Production — Capability Without Certification

Sonesarar (6–7 t/yr jeevamrit, 90% women) and Sideswar (~10 q/yr vermicompost, 100% women) both produce at ₹10/kg but lack a nearby quality lab and PMFME/AIF access — proving that willingness and capability exist, but certification and offtake do not.

Relevance: *the archetype for CBIM's tiered-certification upgrade — moving village SHGs from ₹10/kg community-grade toward ₹25–50/kg FPO/export-grade with institutional procurement.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no nearby quality labs; cold-chain-light storage and branded packaging absent at BRC level.
- **Solution:** deploy 120 district quality labs (FCO Schedule-VI) and 4,500 upgraded BRCs with storage and branded packaging (blended finance).

Financial Barriers

- **Barrier:** no assured offtake or working capital; SHGs cannot access layered scheme support; price case doesn't close alone.
- **Solution:** institutional procurement with T+30 payment; NABARD/SIDBI/AIF working capital and SHG/FPO equity; soil-carbon-credit revenue.

Knowledge & Technical Skill Gaps

- **Barrier:** scheme-silos and certification know-how gaps at SHG level.
- **Solution:** CBIM single-window consolidation and tiered-certification training; FCO Schedule-VI compliance support.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Mitigation Strategy
Market / Price	Vermicompost (₹30,000–36,000/acre) is far costlier than chemical (₹4,000–5,000) — the price case doesn't close alone.	High	Tiered certification (₹10/25/50/kg), premium-crop outlets, institutional procurement (T+30) and soil-carbon credits.
Production / Climate	Feedstock is seasonal; quality is variable without labs.	Med	120 district quality labs and FCO Schedule-VI compliance; BRC standardisation.
Operational / Supply Chain	No assured offtake, storage or working capital at BRC level.	High	Institutional procurement, cold-chain-light storage, branded packaging and NABARD/SIDBI/AIF working capital.
Policy / Governance	Scheme-silos leave SHGs unable to access layered support.	High	Establish CBIM as a single-window authority consolidating PKVY/NMNF/PM-PRANAM/GNY/PMFME/AIF/GOBARDhan.

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Tiered Certification & Pricing Ladder

Community-grade	FPO-grade	Export-grade
Village use; FCO basic ₹10/kg SHG production	Inter-village + institutional ₹25/kg certified BRCs	National retail + export ₹50/kg FCO Schedule-VI

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish the Chhattisgarh Bio-Inputs Mission (CBIM) single-window authority; launch tiered certification/pricing (FCO Schedule-VI, 120 district labs); upgrade 4,500 BRCs; mandate institutional procurement with T+30; monetise soil-carbon credits.

Private Sector & Investors

- Provide certification, branded packaging, storage and retail/export offtake; co-invest via CSR and AIF; enable institutional procurement and premium-crop market linkage.

Development Agencies & NGOs

- Mobilise and skill women SHGs and FPOs, build certification and quality-assurance capacity, and structure working-capital and offtake models on the Gauthan base.

11 Key Departments & Institutional Alignment

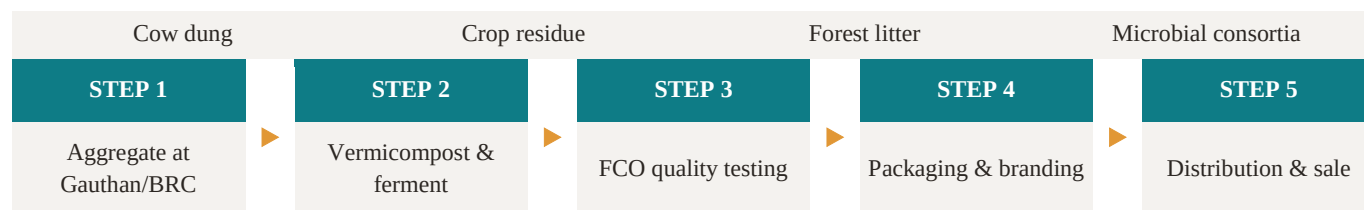
Nodal Institution	Department /	Primary Responsibility in the Bio-Inputs Value Chain
Chhattisgarh Bio-Inputs Mission (CBIM, proposed)		Single-window authority consolidating PKVY, NMNF, PM-PRANAM, GNY, PMFME, AIF and GOBARDhan.
Dept. of Agriculture & Farmers Welfare		NMNF/PKVY/PM-PRANAM delivery, FCO Schedule-VI compliance and farmer extension.
Rural Development / Panchayat (GNY, Gauthans)		Gauthan infrastructure, cow-dung procurement and SHG enterprise base.
Women's SHGs / BIHAN (SRLM)		Bio-Resource Centre production and women-led enterprise (90–100% women).
FPOs		Aggregation, FPO-grade certification, branded packaging and institutional/export offtake.
Quality labs / FCO regulators		120 district quality labs; FCO Schedule-VI certification and grading.
NABARD / SIDBI / Financial Institutions		AIF, concessional debt, working capital and SHG/FPO equity.
Industries / PMFME		Micro-enterprise credit-linked subsidy for BRC upgrades.
MoEFCC / Carbon-market partners		Soil-carbon-credit monetisation for ecosystem services.

[1]**Methodology.** Employment: 72,000 jobs = 28,000 direct FTE + 44,000 indirect, at ~1 direct job/₹2.8 lakh revenue + ~1.6 indirect; 90–100% women. Revenue: ₹2,150 Cr by 2035–36 (from ₹260 Cr) as value/kg rises ₹10 → ₹28 → ₹45; producer-community share ~₹100 Cr → ₹420 Cr → ₹860 Cr. Capital: ₹540 Cr by 2030–31 (₹780 Cr cumulative); blended stack (grants 35% / debt 25% / env funds 20% / CSR 12% / SHG-FPO equity 8%); net fiscal contributor by 2031–32. Base: Godhan Nyay — 7,836 Gauthans, ₹147 Cr cow dung, 9.79 lakh q vermicompost, ₹27.44 Cr to women SHGs. Economics require tiered certification + premium outlets + institutional procurement (T+30) + soil-carbon credits (vermicompost ₹30–36k/acre vs chemical ₹4–5k). CO₂e avoided 1.4 MT/yr. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation

Input / Output Flow

Value Chain Flow · Bio-Inputs

INPUTS



OUTPUTS

Vermicompost

Liquid biofertilizers

Botanical biopesticides

Jeevamrit bio-stimulants

Source: FGDs (Sonesarar, Sideswar); Jashpur (Sogda, Sarudih); 24-village LCAT

N06 Bio-Feed (Nature-Based)

Nbs · NATURE-BASED SOLUTIONS

Processed compound feed for cattle, poultry and aquaculture, formulated from agricultural residues, oil cakes, pulse byproducts and emerging bio-protein sources, produced at cluster scale under FPO-SHG ownership.

1 Executive Dashboard

EXECUTIVE DASHBOARD — BIO-BASED FEED AT A GLANCE (Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 15,000–30,000 direct rural jobs over 2026–32 from a deployment of 200–400 cluster-level feed mills and 500–1,000 dealerships — rural mills employ 8–15 FTE/unit, dealerships 2–4 FTE plus 5–10 indirect — concentrated in feedstock aggregation, milling/packaging, distribution, extension advisory and feed-quality testing across the six major paddy-and-livestock districts.

Market & Investment Opportunity. A ₹500–1,500 Cr opportunity envelope (0.5–1% of India's compound-feed market) across three tracks: cluster feed-mill capex (₹50 lakh–3 Cr mash / ₹5–15 Cr pellet), dealership working capital (₹5–25 lakh/outlet under NLM Entrepreneurship Development + PMFME), and alternative-protein scale-up (Black Soldier Fly, silkworm protein).

Market Context. India's animal-feed market is ₹1.11 trillion (2024), projected to ₹2.02 trillion by 2033 (6.9% CAGR); compound feed grows from USD 27.23 bn to USD 36.6 bn by 2029 — while at village level feed cost is the #1 ranked livestock and fishery constraint.

Strategic Outcome — connect supply to demand. The same FGDs that flag feed cost as the binding constraint (₹2,000–4,000/HH/month; fish feed ₹50/kg) sit beside villages with abundant un-monetised paddy, pulse and millet residues (10.9 MMT surplus paddy straw). The intervention is not to create demand or build the agricultural base — it is to connect the two, converting feed-cost-as-constraint into feed-enterprise-as-livelihood.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Bio-based Feed · Chhattisgarh 2026–36

DIRECT RURAL JOBS	INVESTMENT ENVELOPE	NATIONAL MARKET	BINDING CONSTRAINT
15,000–30,000	₹500–1,500 Cr	₹1.11T → ₹2.02T	feed cost = #1
cluster feed mills, dealerships, ingredient aggregation	0.5–1% addressable share of national market	animal feed by 2033 (6.9% CAGR)	ranked constraint in livestock & fishery FGDs

2 Contextual Overview

National Context

- **Large, growing market:** India's animal-feed market (₹1.11 trillion, 2024) grows to ₹2.02 trillion by 2033; compound feed reaches USD 36.6 bn by 2029, with poultry feed the largest share (44–56%).
- **Alternative-protein frontier:** circular alternatives — Black Soldier Fly (Elmentoz processes ~2,000 MT of industrial byproducts monthly) and silkworm-derived protein (Loopworm) — reduce dependence on maize and soybean meal.

Chhattisgarh Context

- **Uniquely clean supply–demand alignment:** the same geographies show feed cost as the #1 livestock/fishery constraint and abundant un-monetised residues — Bargaon (₹2,000–2,500/HH/month across 250 cow-and-goat households), Dashpur (fish feed ₹50/kg for 30 fisher households, ~100 Qtl/yr), alongside Sonesarar (250 acres paddy) and Sideswar (213 ha paddy/pulses/millet).
- **Institutional familiarity:** poultry feed is already a village livelihood (Tumdibod); feed-production-unit and dealership interest is explicitly confirmed — feed enterprise is culturally familiar, lowering adoption risk.
- **Missing middle:** cluster-level formulation, quality testing and certification do not yet exist — the intervention gap.

3 Demand & Supply Assessment

Supply Analysis

- **Feedstock base:** 10.9 MMT surplus paddy straw plus pulse/millet residues, rice bran/husk and oil cakes — currently un-monetised at village level, aggregable through FPO-SHG clusters.
- **Processing formats:** rural mash feed (SHG/FPO staple) scaling to pelletised feed at MSME tier, with alternative-protein (BSF, silkworm) as a circular substitute.
- **Quality gap:** no cluster-level feed-quality testing or certification — the compliance constraint under tightening FSSAI/BIS norms.

Demand Dynamics

- **Acute, proven demand:** feed cost is the #1 ranked constraint in 2 of 3 livestock FGDs and the #1 cost component in fisheries FGDs (fish selling-price spread ₹120–260/kg depends on feed efficiency).
- **Targeted markets:** tribal and forest-belt districts where large-player distribution is shallow, served by FPO-aggregated direct-to-farmer sales.

Supply–Demand Gaps

- **Disconnection, not scarcity:** demand and feedstock coexist in adjacent villages but are unconnected — cluster hub-and-spoke aggregation is the missing link.
- **Compliance & distribution:** absent testing labs limit offtake to informal buyers; concentrated national players (Godrej Agrovvet, Cargill, Suguna, Amrit, Venkateshwara) compress margins.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Feed (Nature-Based)

CURRENT SITUATION	THE GAP	OPPORTUNITY	RECOMMENDED ACTION
Feed imported; ₹2,000-4,000/HH/mo; informal mixing	No cluster mission, no quality labs, FPO-SHG capital gap	₹500-1,500 Cr; 15-30% feed-cost cut via clusters	Notify mission; 200-400 cluster mills; testing labs

Source: Livestock/Fishery FGDs (Bargaon, Tumdibod, Dashpur); Jashpur (Sogda)

4 Market Ecosystem for the Value Chain

Bio-based feed aggregates un-monetised agri-residues, oil cakes and pulse byproducts (FPO-SHG tier), formulates compound mash and pellet feed at cluster mills, and distributes through village-cluster dealerships to livestock, poultry and aquaculture farmers — with alternative-protein (BSF, silkworm) reducing reliance on maize/soybean. It is the most directly community-anchored value chain in the GETM portfolio, connecting feed-cost demand to residue supply in the same geographies.

Bio-based Feed Value-Chain Architecture

Feedstock Aggregation	Formulation	Cluster Feed Mills	Distribution	Farmers
FPO-SHG: paddy straw · bran · oil cakes	Compound mash / pellet feed	SHG/FPO mash · MSME pellet	Village-cluster dealerships	Cattle · poultry · aquaculture

Market Ecosystem for the Bio-based Feed Value Chain

Inputs & Feedstock	Agri-residues (10.9 MMT paddy straw) · oil cakes · pulse byproducts · BSF / silkworm alt-protein
Producers / Aggregators	FPO-SHG feedstock aggregators · 130+ FPOs · SHG networks in every FGD village
Processing & QC	Cluster feed mills (₹50L–3 Cr mash · ₹5–15 Cr pellet) · feed-quality testing labs

Off-takers & Markets	Livestock / poultry / aquaculture farmers · village-cluster dealerships · FPO direct-to-farmer
Enablers	National Livestock Mission (Entrepreneurship Dev) · PMFME · PMMSY · FSSAI / BIS · KVK / ITI skilling

5 Community & Stakeholder Insights

Data note. *Bio-based feed is deeply community-anchored. Field evidence draws on Livestock/Fishery FGDs (Bargaon-Mathaldabri, Tumdibod, Dashpur) and Agriculture FGDs (Sonesarar, Sideswar) plus a Bio-Manufacturing IDI.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Livestock rearers (Bargaon)	Feed cost ₹2,000–2,500/HH/month is the #1 income barrier across 250 cow-and-goat households; feed-production-unit interest YES.	Deploy cluster feed mills via FPO-SHG consortia (NLM + PMFME); lower feed cost through local residue-based formulation.
Inland fishers (Dashpur)	Fish feed ₹50/kg is the #1 cost component for 30 households (~100 Qtl/yr); selling price ₹120–260/kg hinges on feed efficiency.	Add an aquaculture-feed sub-cluster under PMMSY; FPO-aggregated fish-feed production to cut input cost.
Poultry-feed micro-entrepreneurs (Tumdibod)	Poultry feed already a village livelihood; feed-dealership interest YES.	Support dealership working capital (₹5–25 lakh) and skilling; formalise existing feed enterprise.
Crop farmers (Sonesarar, Sideswar)	Abundant paddy/pulse/millet residues currently un-monetised.	Enable FPO-SHG feedstock aggregation to monetise residues as feed ingredients.
Women's SHGs / FPOs	130+ FPOs and SHG networks provide institutional capacity but lack formulation and testing infrastructure.	Channel capex through FPO-SHG consortia; build feed-quality testing labs and a Bio-Feed Certification framework.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Three investment tracks:** cluster mills, dealerships and alternative-protein scale-up within a ₹500–1,500 Cr envelope — subsidies routed through FPO-SHG consortia address the working-capital gap FGDs document.
- **ROI note:** the source gives no single project IRR; viability rests on cost-saving substitution, NLM/PMFME subsidy and FPO-aggregated direct sales — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Livelihood conversion:** 15,000–30,000 rural jobs turning feed-cost-as-constraint into feed-enterprise-as-livelihood in the same villages that surfaced the problem.

- **Community familiarity:** existing poultry-feed livelihoods and documented skilling willingness lower adoption risk.

3. Environmental & Climate Resilience

- **Residue valorisation:** monetising 10.9 MMT surplus paddy straw diverts residue from burning into productive feed.
- **Circular protein:** BSF and silkworm protein cut dependence on land- and water-intensive maize/soybean meal.

4. Technical Feasibility

- **Field-ready milling:** mash/pellet milling is proven; the constraint is formulation expertise, quality testing and certification, not core technology.
- **Skilling enabler:** KVK/ITI feed-formulation skilling and last-mile Krishi/Kisan Mitra extension are the decisive enablers.

7 Success Stories & Proven Models

CASE STUDY 1 · Feed-Cost Constraint Meets Residue Supply — Bargaon & Sonesarar

Bargaon-Mathaldabri records feed cost of ₹2,000–2,500/HH/month as the binding barrier on livestock livelihoods for 250 households, while adjacent Sonesarar generates residue and bran feedstock from 250 acres of paddy — demand and supply coexisting in neighbouring villages.

Relevance: *the exemplar for cluster hub-and-spoke deployment — an FPO-SHG feed mill connecting residue supply to feed demand in the same geography.*

CASE STUDY 2 · Alternative-Protein Precedents — Elmentoz (BSF) & Loopworm

Elmentoz operates India's largest BSF-oriented facility, processing ~2,000 MT of industrial byproducts monthly, and Loopworm (2024 launch) produces silkworm-derived protein — commercial precedents for circular alternative-protein feed.

Relevance: *the Track-3 template for MSME-tier alternative-protein scale-up that reduces maize/soybean dependence and raw-material price volatility.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no cluster-level formulation, quality-testing or certification infrastructure.
- **Solution:** cluster feed mills (hub-and-spoke) plus state feed-testing labs and a Chhattisgarh Bio-Feed Certification framework.

Financial Barriers

- **Barrier:** working-capital gap at mill and dealership tier; margin competition from concentrated national players.

- **Solution:** route NLM/PMFME capex through FPO-SHG consortia; target tribal/forest-belt markets with FPO-aggregated direct sales.

Knowledge & Technical Skill Gaps

- **Barrier:** absent feed-formulation and ingredient-quality skills at cluster level.
- **Solution:** a Chhattisgarh Bio-Feed Skills Programme via KVKs, agricultural universities and ITIs; leverage Krishi/Kisan Mitra extension.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Concentrated national players (Godrej Agrovet, Cargill, Suguna) compress rural distribution margins.	Med	Target shallow-distribution tribal/forest-belt markets; FPO-aggregated direct-to-farmer sales.	
Production / Climate	Maize/soybean price volatility (weather, pests, food competition) raises feed cost.	Med	Substitute agri-residues, oil cakes, BSF and pulse byproducts; invest in formulation and testing.	
Operational / Supply Chain	Feedstock and demand coexist but are unconnected; no cluster aggregation.	High	Cluster hub-and-spoke feed mills via FPO-SHG consortia connecting residue supply to feed demand.	
Policy / Governance	Tightening FSSAI/BIS feed-safety norms without state labs limit offtake to informal buyers.	High	Notify a Bio-Feed Cluster Mission (nodal: Animal Husbandry & Dairying) with testing labs and certification.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks (Cluster → Alt-protein)

Cluster Feed Mills	Feed Dealerships	Alt-protein Scale-up
Mash feed; SHG/FPO tier ₹50L–3 Cr/unit 8–15 FTE/unit	Last-mile distribution ₹5–25 lakh/outlet 2–4 FTE + 5–10 indirect	BSF / silkworm protein (MSME) ₹5–15 Cr/unit circular, high-value

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Bio-Feed Cluster Mission (Q4 2026) under NLM Entrepreneurship Development, nodal Animal Husbandry & Dairying, aligned to PMMSY for aquaculture feed; build feed-testing labs and certification; route NLM/PMFME capex through FPO-SHG consortia; launch a Bio-Feed Skills Programme.

Private Sector & Investors

- Invest in cluster/MSME feed mills and alternative-protein (BSF, silkworm) scale-up; provide formulation technology, quality systems and offtake; partner on dealership distribution.

Development Agencies & NGOs

- Mobilise FPO-SHG feedstock aggregation, build formulation and extension capacity, and structure working-capital and direct-to-farmer sales models in tribal/forest-belt districts.

11 Key Departments & Institutional Alignment

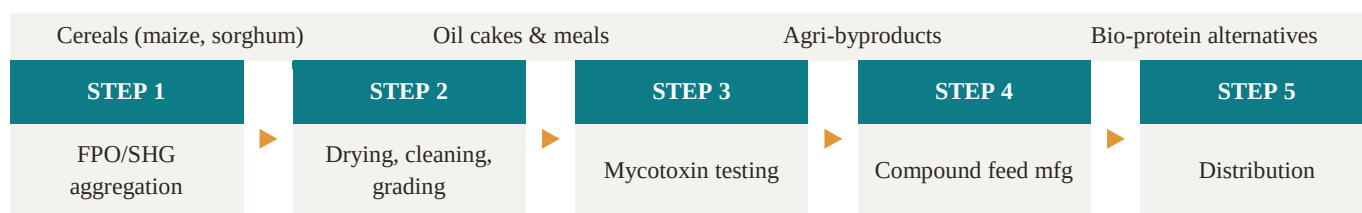
Nodal Institution	Department /	Primary Responsibility in the Bio-Feed Value Chain
Dept. of Animal Husbandry & Dairying (nodal)		Bio-Feed Cluster Mission; NLM Entrepreneurship Development; feed-cluster hub-and-spoke architecture.
Fisheries Department / PMMSY		Aquaculture-feed sub-cluster and fish-feed cost reduction.
Industries / PMFME / CSIDC		Micro-enterprise credit-linked subsidy and MSME pellet-feed support.
Agriculture Department		Residue/feedstock supply, Krishi Mitra extension and FPO linkage.
FPOs / SHGs (130+ FPOs)		Feedstock aggregation, mill/dealership operation and direct-to-farmer sales.
Feed-testing labs / FSSAI-BIS liaison		Feed-safety compliance, quality testing and Bio-Feed Certification.
KVKs / Agricultural Universities / ITIs		Feed-formulation, mill-operations and extension skilling.
NABARD / Financial Institutions		AIF, working capital and credit guarantee for mills and dealerships.
Livestock/Fishery communities	FGD	Demand articulation and enterprise participation (Bargaon, Tumdibod, Dashpur).

[1]**Methodology.** Employment: 15,000–30,000 direct rural jobs from 200–400 cluster feed mills (8–15 FTE/unit) + 500–1,000 dealerships (2–4 FTE + 5–10 indirect) over 2026–32. Investment: ₹500–1,500 Cr envelope (0.5–1% of national compound-feed market) — mills ₹50L–3 Cr (mash) / ₹5–15 Cr (pellet); dealerships ₹5–25 lakh. Market: India animal feed ₹1.11T (2024) → ₹2.02T (2033, 6.9% CAGR); compound feed USD 27.23 bn → 36.6 bn (2029). Feedstock: 10.9 MMT surplus paddy straw + pulse/millet residues + rice bran/husk + oil cakes. FGD demand: feed cost ₹2,000–4,000/HH/month; fish feed ₹50/kg; fish price ₹120–260/kg. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Bio-Feed (Nature-Based)

INPUTS



OUTPUTS

Mash feed	Pellet feed	Crumble feed	Cattle/poultry/aqua feed
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Source: Livestock/Fishery FGDs (Bargaon, Tumdibod, Dashpur); Jashpur (Sogda)

N07 Sustainable Agriculture & Integrated Pest Management (IPM)

NbS · NATURE-BASED SOLUTIONS

The transition of Chhattisgarh's farmland from input-intensive conventional cultivation to certified regenerative and Integrated Pest Management (IPM) systems that restore soil, cut chemical dependency, and lift farmer incomes.

1 Executive Dashboard

EXECUTIVE DASHBOARD — SUSTAINABLE FARMING + IPM AT A GLANCE (Chhattisgarh · Vision 2035)

Direct FTE Employment. 22,880 FTE green jobs by 2035–36 from a knowledge-intensive, decentralised model — 4,800 Van-Goythan Mitras (village extension), 4,800 SHG bio-input producers and 4,000+ post-harvest/technical roles — created by decentralising services rather than importing machines.

Market & Investment Opportunity. A ₹1,250 Cr decade-long investment (Phase 1 pilot ₹109.75 Cr; Phase 2 expansion ₹585.25 Cr) delivering 20 integrated packhouses, 200 upgraded Bio-Resource Centres and 50 mini-processing mills with refrigerated transport — reinforced by reduced input costs, carbon-credit revenue and PM-PRANAM grants (50% of saved fertiliser subsidy returned to the state).

Revenue Potential & Income. ₹5,740 Cr annual revenue stabilised by Vision 2035, with farmer net income rising ~60% to ₹61,600/ha (vs ₹35,000–40,000/ha conventional) — as India's organic food market grows 20–22% CAGR with demand outpacing supply 2:1 and certified produce commanding 20–30% premiums.

Climate & Strategic Outcome. 7.2 lakh tonnes CO₂e sequestered per annum state-wide, converting 4.8 lakh ha (10% of net sown area) to certified regenerative systems by 2035 —

anchored by a ‘Right-to-Win’ Large Area Certification advantage in Bastar/Surguja that bypasses the three-year conversion period.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Sustainable & Regenerative Farming + IPM · Chhattisgarh 2035

TARGET AREA	ANNUAL REVENUE	GREEN JOBS (FTE)	FARMER INCOME
4.8 L Ha	₹5,740 Cr	22,880	+60%
10% of net sown area by 2035 (2.5 L ha by 2030)	stabilised by Vision 2035	by 2035–36 · knowledge-intensive, decentralised	₹61,600/ha net · +7.2 L T CO ₂ e/yr sequestered

2 Contextual Overview

National Context

- **Urgent, financially compelling transition:** ~30% of India’s landmass is soil-degraded and the national fertiliser subsidy burden exceeds ₹2.5 lakh crore (FY 2022–23) — making the shift from input-intensive to regenerative farming a structural economic opportunity, backed by NMNF, PKVY and PM-PRANAM.
- **Premium market pull:** organic food demand grows 20–22% CAGR, outstripping supply 2:1, with 20–30% price premiums in domestic and export markets.

Chhattisgarh Context

- **‘Right-to-Win’ advantage:** large tribal tracts in Bastar and Surguja are ‘organic by default’, enabling Large Area Certification (LAC) that bypasses the three-year conversion period and cuts farmer financial risk.
- **Structural gaps:** cold-chain capacity in tribal regions is below 5% of requirement (forcing distress sales); only two NABL-accredited residue labs exist; extension is overburdened; and FPOs face governance/side-selling risk.
- **Field practice base:** regenerative practice is already taking root (Sonesarar and Sideswar), but its economic potential is unrealised because no market premium or certification pathway is operational — the central finding.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Sustainable Agriculture & IPM

CURRENT SITUATION	THE GAP	OPPORTUNITY	RECOMMENDED ACTION
IPM base live but unrewarded; same price as conventional	No premium/certification, cold chain <5%, weak extension	1.2 lakh/ha; 3,000 Cr by 2030 via 20–30% premium	Notify Bio-Districts; PGS on clusters; Organics brand

3 Demand & Supply Assessment

Supply Analysis

- **Bio-Cluster model:** 1,000-ha clusters spanning 2–3 contiguous Gram Panchayats, each integrating women-SHG Bio-Resource Centres (vermicompost, jeevamrit, bio-pesticides), Van-Goythan Mitra advisory, packhouses/cold rooms/mini-mills and CHiPS blockchain traceability.
- **Practice validation:** Sonesarar — 63 farmers on 65 acres, fertiliser use down 80%, pesticide down 70%, ~₹10,000/acre savings; Sideswar — 100 farmers on 150 acres, ~15% cost reduction — proving agronomic feasibility.
- **Quality-infrastructure gap:** cold chain <5% of requirement and only two NABL residue labs constrain grading, certification and shelf access.

Demand Dynamics

- **Premium & institutional demand:** organic premium markets (domestic + export), institutional buyers and a unified state organic brand — contingent on certification and traceability.
- **Certification is the unlock:** LAC in ‘organic-by-default’ belts can rapidly convert practice into certified, premium-eligible supply.

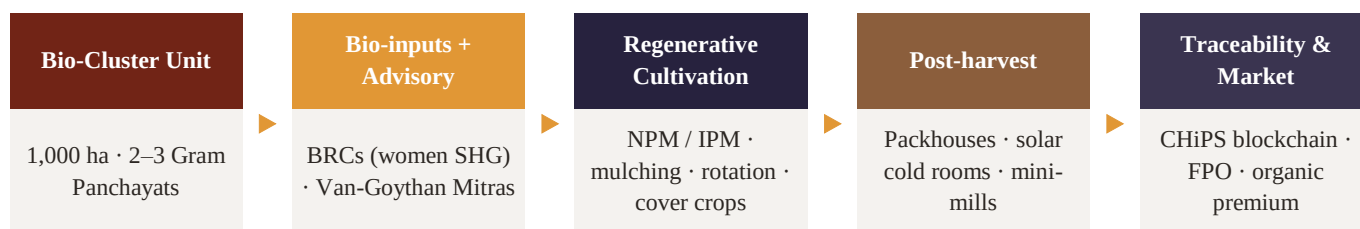
Supply–Demand Gaps

- **The premium gap (central barrier):** in both FGD sites sustainable produce sells at identical prices to conventional (₹31/qtl via society, ₹20/qtl open) — no premium, no operational certification pathway; this disconnect between ecological performance and economic reward is the single biggest barrier to scale.
- **Transition penalty:** a 2–3-year yield dip without a safety net (RTA) risks reversion to chemical farming — confirmed by the ₹4,000–5,000/farmer willingness-to-invest ceiling.

4 Market Ecosystem for the Value Chain

The value chain operates as a circular-economy Bio-Cluster model: 1,000-ha clusters (2–3 Gram Panchayats) integrate women-SHG Bio-Resource Centres for decentralised bio-input production, Van-Goythan Mitra field advisory, regenerative/IPM cultivation, post-harvest infrastructure (packhouses, solar cold rooms, mini-mills) and CHiPS blockchain traceability for seed-to-shelf transparency — with FPO-led aggregation into premium and institutional markets.

Sustainable Farming + IPM Value-Chain Architecture (Bio-Cluster Model)



Market Ecosystem for the Sustainable Farming + IPM Value Chain

Inputs & Bio-resources	BRC vermicompost / jeevamrit / bio-pesticides · quality seed · NABL residue-testing labs
Producers / Aggregators	Regenerative farmers · women SHGs · 4,800 Van-Goythan Mitras · FPOs
Processing & Logistics	20 integrated packhouses · solar cold rooms · 50 mini-mills · CHiPS blockchain traceability
Off-takers & Markets	Organic premium (domestic + export, 20–30% premium) · institutional buyers · state organic brand
Enablers	PKVY · NMNF (Krishi Sakhis) · RTA · PM-PRANAM · BPKP · AIF (NABARD) · Large Area Certification (LAC)

5 Community & Stakeholder Insights

Data note. This is a farmer- and SHG-anchored value chain with strong field evidence. FGDs in Sonesarar (Rajnandgaon, Dongergaon Block) and Sideswar (Kanker Block), March 2026, document practice, savings and the decisive market-premium gap.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Regenerative farmers (Sonesarar)	63 farmers/65 acres; fertiliser –80%, pesticide –70%, ~₹10,000/acre savings — yet produce sells at conventional prices (no premium).	Operationalise LAC certification and a state organic brand so demonstrated ecological performance earns a 20–30% premium.
Regenerative farmers (Sideswar)	100 farmers/150 acres; ~15% cost cut; emerging FPO linkage — but no certification or premium.	Fast-track Bio-District notification and FPO market linkage; disburse RTA (₹6,000/ha) to absorb the transition-period yield dip.
Women's SHGs (bio-input producers)	Local jeevamrit/vermicompost production (6–7 t and 10 q/yr) with no quality lab nearby.	Upgrade Bio-Resource Centres and deploy NABL residue labs; anchor 4,800 SHG bio-input producer roles.
Van-Goythan Mitras (extension)	Extension systems overburdened; KVK training 2–6×/yr is insufficient for a knowledge-intensive model.	Deploy 4,800 Van-Goythan Mitras for daily field advisory, complementing KVK training.
FPOs / institutional buyers	Cold chain <5% of requirement forces distress sales; FPO governance and side-selling risk.	Build 20 packhouses/50 mills and cold rooms (AIF); strengthen FPO governance and CHiPS traceability for institutional offtake.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Income & viability:** net income rising ~60% to ₹61,600/ha, reinforced by reduced input costs, carbon-credit revenue and PM-PRANAM grants — but contingent on certification and premium market access, which do not yet exist.
- **ROI note:** the source states no single project IRR; viability rests on the premium, input-cost savings and PM-PRANAM fiscal return — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Knowledge-economy jobs:** 22,880 FTE created by decentralising services (Van-Goythan Mitras, SHG bio-input producers, post-harvest roles) rather than importing machines — inclusive, women-centred employment.
- **Livelihood stability:** lower input costs and premium access raise smallholder resilience once the premium gap is closed.

3. Environmental & Climate Resilience

- **Carbon & soil health:** 7.2 lakh tonnes CO_{2e}/yr sequestered, with 80% fertiliser and 70% pesticide reductions demonstrated in the field — reversing soil degradation.
- **Resource efficiency:** circular bio-input production turns residues and livestock waste into on-farm nutrients.

4. Technical Feasibility

- **Field-proven agronomy:** NPM/IPM, mulching, rotation and cover cropping are already practised — the model is knowledge- and certification-intensive, not technology-constrained.
- **Digital traceability:** CHiPS blockchain seed-to-shelf traceability is the enabler for premium and export market trust.

7 Success Stories & Proven Models

CASE STUDY 1 · Sonesarar (Rajnandgaon) — Proven Agronomy, Missing Premium

63 farmers practise NPM/IPM across 65 acres with fertiliser use down 80% and pesticide down 70%, delivering ~₹10,000/acre savings; jeevamrit and bio-pesticides are produced locally by 1 SHG and 10 farmers (6–7 t/yr), with KVK training 4–6×/yr — yet the produce sells at the same price as conventional.

Relevance: *the clearest proof that the binding constraint is market and certification, not agronomy — LAC certification and a premium pathway would immediately monetise demonstrated performance.*

CASE STUDY 2 · Large Area Certification in ‘Organic-by-Default’ Bastar/Surguja

Large tribal tracts in Bastar and Surguja remain organic by default, enabling Large Area Certification that bypasses the standard three-year conversion period and sharply reduces farmer financial risk and gestation time.

Relevance: *CG’s ‘Right-to-Win’ — LAC can convert practice into certified, premium-eligible supply faster than any other state, directly closing the premium gap identified in the field.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** cold chain <5% of requirement forces distress sales; only two NABL residue labs limit certification.
- **Solution:** build 20 packhouses, 50 mini-mills and solar cold rooms (AIF), and expand NABL residue-testing capacity.

Financial Barriers

- **Barrier:** a 2–3-year transition yield dip without a safety net risks reversion; farmer willingness-to-invest ceiling ₹4,000–5,000.
- **Solution:** operationalise RTA (₹6,000/ha) in the first two seasons; layer PKVY/BPKP DBT and PM-PRANAM fiscal return.

Knowledge & Technical Skill Gaps

- **Barrier:** overburdened extension and no operational certification pathway; FPO governance gaps.
- **Solution:** deploy 4,800 Van-Goythan Mitras, notify Bio-Districts, operationalise LAC and a state organic brand, and strengthen FPO governance with CHiPS traceability.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Sustainable produce sells at conventional prices — no premium, no certification pathway (the central barrier).	High	Operationalise LAC, Bio-District notification and a unified state organic brand to capture the 20–30% premium.	
Production / Climate	2–3-year transition yield dip risks reversion to chemical farming.	High	Disburse RTA (₹6,000/ha) in the first two seasons; PKVY/BPKP DBT to absorb the yield-dip window.	
Operational Supply Chain	Cold chain <5% of requirement and only two NABL labs force distress sales.	High	Build packhouses/cold rooms/mills (AIF) and expand NABL residue-testing; strengthen FPO governance against side-selling.	

Policy Governance	/	No State Organic Agriculture Act — the ecosystem is vulnerable to programme discontinuity.	Med	Enact a State Organic Agriculture Act to lock in certification, branding and subsidy continuity.
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Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Chain Trajectory: Baseline vs Target

Indicator	Baseline	Target
Farmer Net Income (₹ '000/ha)	37.5 (Conventional ₹35–40k)	61.6 (Regenerative)
Converted Area (lakh ha)	2.5 (By 2030)	4.8 (By 2035)
Price Premium Captured (%)	0 (no premium)	25 (Target 20–30%)

Critical finding: sustainable produce currently sells at the SAME price as conventional (no premium, no certification pathway) — the single biggest barrier. Income uplift assumes certification + premium market access. Source: value-chain document.

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Act as nodal ‘Market Maker’: notify Bio-Districts, operationalise Large Area Certification, restructure subsidies, launch a unified state organic brand, disburse RTA, and enact a State Organic Agriculture Act; deploy CHiPS traceability.

Private Sector & Investors

- Invest in packhouses, cold rooms, mills and premium/export offtake; provide certification, branding and institutional procurement (T+30); co-finance via AIF and CSR.

Development Agencies & NGOs

- Mobilise SHG bio-input producers and Van-Goythan Mitras, build FPO governance and certification capacity, and facilitate premium-market and institutional linkages.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Value Chain
Dept. of Agriculture & Farmers Welfare		Nodal ‘Market Maker’: Bio-District notification, LAC enablement, subsidy restructuring, state organic brand; NMNF (Krishi Sakhis), PKVY, BPKP, RTA.
Horticulture Department		Fruit/vegetable cluster development, packhouse and cold-room linkage.
CHiPS		Blockchain seed-to-shelf digital traceability and QR integration.
Women’s SHGs (SRLM)	/ BIHAN	Bio-Resource Centre bio-input production; SHG enterprise mobilisation.
Van-Goythan Mitra cadre		Daily village-level extension and soil-health advisory.
NABARD Institutions	/ Financial	AIF interest subvention for post-harvest infrastructure.

KVKs / Agriculture Research	Farmer training, IPM/NPM protocols and technical guidance.
FPOs	Aggregation, market linkage, certification compliance and institutional offtake.
MoEFCC / Carbon-market partners	Carbon-credit revenue for sequestration and PM-PRANAM fiscal return.

[1]**Methodology.** Employment: 22,880 FTE = 4,800 Van-Goythan Mitras + 4,800 SHG bio-input producers + 4,000+ post-harvest/technical roles + associated cluster roles, from a knowledge-intensive, decentralised model. Revenue/income: ₹5,740 Cr annual revenue (Vision 2035); net income +60% to ₹61,600/ha vs ₹35,000–40,000/ha conventional, contingent on a 20–30% certified premium (organic market 20–22% CAGR, demand:supply 2:1). Investment: ₹1,250 Cr decade (Phase 1 ₹109.75 Cr; Phase 2 ₹585.25 Cr) — 20 packhouses, 200 BRCs, 50 mills. Area: 2.5 L ha by 2030 → 4.8 L ha (10% of net sown area) by 2035. Carbon: 7.2 L T CO₂e/yr. Central finding: no market premium or certification pathway currently exists (produce sells at ₹31/qtl society, ₹20/qtl open). All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

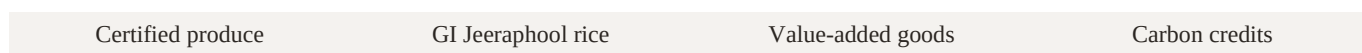
Input / Output Flow

Value Chain Flow • Sustainable Agriculture & IPM

INPUTS



OUTPUTS



Source: FGDs (Sonesarar, Sideswar); Jashpur & LCAT; Bhoomgadi Organic FPO

N08 Pasture Management

Nbs • NATURE-BASED SOLUTIONS

The stewardship, regeneration, and community governance of common grazing land, permanent pasture, silvopasture, and fodder-producing wasteland to secure fodder for Chhattisgarh's rural livestock economy.

Executive Dashboard

EXECUTIVE DASHBOARD — PASTURE MANAGEMENT AT A GLANCE (Chhattisgarh · GETM to 2035–36)

Direct FTE Employment. 85,000 women-led jobs by 2035–36 across pasture regeneration, silage/hay production and a 4,500-strong Pasture Sakhi cadre — systematising Sonesarar’s working model across ~15,000 villages with significant common grazing land.

Market & Investment Opportunity. ₹1,480 Cr capital by 2030–31 via a blended stack — public grants (NLM Feed & Fodder, MGNREGS, NGGB, RKVY) 35%, CAMPA/forest convergence 25%, concessional debt (AHIDF @ 3% subvention, NABARD RIDF) 15%, CSR/NGO-blended (FES, WOTR, PRADAN, AKRSP) 12%, community co-investment 8%, and grassland-carbon revenue 5% — with major NLM headroom (only 3,843 projects approved nationally since 2014).

Revenue & Fodder Security. ₹4,200 Cr economic value by 2035–36, closing India’s 29% aggregate fodder deficit at state scale (34% green-fodder, 11% dry-fodder against 1,183 MT demand) — where 40–70% of green fodder for India’s 535 million animals comes from Common Property Resources declining ~2% every five years.

Strategic Outcome — regenerate the commons. 2.4 million ha of pasture regenerated by 2035 (including 400,000 ha of silvopasture), insulating the ₹7,200 Cr small-livestock economy from the downward spiral that erodes rural resilience each time a grazing-common is lost — anchored in CG’s 44% forest cover, 7,836 Gauthans and statutory charnoi land.

Methodology & assumptions.^[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Pasture Management · Chhattisgarh 2035–36 (Grazing Commons · Fodder · Silvopasture)

ECONOMIC VALUE	JOBS GENERATED	PASTURE REGENERATED	CAPITAL NEEDED
₹4,200 Cr	85,000	2.4 M ha	₹1,480 Cr
by 2035–36 · closes the 29% fodder deficit	by 2035–36 · women-led (Pasture Sakhis)	by 2035 · incl. 400,000 ha silvopasture	by 2030–31 · blended stack

2 Contextual Overview

National Context

- **The invisible backbone:** Common Property Resources cover ~66 million ha (15% of India’s land) and supply 40–70% of green fodder for 535 million animals — yet decline ~2% every five years, driving a 29% aggregate fodder deficit.
- **Underused schemes:** the NLM Feed & Fodder Sub-Mission offers 50% subsidy up to ₹50 lakh (only 3,843 projects since 2014 — major headroom); AHIDF adds 3% interest subvention; CAMPA/MGNREGS/RKVY provide grant channels.

Chhattisgarh Context

- **Structural assets:** 44% forest cover, 7,836 Gauthans, the NGGB/Suraji Gaon framework, and charnoi as a statutorily-recognised land category.
- **A three-stage trajectory:** FGDs show the same pasture trajectory within 200 km — functional (Sonesarar), actively-losing (Tumdibod) and severely-degraded (Dhaneli Kanhal).
- **Scheme non-access:** CAMPA access is zero across all three surveyed villages, and Dhaneli Kanhal has no pasture committee and no grazing rules — a governance collapse.

3 Demand & Supply Assessment

Supply Analysis

- **Land base:** charnoi commons, forest fringe and degraded revenue land — with 400,000 ha targeted for silvopasture by 2035.
- **Production units:** 1,200 SHG-led silage/hay units (NLM 50% subsidy) and NLM fodder-entrepreneur units, FPO-routed to Gauthans, dairy cooperatives and deficit states.
- **Governance spine:** Charnoi Samitis and 4,500 Pasture Sakhis (women-majority, aligned to Bihaan) with Gram Sabha-ratified grazing rules and biomass monitoring.

Demand Dynamics

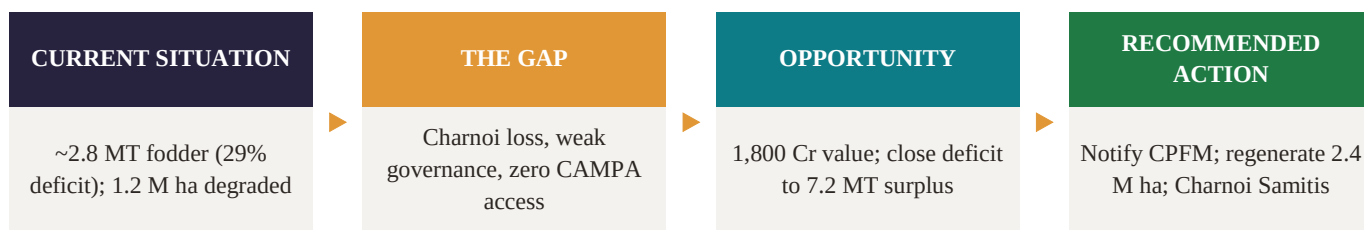
- **Anchored fodder demand:** Gauthans, dairy cooperatives and neighbouring fodder-deficit states provide the external demand anchor that breaks the degradation cycle.
- **Livestock linkage:** fodder security directly protects the ₹7,200 Cr small-livestock economy.

Supply–Demand Gaps

- **Governance collapse & scheme silos:** zero CAMPA access across all three villages and no grazing rules at Dhaneli Kanhal — resolved by a single-window mission and statutory protection.
- **The vicious cycle:** pasture degrades → livestock declines → fodder demand falls → enterprise interest collapses → no investment — broken by an external demand anchor (FPO silage procurement) plus commons protection.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Pasture Management

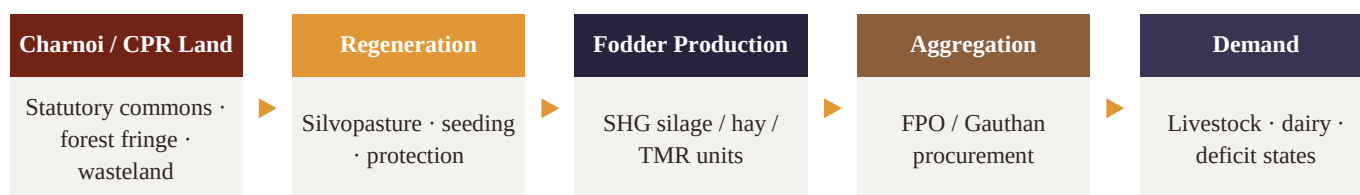


Source: FGDs (Sonesarar, Tumdibod, Dhaneli Kanhal); FES/WOTR/PRADAN templates

4 Market Ecosystem for the Value Chain

The pasture value chain regenerates the grazing commons: statutory charnoi and CPR land is protected and regenerated (silvopasture, seeding); SHG silage/hay/TMR units convert biomass into stored fodder; FPO/Gauthan aggregation links supply to dairy cooperatives and fodder-deficit states — governed by Charnoi Samitis and 4,500 Pasture Sakhis, and anchored in the NGGB/Suraji Gaon framework, with a proposed single-window mission (CPFM) and statutory protection (CCPRA).

Pasture Management Value-Chain Architecture



Market Ecosystem for the Pasture Management Value Chain

Land & Resource	Charnoi (statutory land) · 7,836 Gauthans · 44% forest cover · forest fringe + degraded revenue land
Producers / Governance	Charnoi Samitis · 4,500 Pasture Sakhis (women-majority) · SHG silage/hay units · NLM fodder entrepreneurs
Production & Regeneration	1,200 SHG silage/hay units · 400,000 ha silvopasture · TMR · fodder-seed units
Off-takers & Demand	Gauthans · dairy cooperatives · neighbouring fodder-deficit states · the ₹7,200 Cr small-livestock economy
Enablers	CPFM (proposed) · CCPRA · NLM Feed & Fodder · CAMPA · MGNREGS · RKVY · AHIDF · NGGB / Suraji Gaon

5 Community & Stakeholder Insights

Data note. Pasture management is community-governed. FGDs in Sonesarar, Tumdibod (Rajnandgaon) and Dhaneli Kanhal (Kanker), 16 March 2026, form a before-during-after case study of the same trajectory within 200 km.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Sonesarar (functional)	12-month fodder and active governance — the outcome when institutions hold.	Systematise this working model across ~15,000 villages via CPFM and Charnoi Samitis.
Tumdibod (actively-losing)	Pasture converting to factories — the degradation path in motion.	Enact CCPRA statutory protection; compensatory 1.25:1 pasture allocation when conversion is unavoidable.
Dhaneli Kanhal (degraded)	4-month fodder, no pasture committee, no grazing rules — governance collapse.	Form Charnoi Samitis with Gram Sabha grazing rules; anchor an external demand

		(FPO silage procurement) to restart investment.
Women (Pasture Sakhis)	Pasture governance is women-managed but under-supported.	Deploy 4,500 Pasture Sakhis (Bihaan-aligned) with grazing-card issuance and biomass monitoring.
All three villages	Zero CAMPA access despite acute need.	End the scheme-silo via CPFM single-window; saturate NLM Feed & Fodder + CAMPA silvopasture.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Fodder-security value:** ₹4,200 Cr economic value by closing the 29% fodder deficit and protecting the ₹7,200 Cr livestock economy; ₹1,480 Cr capital via a blended stack including grassland-carbon revenue.
- **External demand is the lever:** FPO-level silage procurement is the anchor that breaks the degradation cycle — the source frames value defensively rather than via a single project IRR.

2. Social Benefits

- **Women-led governance & jobs:** 85,000 women-led jobs and a 4,500-strong Pasture Sakhi cadre with statutory grazing-card authority.
- **Commons stewardship:** Charnoi Samitis restore community governance of the grazing commons.

3. Environmental & Climate Resilience

- **Regeneration at scale:** 2.4 M ha regenerated, including 400,000 ha silvopasture on forest fringe and degraded revenue land.
- **Carbon & resilience:** grassland carbon sequestration and climate-resilient fodder buffers.

4. Technical Feasibility

- **Low-tech, governance-led:** silage, hay and TMR are established technologies; the binding constraint is statutory protection and scheme convergence, not technology.
- **Digital demarcation:** CCPRA digital bhulekh demarcation of charnoi land within 18 months is the enabling reform.

7 Success Stories & Proven Models

CASE STUDY 1 · The Three-Stage Trajectory — Sonesarar to Dhaneli Kanhal

Within 200 km, Sonesarar (12-month fodder, active governance), Tumdibod (shrinking to factories) and Dhaneli Kanhal (4-month fodder, no committee) show the same pasture trajectory at three stages — a natural before-during-after experiment.

Relevance: *proof that outcomes are governance-determined; systematising Sonesarar's institutions and protecting the commons (CCPRA) is the intervention, not new technology.*

CASE STUDY 2 · Breaking the Vicious Cycle — External Demand Anchor

Dhaneli Kanhal's cycle — pasture degrades, livestock declines, fodder demand falls, enterprise interest collapses, investment stops — is instructive; breaking it requires an external demand anchor (FPO-level silage procurement) plus statutory protection of remaining commons.

Relevance: *the rationale for FPO-routed silage offtake to Gauthans, dairy cooperatives and deficit states as the demand lever that restarts investment.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** undemarcated charnoi land and few silage/hay units.
- **Solution:** CCPRA digital bhulekh demarcation (18 months) and 1,200 SHG silage/hay units plus 400,000 ha silvopasture.

Financial Barriers

- **Barrier:** zero CAMPA access and scheme silos across all three villages.
- **Solution:** CPFEM single-window consolidating NLM, CAMPA, MGNREGS, RKVY, NGGB and 15th FC; AHIDF concessional debt and grassland-carbon revenue.

Knowledge & Technical Skill Gaps

- **Barrier:** governance collapse — no pasture committees or grazing rules at the degraded end.
- **Solution:** Charnoi Samitis + 4,500 Pasture Sakhis with Gram Sabha-ratified rules, biomass monitoring and grazing-card issuance.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Fodder demand collapses as pasture degrades (the vicious cycle).	High	External demand anchor — FPO-level silage procurement	

			to Gauthans, dairy and deficit states.
Production Climate	/ CPR land declining ~2%/5 years; 29% fodder deficit; climate stress.	High	Regenerate 2.4 M ha incl. 400,000 ha silvopasture; NLM Feed & Fodder + CAMPA saturation.
Operational Supply Chain	/ Land-use conversion (factories, infrastructure) consuming commons.	Med	CCPRA moratorium on conversion without Gram Sabha approval; 1.25:1 compensatory allocation.
Policy Governance	/ Zero CAMPA access; no pasture committees/rules; scheme silos.	High	CPFM single-window authority + CCPRA statutory protection; Charnoi Samitis and Pasture Sakhis.

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

The Same Trajectory in Three Stages (within 200 km)

Sonesarar — Functional	Tumdibod — Actively Losing	Dhaneli Kanhal — Degraded
12-month fodder · active governance Systematise <i>Outcome when institutions hold</i>	Converting to factories Arrest & reverse <i>Degradation path</i>	4-month fodder · no committee Regenerate + protect <i>End-state to break</i>

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish the Chhattisgarh Pasture and Fodder Mission (CPFM) single-window authority; enact the Charnoi Protection and Regeneration Act (CCPRA — 18-month digital demarcation, conversion moratorium, block-level tribunals, 1.25:1 compensation); form Charnoi Samitis and deploy 4,500 Pasture Sakhis; saturate NLM Feed & Fodder + CAMPA silvopasture.

Private Sector & Investors

- Invest in silage/hay/TMR units and fodder-seed supply; provide FPO-routed silage offtake to Gauthans, dairy cooperatives and deficit states; co-finance via CSR (FES, WOTR, PRADAN, AKRSP).

Development Agencies & NGOs

- Mobilise Charnoi Samitis and women Pasture Sakhis, build grazing-rule governance and biomass monitoring, and structure grassland-carbon and blended finance.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Pasture Management Value Chain
Animal Husbandry & Dairying (nodal)		Fodder security, NLM Feed & Fodder Sub-Mission and dairy-cooperative demand.
Chhattisgarh Pasture & Fodder Mission (proposed)		Single-window consolidation of NLM, CAMPA, MGNREGS, RKVY, NGGB and 15th FC grants.
Revenue Department		Charnoi demarcation (digital bhulekh), conversion moratorium and Charnoi Tribunals.
Forest Department / CAMPA		Silvopasture on forest fringe and CAMPA convergence.
Panchayat & Rural Development (NGGB/Suraji Gaon)		Gauthan fodder activity, MGNREGS pasture works and Gram Sabha grazing rules.
Women's SHGs / Bihaan (SRLM)		Pasture Sakhi cadre, Charnoi Samitis and SHG silage/hay units.
NABARD / AHIDF		Concessional debt (AHIDF 3% subvention, RIDF) for fodder enterprises.
CSR / NGO partners (FES, WOTR, PRADAN, AKRSP)		Blended capital, community mobilisation and regeneration expertise.
Carbon-market partners		Grassland-carbon-credit monetisation.

[1]**Methodology.** Employment: 85,000 women-led jobs by 2035–36 (regeneration, silage/hay, 4,500 Pasture Sakhis). Capital: ₹1,480 Cr by 2030–31 — grants 35% / CAMPA 25% / concessional debt 15% / CSR-NGO 12% / community 8% / grassland-carbon 5%. Value: ₹4,200 Cr economic value by 2035–36 (largely loss-avoidance, protecting the ₹7,200 Cr livestock economy). Regeneration: 2.4 M ha incl. 400,000 ha silvopasture; 1,200 SHG silage/hay units. Context: CPRs supply 40–70% of green fodder for 535 M animals; 29% aggregate fodder deficit vs 1,183 MT demand; CPR declining ~2%/5 years. NLM Feed & Fodder: 50% subsidy up to ₹50 lakh (only 3,843 projects since 2014). FGD: Sonesarar (12-mo fodder) / Tumdibod (losing) / Dhanali Kanhal (4-mo fodder, no committee); zero CAMPA all three. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Pasture Management

INPUTS



OUTPUTS

Green & dry fodder	Hay, silage, pellets	Fodder seed	Silvopasture timber
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Source: FGDs (Sonesarar, Tumdibod, Dhaneli Kanhal); FES/WOTR/PRADAN templates

N09 Small Livestock Rearing

NbS · NATURE-BASED SOLUTIONS

The transformation of backyard cattle, goat, poultry, and buffalo rearing in Chhattisgarh from a subsistence risk-buffer into a decentralised, women-led commercial enterprise sector.

Executive Dashboard

EXECUTIVE DASHBOARD — SMALL LIVESTOCK REARING AT A GLANCE (Chhattisgarh · GETM to 2035–36)

Direct FTE Employment. 220,000 jobs by 2035–36 across a predominantly women-managed sector — spanning care cadres (Pashu Sakhi), shared-infrastructure clusters and value-addition — converting subsistence rearing into commercial enterprise.

Market & Investment Opportunity. ₹1,240 Cr capital by 2030–31 via a blended stack — public grants (NLM, State AH Dept., MGNREGS) 30%, concessional debt (AHIDF @ 3% subvention, AIF, NABARD, SIDBI) 25%, convergence funds (CAMPAs, DMF, Gauthan) 20%, CSR/blended philanthropy (PRADAN, BAIF, Heifer, Goat Trust models) 15%, and SHG/FPO equity 10% — building 600 shared-infrastructure clusters (200 by 2028).

Revenue & GVA. ₹7,200 Cr sectoral GVA by 2035–36, riding two tailwinds — India's poultry market growing from USD 32.93 bn (2025) to USD 71.75 bn by 2035 (8.1% CAGR), and India's position as the world's largest sheep-and-goat-meat exporter (₹835 Cr/yr to UAE, Qatar, Kuwait) — against a persistent per-capita meat deficit (15 g/person/day).

Strategic Outcome — survival is the income lever. Reducing village mortality from 40–50% (worst case) to below 8% is the single largest determinant of livestock income. Anchored by ~9.98 million cattle, 7,836 Gauthans and the state-headquartered IB Group (₹9,700 Cr), with NGO models (PRADAN, BAIF, Heifer, Goat Trust) demonstrating up to 75% income growth.

Methodology & assumptions.^[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Small Livestock Rearing · Chhattisgarh 2035–36 (Cattle · Goat · Poultry · Buffalo)

SECTORAL GVA	JOBS GENERATED	MORTALITY	CAPITAL NEEDED
₹7,200 Cr	220,000	40–50% → 8%	₹1,240 Cr
by 2035–36	by 2035–36 · women-managed	the single largest income determinant	by 2030–31 · blended stack

2 Contextual Overview

National Context

- **Large, women-led sector:** livestock contributes 30.1% of India's agricultural GVA, employs 80 million people (8% of the workforce), and is managed predominantly by rural women.
- **Two demand tailwinds:** poultry USD 32.93 bn → 71.75 bn by 2035 (8.1% CAGR); India is the world's largest sheep-and-goat-meat exporter (₹835 Cr/yr), against a 15 g/person/day per-capita meat deficit.

Chhattisgarh Context

- **Structural assets:** ~9.98 million cattle, 7,836 operational Gauthans and the state-headquartered IB Group (₹9,700 Cr) — one of India's largest protein-centric conglomerates.
- **Subsistence to enterprise:** the challenge is converting subsistence backyard rearing into commercial enterprise; NGO models show up to 75% income growth and dramatic mortality reduction are achievable.
- **Survival gap:** FGDs show wildly different economics within 30 km — driven by animal survival, not herd size.

3 Demand & Supply Assessment

Supply Analysis

- **Mortality control first:** expanding Mobile Veterinary Units from ~60 to 200, deploying a Pashu Sakhi cadre and making vaccination mandatory via Gauthan registration is the primary supply-side intervention.
- **Shared infrastructure:** 600 clusters (200 by 2028) each with slaughter, feed mill and cold chain on a 3–5-village basis, SHG-federation or FPO-owned.
- **Fodder security:** Napier grass on 80,000 ha of degraded common land plus Gauthan-level silage banks and heat-resilient sheds.

Demand Dynamics

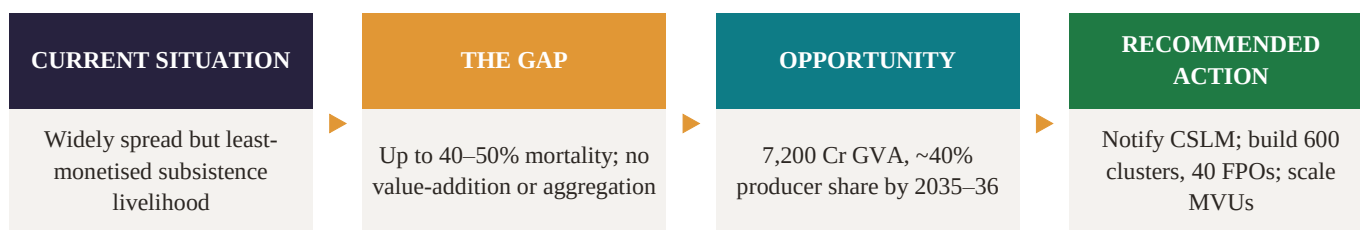
- **Assured offtake:** meat, dairy and poultry markets plus assured buy-back — one of five unanimous community investment triggers.
- **Value retention:** transparent service-fee models at shared-infra clusters keep margins in the producer community.

Supply–Demand Gaps

- **Five unanimous triggers:** all three FGD villages named the same five investment triggers — assured buy-back, lower feed cost, interest-free loan, cold chain and better veterinary access.
- **Scheme silos:** households cannot access layered support (NLM, AHIDF, NADCP, Insurance, DAY-NRLM, MGNREGS, PMFME, AIF, Gauthan-GNY) — resolved by a single-window mission.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Small Livestock Rearing

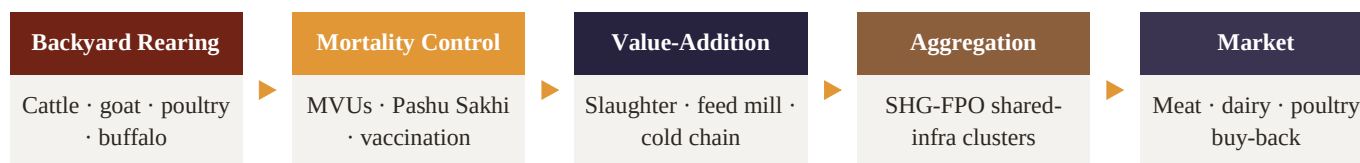


Source: FGDs (Bargaon, Tumdibod, Dashpur); LCAT synthesis; 20th Livestock Census 2019

4 Market Ecosystem for the Value Chain

The small-livestock value chain converts subsistence backyard rearing into commercial enterprise: mortality control (Mobile Veterinary Units, Pashu Sakhi, mandatory vaccination via Gauthans) is the foundation; shared-infrastructure clusters (slaughter, feed mill, cold chain) add value; SHG-FPO federations aggregate to meat, dairy and poultry markets with assured buy-back — backed by a Fodder Security Programme (Napier grass, silage banks) and a proposed single-window mission (CSLM).

Small Livestock Value-Chain Architecture



Market Ecosystem for the Small Livestock Value Chain

Inputs & Resource	~9.98M cattle · 7,836 Gauthans · Napier grass (80,000 ha) · IB Group anchor (₹9,700 Cr)
Producers / Care Cadre	Backyard rearers (women-managed) · Pashu Sakhi cadre · SHG-FPO federations
Shared Infrastructure	600 clusters (slaughter + feed mill + cold chain) · 200 by 2028 · MVUs 60 → 200
Off-takers & Markets	Meat exports (₹835 Cr) · domestic protein · dairy · assured buy-back
Enablers	CSLM (proposed) · NLM · AHIDF · NADCP · Livestock Insurance · DAY-NRLM · MGNREGS · PMFME · AIF · Gauthan-GNY

5 Community & Stakeholder Insights

Data note. Small livestock is women-managed and community-anchored. FGDs in Bargaon, Tumdibod (Rajnandgaon) and Dashpur (Kanker), March 2026, reveal a stark before-and-after within a 30-km radius.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Rearers (Bargaon)	40–50% mortality destroys any asset accumulation.	Launch the Livestock Mortality Compact; expand MVUs (60→200), Pashu Sakhi and mandatory vaccination.
Rearers (Dashpur)	10–15% mortality + cold chain enables ~₹30,000/yr income — the target model.	Replicate cold-chain + veterinary access; build 600 shared-infra clusters (slaughter/feed mill/cold chain).
Rearers (Tumdibod)	~10% mortality (road accidents); enterprise interest present.	Feed-mill and buy-back linkage; heat-resilient sheds and fodder security.
Women (Pashu Sakhi cadre)	Care is women-managed but under-supported.	Deploy Pashu Sakhi cadre through CGSRLM; cover insurance premium from SHG revolving fund for two years.
All three villages	Five unanimous triggers: buy-back, lower feed, interest-free loan, cold chain, vet access.	Establish CSLM single-window; assured buy-back, AHIDF/AIF credit and Napier-grass fodder security.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Survival drives income:** Dashpur’s low-mortality model yields ~₹30,000/yr where Bargaon’s high mortality yields none — the ₹7,200 Cr GVA hinges on mortality reduction to <8%.
- **Proven uplift:** NGO models (PRADAN, BAIF, Heifer, Goat Trust) show up to 75% income growth — the source structures the case around mortality and value-addition rather than a single IRR.

2. Social Benefits

- **Women-led, widely distributed:** 220,000 jobs in a women-managed sector, one of CG’s most widely distributed rural livelihoods.
- **Care cadre:** a Pashu Sakhi cadre embeds animal-health services at village level.

3. Environmental & Climate Resilience

- **Fodder & heat resilience:** Napier grass on 80,000 ha, silage banks and heat-resilient sheds address the 2–3-month fodder deficit and heat-stress signals.

- **Gauthan integration:** 7,836 Gauthans anchor vaccination, fodder and shared infrastructure.

4. Technical Feasibility

- **Animal health is the technology:** the binding constraint is mortality control (veterinary access, vaccination), value-addition infrastructure and market aggregation — not raw materials or willingness.
- **Cold chain & feed:** cold chain and lower feed cost are decisive enablers named unanimously in the field.

7 Success Stories & Proven Models

CASE STUDY 1 · Bargaon vs Dashpur — Survival Determines Income

Within 30 km, Bargaon's 40–50% mortality destroys asset accumulation, while Dashpur's 10–15% mortality plus cold chain enables ~₹30,000/yr income — the same cropping systems, wildly different livestock economics.

Relevance: *the empirical basis for prioritising mortality reduction (the Livestock Mortality Compact) as the first and largest income lever.*

CASE STUDY 2 · NGO Models — Up to 75% Income Growth

Proven NGO interventions (PRADAN, BAIF, Heifer, Goat Trust) show that community-based, women-centric models can deliver up to 75% income growth and dramatic mortality reduction.

Relevance: *the template for CSR-blended delivery (15% of the capital stack) and the Pashu Sakhi cadre — de-risking the transition from subsistence to enterprise.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no shared slaughter, feed-mill or cold-chain infrastructure at village tier.
- **Solution:** 600 shared-infra clusters (200 by 2028), SHG-federation or FPO-owned, financed via AHIDF and AIF.

Financial Barriers

- **Barrier:** households cannot access layered scheme support; no interest-free credit or insurance.
- **Solution:** CSLM single-window; AHIDF/AIF/NABARD/SIDBI credit; SHG-revolving-fund insurance premium for two years.

Knowledge & Technical Skill Gaps

- **Barrier:** veterinary access and vaccination gaps drive 40–50% mortality.
- **Solution:** Livestock Mortality Compact — MVUs 60→200, Pashu Sakhi cadre, mandatory Gauthan-linked vaccination.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Subsistence rearing captures little value; no assured buy-back.	Med	Assured buy-back and shared-infra value-addition with transparent producer-margin service fees.	
Production / Climate	40–50% mortality and 2–3-month fodder/heat-stress destroy asset accumulation.	High	Livestock Mortality Compact (MVUs 60→200, Pashu Sakhi, vaccination); Napier grass and heat-resilient sheds.	
Operational / Supply Chain	No shared slaughter/feed-mill/cold-chain infrastructure.	High	Build 600 shared-infra clusters (200 by 2028) via AHIDF/AIF, SHG/FPO-owned.	
Policy / Governance	Scheme-silos leave households unable to access layered support.	High	Establish CSLM single-window consolidating NLM, AHIDF, NADCP, Insurance, DAY-NRLM, MGNREGS, PMFME, AIF, Gauthan-GNY.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Baseline vs Target: Survival Drives Income

Indicator	Baseline	Target 2035
Village Mortality Rate (%)	45 (Worst case, Bargaon)	8
Mobile Veterinary Units (MVUs)	60 (Now)	200
Shared-infra Clusters	0 (none)	600 (by 2028)

Household income is determined by animal survival, not herd size: Bargaon's 40–50% mortality destroys asset accumulation, while Dashpur's 10–15% enables ~₹30,000/yr income. NGO models (PRADAN, BAIF, Heifer, Goat Trust) show up to 75% income growth. Source: value-chain document.

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish the Chhattisgarh Small Livestock Mission (CSLM) single-window authority; launch the Livestock Mortality Compact (MVUs 60→200, Pashu Sakhi, mandatory Gauthan-linked vaccination); build 600 shared-infra clusters; deliver a Fodder Security Programme (Napier grass 80,000 ha, silage banks, heat-resilient sheds).

Private Sector & Investors

- Invest in slaughter, feed-mill and cold-chain clusters and processing; provide assured buy-back, breed inputs and market linkage (meat/dairy/poultry); partner via IB Group-class offtake.

Development Agencies & NGOs

- Mobilise women rearers and the Pashu Sakhi cadre, build SHG-FPO federations and insurance access, and replicate PRADAN/BAIF/Heifer/Goat-Trust income-growth models.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Small Livestock Value Chain
Animal Husbandry & Dairying (nodal)		Mortality control, veterinary services, NLM/NADCP delivery and Livestock Insurance.
Chhattisgarh Small Livestock Mission (proposed)		Single-window consolidation of NLM, AHIDF, NADCP, Insurance, DAY-NRLM, MGNREGS, PMFME, AIF, Gauthan-GNY.
Panchayat & Rural Development (Gauthan/GNY)		Gauthan-linked vaccination, fodder and shared-infra siting.
Women's SHGs / Bihaan (CGSRLM)		Pashu Sakhi cadre, SHG-FPO federations and revolving-fund insurance.
Industries / PMFME		Feed-mill and value-addition micro-enterprise support.
NABARD / AHIDF / SIDBI		Concessional debt, AIF and shared-infra cluster finance.
Fisheries/Agriculture convergence (Napier/fodder)		Fodder Security Programme on degraded common land (MGNREGS + CAMPA).
CSR / NGO partners (PRADAN, BAIF, Heifer, Goat Trust)		Community-based, women-centric models and blended philanthropy.
Private processors (IB Group-class)		Buy-back, processing and market linkage for meat/dairy/poultry.

[1]**Methodology.** Employment: 220,000 jobs by 2035–36 (women-managed). Capital: ₹1,240 Cr by 2030–31 — grants 30% / concessional debt 25% / convergence funds 20% / CSR-philanthropy 15% / SHG-FPO equity 10%. GVA: ₹7,200 Cr by 2035–36. Mortality: 40–50% (worst case, Bargaon) → <8% target; Dashpur 10–15% enables ~₹30,000/yr income. Infrastructure: 600 shared-infra clusters (200 by 2028); MVUs 60 → 200; Napier grass 80,000 ha. Context: livestock 30.1% of India agri-GVA, 80 M jobs; poultry USD 32.93 bn → 71.75 bn (2035, 8.1% CAGR); sheep/goat-meat exports ₹835 Cr; per-capita meat 15 g/day. Assets: ~9.98 M cattle, 7,836 Gauthans, IB Group ₹9,700 Cr. NGO models (PRADAN/BAIF/Heifer/Goat Trust) up to 75% income growth. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Small Livestock

INPUTS



OUTPUTS

Goat & poultry meat	Milk & eggs	Live animals	Cow dung by-product
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Source: FGDs (Bargaon, Tumdibod, Dashpur); LCAT synthesis; 20th Livestock Census 2019

N10 Inland Fishery

NbS · NATURE-BASED SOLUTIONS

A circular "Waste-to-Nutrition" value chain that converts organic municipal and agro-industrial waste into standardised fish feed and seed to power intensive, branded inland aquaculture across Chhattisgarh's ponds, reservoirs and rehabilitated mining pits.

1 Executive Dashboard

EXECUTIVE DASHBOARD — INLAND FISHERIES AT A GLANCE (Chhattisgarh · GETM 2026–2035)

Direct FTE Employment. 15,000+ FTE jobs by 2035, with Phase 1 alone anchoring 150+ FPOs and 2,000 women enterprises — built on a Hub-and-Spoke 'Waste-to-Nutrition' model spanning bio-feed hubs, hatcheries, cage culture, packhouses and processing mills.

Market & Investment Opportunity. A ₹1,251.75 Cr ten-year investment (2026–35): Phase 1 pilot ₹109.75 Cr (2026–28; 5 bio-feed hubs, 5 hatcheries, 5,000 cages, pond renovation, IoT biosecurity, 28 district labs) with a Gated Execution trigger; Phase 2 expansion ₹475.50 Cr (30 bio-feed mills, 15 seed hubs, 20,000 cages, 20 packhouses, 50 mini-mills).

Revenue & Value Retention. 1.2 million MT production, ₹7,250 Cr annual gross revenue and ₹982 Cr net profit — closing a ~₹2,500 Cr/yr value leak by manufacturing feed and seed in-state, professionalising production and capturing downstream value through cold-chain, 'CG-FISH' branding and processing.

Strategic Outcome — India's #1 producer, plugging the leak. Chhattisgarh produced 6,51,950 tonnes in 2023 (the highest in India) yet exports raw, unchilled fish while importing ~70% of seed and ~65% of feed — a price-taker position leaking ₹2,500 Cr annually. The value chain also avoids 2.5 lakh tonnes CO_{2e} per year. Field evidence confirms strong willingness to scale, but that none of the four preconditions (feed, cold-chain, cooperative, tenure) is currently in place.

Methodology & assumptions.[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Inland Fisheries · Chhattisgarh 2026–35 (Hub-and-Spoke 'Waste-to-Nutrition')

FTE JOBS	10-YEAR INVESTMENT	PRODUCTION	ANNUAL NET PROFIT
15,000+	₹1,251.75 Cr	6.52 → 12 lakh MT	₹982 Cr
by 2035 · 150+ anchor FPOs, 2,000 women enterprises	Phase 1 pilot ₹109.75 Cr (2026–28)	India's #1 freshwater producer scaling up	₹7,250 Cr gross · plugs ₹2,500 Cr value leak

2 Contextual Overview

National Context

- **Strong scheme support:** PMMSY (40–60% grants), PMFME (35% for feed mills), AIF (3% interest subvention), MGNREGS (60% pond restoration), plus SBM, RKVY, DMF and KUSUM provide a convergence stack.
- **Nutrition demand:** the 'Waste-to-Nutrition' model links agri/livestock waste streams to affordable fish protein at scale.

Chhattisgarh Context

- **India's #1 freshwater producer:** 6,51,950 tonnes in 2023 — the highest in India — yet 3,52,000 tonnes are exported raw and unchilled.
- **The value leak:** ~70% seed and ~65% feed imported leaves CG a price-taker, leaking ₹2,500 Cr/yr to neighbouring states.
- **Preconditions absent:** FGDs confirm that none of the four preconditions — feed, cold-chain, cooperative, tenure — is currently in place on the ground, despite strong willingness to scale.

3 Demand & Supply Assessment

Supply Analysis

- **Close-the-loop supply:** in-state bio-feed (65 mills at ₹15–18/kg, eliminating 35% leakage) and seed hatcheries replace imported feed/seed; 2,000 ha of reclaimed mining pits add water area.
- **Production infrastructure:** cage culture (scaling to 20,000 cages), pond renovation and IoT biosecurity firewalls professionalise production.
- **Quality & tenure spine:** 28 district labs and a 15-year Blue-Lease (unlocking bank finance) underpin scale-up.

Demand Dynamics

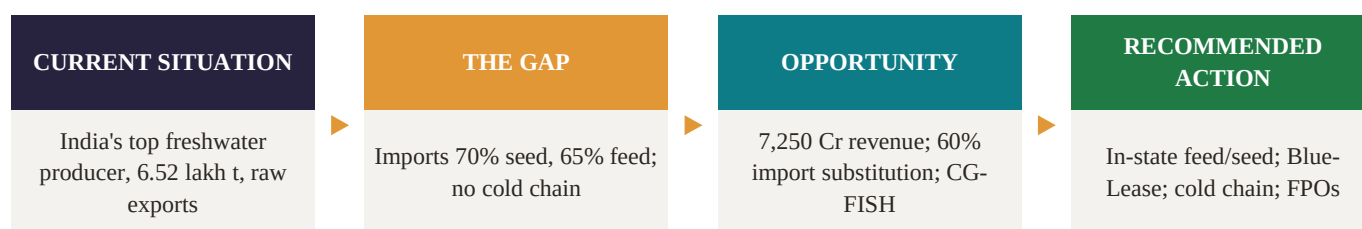
- **Branded, processed demand:** 'CG-FISH' national retail and APEDA export readiness capture downstream value beyond raw fish.
- **Fair pricing:** a notified Fair Remunerative Price (20% producer margin) anchors producer economics.

Supply–Demand Gaps

- **Four missing preconditions:** feed (no local supply — producers avoid commercial feed or pay ~₹50/kg), cold-chain, cooperative structure and secure tenure (3–5-year leases) are all absent.
- **Scheme non-uptake:** PMMSY uptake is zero in all three FGD villages (subsidy received only in Dashpur) — an awareness and facilitation gap addressed by Aqua-Extension Officers.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Inland Fishery



Source: FGDs (Bargaon & Mathaldabri, Tumdibod, Dashpur); Jashpur FGD; LCAT synthesis of 24 villages

4 Market Ecosystem for the Value Chain

The inland fisheries value chain closes CG's import loop via a Hub-and-Spoke 'Waste-to-Nutrition' model: in-state bio-feed mills and seed hatcheries feed pond and cage grow-out (including reclaimed mining pits), backed by IoT biosecurity; cold-chain, packhouses and mini-mills capture downstream value; and a 'CG-FISH' brand reaches national retail and APEDA export — anchored by a 15-year Blue-Lease, a Waste-Security MoU and a State Aqua Revolving Fund, with a Gated Execution trigger on Phase 1.

Inland Fisheries Value-Chain Architecture (Closing the Loop)



Market Ecosystem for the Inland Fisheries Value Chain

Inputs (in-state)	65 bio-feed mills (₹15–18/kg) · seed hatcheries · 2,000 ha reclaimed mining pits · IoT biosecurity firewalls
Producers / Aggregators	150+ anchor FPOs · 2,000 women enterprises · fisher households · Bihaan (NRLM)
Processing & Logistics	Cold chain · 20 integrated packhouses · 50 mini-processing mills · 28 district labs

Off-takers & Markets	'CG-FISH' national retail · APEDA export readiness · domestic wholesale · Fair Remunerative Price
Enablers	Green Fisheries Cell · 15-yr Blue-Lease · Waste-Security MoU · PMMSY / PMFME / AIF / MGNREGS / DMF / KUSUM

5 Community & Stakeholder Insights

Data note. *Inland fisheries is deeply community-anchored. FGDs at Bargaon-Mathaldabri, Tumdibod (Rajnandgaon) and Dashpur (Kanker), March 2026, test the vision against community experience and confirm affordability if credit is unlocked.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Fisher households (Dashpur)	Fish feed ~₹50/kg is the #1 cost; cold chain present but feed/seed imported.	Deploy PMFME mini-feed-mills per block (₹15–18/kg) to cut cost and lift yield.
Producers (Bargaon, Tumdibod)	Avoid commercial feed entirely; no local supply; strong FPO interest.	Localise bio-feed via 65 mills; anchor 150+ FPOs; eliminate 35% feed leakage.
FPOs / cooperatives	No cooperative structure; leases only 3–5 years; no bank lending.	Notify the 15-year Blue-Lease before Phase 1 to unlock bank finance and Blue-KCC.
Women enterprises	Affordable HH contribution ₹4–10k; EMI ₹1–5k/month — viability confirmed if credit unlocked.	Blended finance + 40–60% PMMSY grants + Blue-KCC; anchor 2,000 women enterprises.
All three FGD villages	PMMSY uptake zero (subsidy only in Dashpur); awareness/facilitation gap.	Deploy Aqua-Extension Officers; convene the Green Fisheries Cell for scheme convergence.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Value retention:** ₹7,250 Cr gross / ₹982 Cr net profit by closing the ₹2,500 Cr leak — with a notified Fair Remunerative Price (20% margin) and a State Aqua Revolving Fund.
- **Affordability confirmed:** HH contribution ₹4–10k and EMI ₹1–5k/month indicate viability if credit (Blue-KCC) is unlocked — the source provides gross/net revenue but structures the case around Gated Execution rather than a single IRR.

2. Social Benefits

- **Women-led enterprise:** 2,000 women enterprises and 150+ anchor FPOs in Phase 1; 15,000+ FTE by 2035.
- **Nutrition security:** affordable fish protein via the ‘Waste-to-Nutrition’ model.

3. Environmental & Climate Resilience

- **Emissions avoided:** 2.5 lakh tonnes CO₂e/yr avoided through in-state, waste-integrated production and reduced import logistics.
- **Circularity & reclaimed water:** agri/livestock waste feeds fish; 2,000 ha of reclaimed mining pits add productive water area.

4. Technical Feasibility

- **Biosecurity & IoT:** IoT biosecurity firewalls and 28 district labs professionalise health management and quality.
- **Feed/seed self-reliance:** in-state hatcheries and bio-feed mills are the decisive technical unlocks against import dependency.

7 Success Stories & Proven Models

CASE STUDY 1 · The Four Missing Preconditions — Field Test Across Three Villages

Across Bargaon-Mathaldabri, Tumdibod and Dashpur, FGDs confirm strong willingness to scale but that none of the four preconditions — feed, cold-chain, cooperative and secure tenure — is in place; PMMSY uptake is zero in all three (subsidy received only in Dashpur).

Relevance: *the diagnostic basis for the Gated Execution design — Phase 1 must install feed mills, cold-chain, FPO structure and the 15-year Blue-Lease before expansion.*

CASE STUDY 2 · Affordability Confirms Viability — If Credit Is Unlocked

Communities report affordable household contributions of ₹4–10k and EMIs of ₹1–5k/month with strong FPO interest — indicating the model is viable where credit is available, but constrained today by 3–5-year leases and no bank lending.

Relevance: *the rationale for notifying the 15-year Blue-Lease before Phase 1 release to unlock bank finance and Blue-KCC.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no local feed supply, cold-chain gaps and import-dependent seed.
- **Solution:** 65 bio-feed mills, seed hatcheries, cold-chain, 20 packhouses, 50 mini-mills and 28 district labs (Hub-and-Spoke).

Financial Barriers

- **Barrier:** 3–5-year leases prevent bank lending; PMMSY uptake zero.
- **Solution:** 15-year Blue-Lease, Blue-KCC, blended finance with 40–60% PMMSY grants, AIF subvention and a State Aqua Revolving Fund.

Knowledge & Technical Skill Gaps

- **Barrier:** awareness and facilitation gap; no cooperative structure.
- **Solution:** deploy Aqua-Extension Officers and convene the Green Fisheries Cell; organise 150+ anchor FPOs.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Price-taker position leaks ₹2,500 Cr/yr; raw unchilled exports.	High	In-state feed/seed, cold-chain and 'CG-FISH' branding; notified Fair Remunerative Price (20% margin).	
Production / Climate	Import dependency (70% seed, 65% feed) and disease risk.	High	In-state hatcheries and bio-feed mills; IoT biosecurity firewalls and 28 district labs.	
Operational / Supply Chain	None of the four preconditions (feed/cold-chain/cooperative/tenure) in place.	High	Gated Execution — install all four in Phase 1 before expansion; 150+ anchor FPOs.	
Policy / Governance	3–5-year leases block finance; PMMSY uptake zero.	High	Notify 15-year Blue-Lease and Waste-Security MoU; deploy Aqua-Extension Officers for scheme uptake.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Baseline vs Target: Closing the Import Loop (bar graph → editable data table)

Indicator	Baseline	Target
Production (lakh MT)	6.52 (2023, #1 in India)	12 (Target 2035)
Feed Import Dependency (%)	65 (Now imported)	26 (Ph2 substitution)
Seed Import Dependency (%)	70 (Now imported)	30 (in-state hatcheries)

CG is India's #1 freshwater producer (6.52 lakh MT, 2023) yet ~₹2,500 Cr/yr leaks out-of-state on 70% seed and 65% feed imports. In-state feed/seed manufacture plus cold-chain and 'CG-FISH' branding close the loop. Phase-2 targets ~60% import substitution. Source: value-chain document.

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Convene a Green Fisheries Cell; notify the 15-year Blue-Lease (water bodies + 2,000 ha reclaimed mining pits), 10-year Waste-Security MoUs, a Fair Remunerative Price (20% margin) and a State Aqua Revolving Fund; approve Phase 1 with a Gated Execution trigger; deploy Aqua-Extension Officers.

Private Sector & Investors

- Invest in bio-feed mills, hatcheries, cage culture, cold-chain and processing; partner on 'CG-FISH' branding and APEDA export; provide technology and offtake under Waste-Security MoUs.

Development Agencies & NGOs

- Organise 150+ anchor FPOs and 2,000 women enterprises, build Blue-KCC credit access and biosecurity capacity, and structure blended finance with PMMSY/AIF.

11 Key Departments & Institutional Alignment

Nodal Institution / Department	Primary Responsibility in the Inland Fisheries Value Chain
Green Fisheries Cell (anchor body)	Convening authority across departments; Gated Execution oversight and scheme convergence.
Fisheries Department	Nodal delivery: hatcheries, cage culture, Blue-Lease, PMMSY and CG-FISH brand.
Water Resources Department	Water-body allocation, pond renovation and irrigation-linked water area.
Mining Department	Reclaimed mining pits (2,000 ha) for aquaculture under Blue-Lease.
Urban Admin & Dev (UADD) / CECB	Waste-Security MoUs and environmental compliance for 'Waste-to-Nutrition'.
Bihaan (NRLM)	Women-enterprise mobilisation and FPO/SHG organisation.
NABARD / Financial Institutions	Blue-KCC, AIF subvention, blended finance and the State Aqua Revolving Fund.
Mandi Boards / APEDA	Market linkage, Fair Remunerative Price and export facilitation.
Aqua-Extension Officers	Last-mile scheme facilitation, PMMSY uptake and technical extension.

[1]**Methodology.** Employment: 15,000+ FTE by 2035; Phase 1 anchors 150+ FPOs and 2,000 women enterprises. Investment: ₹1,251.75 Cr over 2026–35 — Phase 1 pilot ₹109.75 Cr (5 bio-feed hubs, 5 hatcheries, 5,000 cages, pond renovation, IoT biosecurity, 28 district labs); Phase 2 ₹475.50 Cr (30 mills, 15 seed hubs, 20,000 cages, 20 packhouses, 50 mini-mills). Production/revenue: 6,51,950 t (2023) → 1.2 M MT; ₹7,250 Cr gross; ₹982 Cr net; ₹2,500 Cr/yr leak plugged; 2.5 lakh t CO₂e/yr avoided. Import dependency: seed ~70%, feed ~65% (Phase-2 target ~60% substitution). Policy: 15-yr Blue-Lease (+2,000 ha reclaimed mining pits), Waste-Security MoU, Fair Remunerative Price (20% margin), State Aqua Revolving Fund. FGD: HH contribution ₹4–10k, EMI ₹1–5k/month; PMMSY uptake zero in all 3 villages. No single project IRR is stated; the source uses Gated Execution. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Inland Fishery

INPUTS



Bio-feed & hatcheries

Intensive fish
production

Chilling & packhouse

Mini-processing mills

CG-FISH branding

OUTPUTS

Branded fish products

Institutional & retail

GCC/EU exports

Carbon credits

Source: FGDs (Bargaon & Mathaldabri, Tumdibod, Dashpur); Jashpur FGD; LCAT synthesis of 24 villages

N11 Water Security

Nbs · NATURE-BASED SOLUTIONS

A public-goods value chain — spanning drinking water, irrigation, groundwater, watershed and micro-irrigation — that converts precipitation, surface water and groundwater into reliable drinking-water delivery, assured irrigation and ecosystem-service flows through infrastructure, institutions and behaviour.

Executive Dashboard

EXECUTIVE DASHBOARD — WATER SECURITY AT A GLANCE (Chhattisgarh · GETM to 2035–36)

Direct FTE Employment. 145,000 jobs by 2035 — 58,000 direct FTE (watershed development, micro-irrigation installation and maintenance, solar pumping, water-quality testing) plus 87,000 indirect (scheme-convergence, agriculture intensification, fisheries and enabled services) — anchored by a 4,500-member Bhujal Mitra and Jal Sakhi cadre.

Market & Investment Opportunity. ₹3,800 Cr capital by 2030–31 via a blended stack — public grants (JJM, PMKSY, MGNREGS, ABY, 15th FC, CAMPA) 40%, state budget 20%, World Bank/multilateral (ABY extension) 15%, CSR/blended 12%, NABARD concessional debt 8%, and community co-investment 5% — unlocking approximately ₹4,800 Cr in annual loss-avoidance.

Revenue & Defensive Value. ₹8,100 Cr economic value by 2035–36 — primarily defensive (avoided fallowing, avoided crop failure, avoided migration). In the three FGD villages alone, 835 acres are fallow due to water shortage, with Dhaneli Kanhal reporting 70% fallowing and ~50% per-household income loss directly attributable to water scarcity.

Strategic Outcome — the connective tissue. Water security is the foundation layer on which every green value chain in CG stands. Agriculture consumes ~85% of India's freshwater; paddy uses 3,000–5,000 mm/ha/cycle. The task is to consolidate near-universal Har Ghar Jal drinking-water gains and accelerate on irrigation, watershed and groundwater — delivering 3.5 million ha of assured irrigation by 2035 and converting agriculture, livestock and NTFP chains from climate-exposed to climate-resilient.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Water Security · Chhattisgarh 2035–36 (Drinking · Irrigation · Groundwater · Watershed)

ECONOMIC VALUE	JOBS GENERATED	ASSURED IRRIGATION	CAPITAL NEEDED
₹8,100 Cr	145,000	3.5 M ha	₹3,800 Cr
by 2035–36 · unlocks ₹4,800 Cr/yr loss-avoidance	58,000 direct FTE + 87,000 indirect by 2035–36	by 2035	by 2030–31 · blended stack

2 Contextual Overview

National Context

- **Strong policy tailwinds:** Jal Jeevan Mission received ₹67,000 Cr in Budget 2025–26 (a 195% jump) and extends to 2028–29 for 100% coverage; PMKSY-PDMC has released ₹23,232 Cr for 96.83 lakh ha of micro-irrigation; Atal Bhujal Yojana (₹6,000 Cr, World Bank-backed) is the community-led groundwater-governance template.
- **Structural exposure:** India is the world’s largest groundwater extractor and ~25% of extraction is unsustainable (CGWB), making preventive investment prudent.

Chhattisgarh Context

- **Drinking water delivered:** CG has reached near-universal Har Ghar Jal; the task now is consolidation on drinking water and acceleration on irrigation, watershed and groundwater.
- **Structural assets:** ~16,000 rural ponds, an active NGGB (Narva-Garuwa-Ghurwa-Baari) framework, near-universal MGNREGS pond-creation and a PRI cadre trained in water-quality monitoring.
- **Early-warning signs:** CG is not yet on the ABY chronically-stressed list, but FGDs show early warning signs that should trigger preventive, not reactive, investment.

3 Demand & Supply Assessment

Supply Analysis

- **Storage & recharge:** a rolling 3-year de-siltation and rejuvenation programme across all 16,000+ rural ponds (MGNREGS + PMKSY-WDC convergence, ~₹800 Cr) lifting storage availability by 25–30%.
- **Micro-irrigation & solar:** PMKSY-PDMC micro-irrigation and solar pumping extend assured irrigation to 3.5 million ha by 2035.
- **Cadre & digital spine:** 4,500 Bhujal Mitra/Jal Sakhi plus the JalConnect digital platform integrate Water Security Plans, quality tests, de-siltation schedules and fund flow.

Demand Dynamics

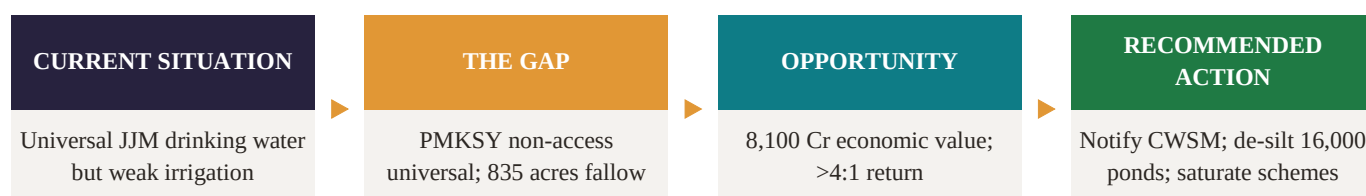
- **Universal, foundational demand:** reliable water underpins agriculture, livestock, fisheries and NTFP — the connective tissue for every other value chain.
- **Acute irrigation need:** all three FGD villages report strong irrigation demand and unanimous climate stress (delayed monsoons, extreme rainfall, drought).

Supply–Demand Gaps

- **Irrigation-layer crisis:** PMKSY non-access is 100% across all three surveyed villages despite acute need — the binding constraints are last-mile convergence and maintenance credibility, not scheme absence.
- **Maintenance trust deficit:** the Dhaneli Kanhal ‘no trust on subsidy’ signal requires user-linked maintenance financing and transparent governance.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Water Security

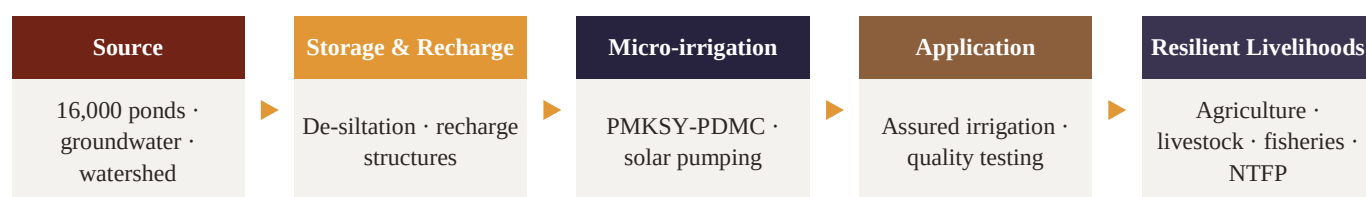


Source: FGDs (Sonesarar, Tumdibod, Dhaneli Kanhal); Jashpur FGD; LCAT synthesis of 24 villages

4 Market Ecosystem for the Value Chain

The water-security value chain fuses existing programmes into a single village-level water economy: source strengthening (de-siltation of 16,000+ ponds, recharge), micro-irrigation and solar pumping (PMKSY-PDMC), and a Bhujal Mitra/Jal Sakhi cadre with the JalConnect digital platform — governed by a proposed Water Security Mission (CWSM) and an Atal Bhujal Yojana extension, delivering primarily defensive value (avoided fallowing, crop failure and migration) across agriculture, livestock, fisheries and NTFP.

Water Security Value-Chain Architecture



Market Ecosystem for the Water Security Value Chain

Source & Assets	~16,000 rural ponds · NGGB (Narva-Garuwa-Ghurwa-Baari) · MGNREGS ponds · groundwater · watersheds
Cadre & Governance	4,500 Bhujal Mitra / Jal Sakhi · PRI water-quality cadre · Water User Associations
Infrastructure & Digital	Rolling de-siltation · micro-irrigation · solar pumping · JalConnect digital platform
Beneficiaries (defensive value)	Agriculture · livestock · fisheries · NTFP — avoided fallowing / crop failure / migration
Enablers	CWSM (proposed) · JJM (₹67,000 Cr) · PMKSY-PDMC · Atal Bhujal Yojana (₹6,000 Cr) · MGNREGS · 15th FC · CAMPAA

5 Community & Stakeholder Insights

Data note. Water security is community-governed and foundational. FGDs in Sonesarar, Tumdibod (Rajnandgaon) and Dhaneli Kanhal (Kanker), 16–17 March 2026, show drinking water delivered but irrigation resilience weak, with unanimous climate signals.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Farmers (Dhaneli Kanhal)	70% of land fallow; ~50% HH income loss; irrigation only 6 months.	Prioritise de-siltation and micro-irrigation here; recover fallow land through assured irrigation.
Farmers (Sonesarar, Tumdibod)	Irrigation 10 months but PMKSY non-access 100%; climate stress rising.	Close the last-mile convergence gap on PMKSY-PDMC micro-irrigation and solar pumping.
Water User Associations / PRIs	PRI water-quality cadre exists but irrigation governance is weak.	Deploy CWSM governance and community Water Security Plans (ABY template).
Women (Jal Sakhi cadre)	Water management is women-involved but under-supported.	Deploy 4,500 Bhujal Mitra/Jal Sakhi with JalConnect digital tools and grazing/water-card authority.
Community (maintenance trust)	‘No trust on subsidy’; maintenance failures erode confidence.	User-linked maintenance financing (30–50% active-user contribution in stressed blocks) and transparent JalConnect fund-flow.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Loss-avoidance value:** ₹3,800 Cr capital unlocks ~₹4,800 Cr/yr in loss-avoidance; the ₹8,100 Cr economic value is primarily defensive (prevented fallowing, crop failure and migration).
- **Convergence, not new spend:** the model fuses JJM, PMKSY, MGNREGS and NGGB rather than creating parallel schemes — the source frames value defensively rather than via a single IRR.

2. Social Benefits

- **Broad employment:** 145,000 jobs (58,000 direct + 87,000 indirect) with a women-inclusive Jal Sakhi cadre.
- **Migration prevention:** assured irrigation reduces distress migration from water-scarce villages.

3. Environmental & Climate Resilience

- **Groundwater sustainability:** ABY-style community groundwater governance and recharge address early-warning stress before it becomes chronic.

- **Storage restoration:** de-siltation of 16,000+ ponds lifts storage 25–30% and restores surface buffers.

4. Technical Feasibility

- **Proven delivery mechanisms:** JJM (drinking water), MGNREGS (asset creation) and NGGB (convergence) already work — the gap is fusing them into a single water economy.
- **Digital governance:** JalConnect integrates planning, quality data, de-siltation schedules and fund flow — the enabling platform.

7 Success Stories & Proven Models

CASE STUDY 3 · Chhattisgarh — Mor Gaon Mor Paani Mahabhiyan (flagship model, Transform Rural India)

Mor Gaon Mor Paani Mahabhiyan is a statewide community-led water conservation campaign that prepares village-level Integrated Natural Resource Management (INRM) plans and implements recharge structures — staggered contour trenches, loose boulder check dams, gabions, contour bunds and farm ponds — through convergence with MGNREGA and Gram Panchayats. It integrates technical watershed planning with community participation to retain rainwater within village landscapes, strengthen groundwater recharge and improve long-term water security.

The environmental gain is enhanced aquifer recharge and watershed resilience; the scale lever is the existing MGNREGA implementation architecture supported by village-level planning across thousands of Gram Panchayats; the economic return is improved irrigation potential, revived wells, higher agricultural productivity and reduced rural distress.

Relevance: *the exact landscape-based recharge model that LCAT villages are seeking — demonstrating how decentralised planning can deliver groundwater restoration at scale.*

India — Hiware Bazar / Ralegan Siddhi watershed governance (Maharashtra): Village-led watershed development paired with strict community rules — a ban on water-intensive crops, borewell regulation and Gram-Sabha control of the water budget — reversed acute water scarcity and raised incomes over two decades. The decisive factor was institutional: collective rules on extraction, not just structures. The read-across for CG directly answers the LCAT's root-cause diagnosis (the "fading of working together") — recharge structures endure only when backed by Gram-Sabha water budgeting and borewell regulation, validating the Jal Vahini and Water Security Plan governance layer.

Rajasthan — Atal Bhujal Yojana participatory groundwater management: ABY's community Water Security Plans, Bhujal Mitra cadre and performance-linked funding provide the only proven template for participatory groundwater governance, backed by World Bank co-finance. The read-across is direct: CG should pre-emptively opt into the ABY expanded cohort (40 water-stressed blocks, ₹1,200 Cr, 50% World Bank loan) to build community governance and performance-linked funding before decline becomes chronic.

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** pond siltation and maintenance failures; weak irrigation infrastructure.
- **Solution:** a rolling 3-year de-siltation of 16,000+ ponds (~₹800 Cr, +25–30% storage) and PMKSY-PDMC micro-irrigation/solar pumping.

Financial Barriers

- **Barrier:** maintenance-financing gap and ‘no trust on subsidy’.
- **Solution:** user-linked maintenance financing (30–50% active-user contribution in stressed blocks); ABY opt-in (₹1,200 Cr, 50% World Bank, 40 blocks).

Knowledge & Technical Skill Gaps

- **Barrier:** 100% PMKSY non-access; last-mile convergence gap.
- **Solution:** CWSM governance, 4,500 Bhujal Mitra/Jal Sakhi and the JalConnect platform for planning, quality and fund-flow transparency.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Water scarcity causes fallowing (835 acres in 3 villages) and ~50% income loss.	High	Recover fallow land via de-siltation and micro-irrigation; assured irrigation to 3.5 M ha.	
Production / Climate	Unanimous climate stress (delayed monsoons, extreme rainfall, drought); paddy is water-intensive.	High	Preventive groundwater governance (ABY), recharge and climate-resilient water planning.	
Operational / Supply Chain	Pond siltation and maintenance failures reduce storage and trust.	Med	Rolling 3-year de-siltation (+25–30% storage); JalConnect transparency and user-linked maintenance.	
Policy / Governance	100% PMKSY non-access; last-mile convergence and maintenance-credibility gap.	High	Establish CWSM governance fusing JJM/PMKSY/MGNREGS/NG GB; ABY opt-in and Bhujal Mitra cadre.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Baseline vs Target: From Water-Exposed to Water-Resilient

Indicator	Baseline	Target
Fallow Land, 3 FGD villages (acres)	835 (Now, water shortage)	0 (Recovered)
Irrigation Availability, Dhaneli Kanhal (months)	6 (Now)	10 (Target)
Pond Storage (index, now=100)	100 (Now)	128 (After de-siltation)

Outputs are primarily defensive — avoided fallowing, crop failure and migration. In three FGD villages, 835 acres lie fallow (Dhaneli Kanhal: 70% fallow, ~50% HH income loss). PMKSY non-access is 100% across all three despite acute need. De-siltation of 16,000+ ponds lifts storage 25–30%. Source: value-chain document.

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Establish CWSM governance fusing JJM, PMKSY, MGNREGS and NGGB into a village-level water economy; opt into Atal Bhujal Yojana (₹1,200 Cr, 40 blocks); launch a rolling 3-year de-siltation of 16,000+ ponds; deploy 4,500 Bhujal Mitra/Jal Sakhi and the JalConnect platform.

Private Sector & Investors

- Invest in micro-irrigation, solar pumping and water-quality-testing supply chains and services; provide digital-platform and maintenance solutions; co-finance via CSR.

Development Agencies & NGOs

- Mobilise Water User Associations and the Jal Sakhi cadre, build community Water Security Plans (ABY template) and user-linked maintenance financing, and strengthen last-mile scheme convergence.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Water Security Value Chain
Water Resources Department		Irrigation, watershed and surface-storage infrastructure; CWSM anchor.
Public Health Engineering (PHED) / JJM		Drinking-water consolidation (Har Ghar Jal) and water-quality monitoring.
Agriculture / Horticulture (PMKSY-PDMC)		Micro-irrigation, solar pumping and on-farm water efficiency.
Panchayat & Rural Development (NGGB/MGNREGS)		Pond de-siltation, recharge structures and Gram Sabha water governance.
Groundwater / Atal Bhujal Yojana cell		Community groundwater governance and Water Security Plans (40 blocks).
Women's SHGs / Bihaan (Jal Sakhi)		Bhujal Mitra/Jal Sakhi cadre and community mobilisation.
State IT / JalConnect		Digital platform for planning, quality data, de-siltation schedules and fund flow.
World Bank / NABARD / 15th FC		Multilateral and concessional finance and tied grants.

CAMPA / CSR partners

Watershed convergence and blended community co-investment.

[1]**Methodology.** Employment: 145,000 jobs by 2035 = 58,000 direct FTE (watershed, micro-irrigation, solar pumping, quality testing) + 87,000 indirect. Capital: ₹3,800 Cr by 2030–31 — grants 40% / state 20% / World Bank 15% / CSR 12% / NABARD 8% / community 5% — unlocking ~₹4,800 Cr/yr loss-avoidance. Value: ₹8,100 Cr economic value by 2035–36 (primarily defensive). Irrigation: 3.5 M ha assured by 2035. Assets: ~16,000 rural ponds; de-siltation lifts storage 25–30% (~₹800 Cr). Policy: JJM ₹67,000 Cr (Budget 2025–26, +195%); PMKSY-PDMC ₹23,232 Cr / 96.83 lakh ha; Atal Bhujal Yojana ₹6,000 Cr; ABY opt-in proposal ₹1,200 Cr / 40 blocks. FGD: 835 acres fallow across 3 villages (Dhaneli Kanhal 70% fallow, ~50% income loss); irrigation 10/10/6 months; PMKSY non-access 100%. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

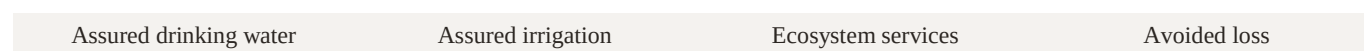
Input / Output Flow

Value Chain Flow · Water Security

INPUTS



OUTPUTS



Source: FGDs (Sonesarar, Tumdibod, Dhaneli Kanhal); Jashpur FGD; LCAT synthesis of 24 villages

B01 Bamboo-Based Products

BE · BIO-ECONOMY

The cultivation, primary processing, and industrial value-addition of bamboo into furniture, packaging, construction materials, infrastructure components, handicrafts, and emerging thermal-fuel ("white coal") applications.

Executive Dashboard

EXECUTIVE DASHBOARD — BAMBOO AT A GLANCE (Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 80,000–150,000 direct rural jobs over 2026–32 — Chhattisgarh capturing 1–2% of the National Bamboo Mission’s 8-million-job national target — across four layers: cultivation/harvesting, primary processing (treatment/seasoning/baling), product manufacturing (furniture/packaging/construction) at SHG/FPO/MSME tier, and high-value engineering (bridges/crash barriers/composites).

Market & Investment Opportunity. A cumulative public-investment opportunity of ₹500–1,000 Cr over 2026–32 via the NBM subsidy stack (50% of ₹1.0 lakh/ha for farmers; 100% for agencies/entrepreneurs; 60:40 Centre:State), plus private industrial scale-up in furniture (₹2,500 Cr 2023 export base), packaging, construction and the emerging ‘white-coal’ fuel substitute.

Resource & Industrial Base. 1.05 million ha under bamboo (16.78 MT standing stock, 4.2% of India, 6th nationally) across six districts, plus a globally-recognised proof-of-concept — Bhavya Srishti Udyog and the world’s tallest bamboo tower (140 ft, Bemetara), products validated by NATRAX, CBRI, Indian Railways and the Indian Road Congress.

Strategic Outcome. A paradox of plenty — abundant national resource and industrial leadership alongside village-level depletion (‘no bamboo left in forest’, Berchegondi). What is missing is a state policy framework that converts these advantages into a deployable value chain and answers both the depletion crisis and the Just Transition workforce question.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Bamboo-based Products · Chhattisgarh 2026–36

CULTIVATION BASE	DIRECT RURAL JOBS	INDUSTRY SCALE-UP	RESOURCE ALERT
1.05M ha	80,000–150,000	₹500–1,000 Cr	regeneration
16.78 MT standing stock · 6th nationally · 4.2% of India	at 1–2% of NBM’s 8M-job national target	cumulative public investment 2026–32 (NBM subsidy stack)	“No bamboo left in forest” (Berchegondi) — depletion at village level

2 Contextual Overview

National Context

- **Large, growing sector:** India’s bamboo & rattan industry is valued at ₹28,005 Cr with ~14.6 MT annual production and ~12 million workers; the National Bamboo Mission (restructured 2018) targets 4,000 product-development units, 100,000+ ha under plantation and 8 million additional rural jobs.

- **Value-mix problem:** of 136 Indian bamboo species only ~15 are commercially viable; reliance on manual methods leaves low-value products (agarbatti sticks) dominant and high-value global markets untapped.

Chhattisgarh Context

- **Structurally distinctive endowment:** 6th-largest cultivation area (1.05 M ha), a world-record industrial proof-of-concept (Bhavya Srishti Udyog), active JFM capacity (Berchegondi Van Samiti since 2006, 92 IFR titles) and explicit central attention (Gadkari's Sept 2024 call for a state bamboo policy and design centre).
- **The missing framework:** unlike Maharashtra (Atal Bamboo Samriddhi Yojana), Madhya Pradesh (SHG–MGNREGA convergence) and Assam (Bamboo Industrial Park), Chhattisgarh has no notified state bamboo policy — so NBM funds flow at suboptimal scale without state-level convergence.
- **Village-level depletion:** national rank-six co-exists with local scarcity — Berchegondi records over-harvest depletion, with community appetite for regeneration (50 women interested in nursery raising) but currently zero bamboo-specific enterprise interest.

3 Demand & Supply Assessment

Supply Analysis

- **Resource base:** 1.05 M ha, 16.78 MT standing stock, yield 1–3 t/ha, 3–5-year harvest cycles, concentrated in Raipur, Bilaspur, Rajnandgaon, Raigarh, Durg and Bastar — a geographic concentration that supports NBM's cluster hub-and-spoke model.
- **Processing spine:** cluster-level primary processing (treatment, seasoning, baling) close to source, feeding SHG/FPO/MSME product manufacturing and Bhavya Srishti-class high-value engineering.
- **Depletion caveat:** local forest stock is over-harvested in tribal-belt geographies — regeneration must pair cultivation with controlled-harvest protocols.

Demand Dynamics

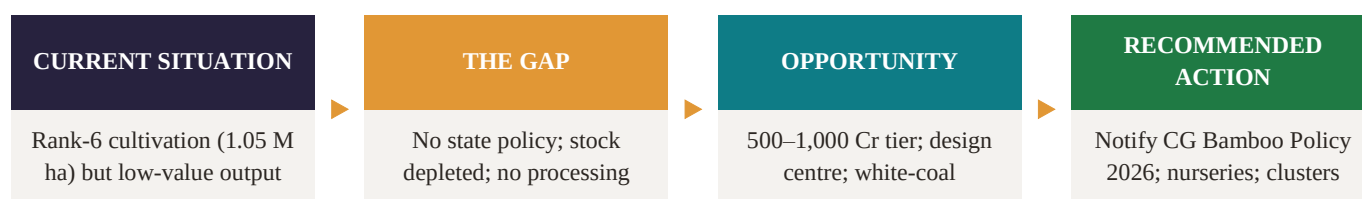
- **Diversified demand:** furniture (₹2,500 Cr 2023 exports; 15%+ of new furniture brands using bamboo), packaging (plastic substitution), construction and infrastructure (bridges, crash barriers, towers), plus an emerging white-coal thermal substitute.
- **High-value pull:** validated engineering demand (NATRAX/CBRI/Railways/IRC) signals a scalable high-margin tier if a design centre and vocational pipeline exist.

Supply–Demand Gaps

- **Policy gap:** no notified state bamboo policy or nodal department; the Gadkari mandate remains unresponded — the binding convergence gap.
- **Value-addition gap:** output concentrated in low-value agarbatti sticks; high-value engineering remains an isolated proof-of-concept without a design centre and supply-chain support for SHG/FPO units.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bamboo-Based Products



Source: Berchegondi FGD (Kanker); Jashpur FGD; LCAT synthesis; National Bamboo Mission

4 Market Ecosystem for the Value Chain

The bamboo value chain spans upstream nursery and plantation (superior species, 3–5-year harvest cycles); midstream primary treatment, seasoning, baling and aggregation via FPOs/SHGs in a cluster hub-and-spoke model; and downstream product manufacturing (furniture, packaging, construction) and high-value engineering (bridges, crash barriers, composites, towers) for domestic and export markets — with a design centre as the missing catalyst for the high-value tier.

Bamboo Value-Chain Architecture



Market Ecosystem for the Bamboo Value Chain

Inputs & Planting Material	Genetically-superior species · community nurseries (seed-balls) · treatment & seasoning equipment
Producers / Aggregators	Farmers · Van Samitis · SHGs / FPOs · Bhavya Srishti Udyog (engineering anchor)
Processing & Design	Cluster hub-and-spoke primary units · Bamboo Design Centre · seasoning / baling / composites
Off-takers & Markets	Furniture (₹2,500 Cr exports) · packaging · construction · Indian Railways / IRC exports · white coal
Enablers	National Bamboo Mission · CG Bamboo Policy 2026 (pending) · MGNREGA/JFM/FRA convergence · CSIDC · NID/NIFT/CBRI

5 Community & Stakeholder Insights

Data note. Bamboo bridges the state's rural-livelihood reality and its industrial-policy ambition. Field evidence draws on the Berchegondi Forest Management FGD (Kanker; 120 forest-

dependent households, active Van Samiti since 2006, 8 SHGs, 92 IFR titles) and a Horticulture Department IDI on cluster-based delivery, alongside the Bhavya Srishti industrial anchor.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Forest communities (Berchegondi FGD)	‘No bamboo left in forest due to excess harvest’; forest recovering post-Van-Samiti; 50 women keen on nursery raising but zero current bamboo-enterprise interest.	Launch a Bamboo Regeneration & Community Nursery Programme (NBM 100% subsidy to SHGs/FPOs) with Van Samiti-led plantation governance in depleted tribal-belt geographies.
Women’s SHGs & youth	50 women interested in nursery/seed-ball raising; 40 youth interested in forest-based enterprise — real absorptive capacity.	Channel NBM entrepreneur subsidy and vocational training to SHG/FPO nursery and primary-processing units; link youth to design-centre skilling.
Industrial anchor (Bhavya Srishti Udyog)	World-record engineering proof-of-concept validated by NATRAX/CBRI/Railways/IRC — but an isolated tier without a design centre.	Establish a Chhattisgarh Bamboo Design Centre (Gadkari recommendation), anchored on Bhavya Srishti and partnered with NID/NIFT/CBRI for design and certification.
FPOs / MSMEs / processors	Weak cluster-level primary processing and missing market linkages compress product-tier value.	Build cluster-based primary-processing units near source (NBM 100% subsidy + PMFME + CSIDC industrial-zone access) in the six districts.
State government (policy)	No notified bamboo policy or nodal department; NBM funds flow without state convergence.	Notify the Chhattisgarh Bamboo Policy 2026 with hub-and-spoke clusters, nodal-department designation and MGNREGA/JFM/FRA/CSR convergence.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Two investment tracks:** the NBM subsidy stack (₹500–1,000 Cr cumulative public investment 2026–32) plus private industrial scale-up in furniture, packaging, construction and white coal — de-risked by NBM’s 50–100% subsidy and central attention.
- **ROI note:** the source states no bamboo-specific project IRR; enterprise returns would be an analyst estimate — the economic case rests on the NBM subsidy stack and validated high-value engineering demand.

2. Social Benefits

- **Labour-intensive livelihoods:** 80,000–150,000 rural jobs across cultivation, processing, product and engineering tiers, with confirmed SHG/FPO absorptive capacity — well-suited to converting coal-transition workforce in Raigarh/Korba/Surguja.
- **Community regeneration:** women-led nurseries and Van Samiti governance embed benefit-sharing and resource stewardship.

3. Environmental & Climate Resilience

- **Carbon & substitution:** bamboo is a fast-regenerating carbon sink and a substitute for plastic (packaging), steel/concrete (construction) and coal (white-coal thermal fuel).
- **Sustainability guardrail:** the Berchegondi depletion warning makes controlled-harvest protocols and regeneration non-negotiable to avoid resource cannibalisation.

4. Technical Feasibility

- **Proven high-value capability:** Bhavya Srishti's validated engineering (bridges, towers, crash barriers) shows the high-value tier is technically achievable in-state.
- **Binding enabler:** a design centre, vocational pipeline and cluster primary-processing are the decisive prerequisites to scale beyond agarbatti-tier output.

7 Success Stories & Proven Models

CASE STUDY 1 · Bhavya Srishti Udyog & the World's Tallest Bamboo Tower (Bemetara)

Bhavya Srishti Udyog built the world's tallest bamboo tower (140 ft, 7,400 kg, ₹11 lakh) at Kathia, Bemetara — inaugurated by Union Minister Nitin Gadkari on World Bamboo Day 2024 and entered in the Golden Book of World Records; the firm's products are validated by NATRAX, CBRI, Indian Railways and the Indian Road Congress.

Relevance: *an in-state proof that high-value bamboo engineering is achievable — the anchor for a Bamboo Design Centre and the high-margin tier that lifts the state above agarbatti-dominated output.*

CASE STUDY 2 · Vani-Warora Bamboo Crash Barrier & Peer-State Policy Templates

Maharashtra's Vani-Warora highway 200-metre bamboo crash barrier is the national infrastructure precedent, while Maharashtra (Atal Bamboo Samridhi Yojana), Madhya Pradesh (SHG–MGNREGA convergence) and Assam (Bamboo Industrial Park) provide operational state-policy templates.

Relevance: *directly transferable models for the Chhattisgarh Bamboo Policy 2026 — infrastructure demand (crash barriers), SHG–MGNREGA plantation convergence and an industrial-park anchor.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** weak cluster-level primary processing and no design centre; local resource depletion in tribal-belt forests.
- **Solution:** build cluster primary-processing units near source (NBM 100% subsidy + CSIDC) and a Bamboo Design Centre; run a community-nursery regeneration programme.

Financial Barriers

- **Barrier:** NBM funds flow without state convergence; SHG/FPO units lack supply-chain and working-capital support.
- **Solution:** notify the state bamboo policy to converge NBM with MGNREGA/JFM/FRA/CSR; channel PMFME credit-linked subsidy and FPO equity to SHG/FPO units.

Knowledge & Technical Skill Gaps

- **Barrier:** reliance on manual methods and low-value products; no vocational/design pipeline for high-value engineering.
- **Solution:** partner NID/NIFT/CBRI for design and certification; build a vocational training pipeline anchored on Bhavya Srishti-class engineering.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Output concentrated in low-value agarbatti sticks; high-value engineering an isolated proof-of-concept.	Med	Establish a design centre and vocational pipeline; sequence infrastructure demand (crash barriers, construction) and exports.	
Production / Climate	Village-level over-harvest depletion ('no bamboo left in forest') risks cannibalising the resource base.	High	Pair cultivation with controlled-harvest protocols and community nurseries under Van Samiti governance.	
Operational / Supply Chain	Weak cluster primary processing and missing market linkages for forest-dependent communities.	High	Build cluster hub-and-spoke primary units near source; strengthen FPO/SHG aggregation and CSIDC access.	
Policy Governance	No notified state bamboo policy or nodal department; Gadkari mandate unresponded.	High	Notify the Chhattisgarh Bamboo Policy 2026 with nodal designation and MGNREGA/JFM/FRA/CSR convergence.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Bamboo Value-Addition Ladder & Employment Layers

Cultivation & Harvesting	Primary + Product Mfg	High-value Engineering
6 districts; 3–5-yr harvest cycle NBM 50% ₹1 lakh/ha <i>cultivation / harvest jobs</i>	Treatment/seasoning + furniture/packaging SHG / FPO / MSME tier <i>bulk of 80K–150K jobs</i>	Bridges / crash barriers / composites Bhavya Srishti-class <i>export-worthy, high-margin</i>

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify the Chhattisgarh Bamboo Policy 2026 (hub-and-spoke clusters, nodal department, MGNREGA/JFM/FRA/CSR convergence); establish a Bamboo Design Centre; launch a community-nursery regeneration programme; build cluster primary-processing units; sequence bamboo into Just Transition workforce design for coal districts.

Private Sector & Investors

- Scale industrial tiers — furniture, packaging, construction, crash barriers, composites and white coal — anchored on Bhavya Srishti-class engineering; provide technology, design and export offtake; access NBM 100% entrepreneur subsidy and CSIDC zones.

Development Agencies & NGOs

- Mobilise Van Samitis, SHGs and FPOs for nurseries and primary processing; build design/vocational capacity (NID/NIFT/CBRI); facilitate FRA/JFM plantation governance and MGNREGA convergence.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Bamboo Value Chain
National (Central)	Bamboo Mission	Cluster hub-and-spoke framework; subsidy stack (50% ₹1 lakh/ha farmers; 100% agencies/entrepreneurs; 60:40 funding).
State Nodal	Department (to be designated)	Chhattisgarh Bamboo Policy 2026; state convergence and nodal coordination.
Forest Department	/ JFM (Van Samitis)	Plantation governance, controlled-harvest protocols, regeneration, FRA/IFR facilitation.
Horticulture Department	/ Agriculture	Cluster-based subsidy delivery; FPO/FIG aggregation; nursery and planting-material supply.
Industries Department	/ CSIDC	Industrial-zone access, cluster primary-processing units, PMFME credit-linked subsidy.
Bamboo (proposed) + NID/NIFT/CBRI	Design Centre	Export-worthy design, product development, certification and vocational skilling.

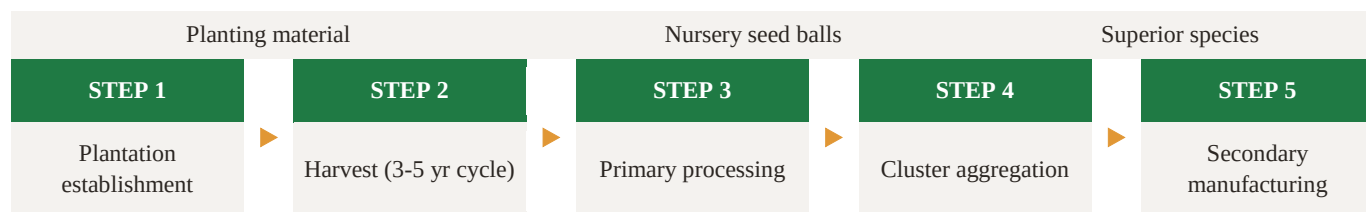
Rural Development / MGNREGA	SHG plantation convergence (MP template) and rural-livelihood employment.
Bhavya Srishti Udyog (industrial anchor)	High-value engineering proof-of-concept and design-centre anchor.
NABARD / CSR partners	Enterprise finance, FPO support and PPP/CSR mobilisation.

[1]**Methodology.** Employment: 80,000–150,000 direct rural jobs = 1–2% of NBM’s 8-million-job national target, across cultivation, primary processing, product manufacturing and high-value engineering layers. Investment: ₹500–1,000 Cr cumulative public investment 2026–32 via the NBM subsidy stack (50% of ₹1.0 lakh/ha farmers; 100% agencies/entrepreneurs; 60:40 Centre:State). Resource: 1.05 M ha, 16.78 MT standing stock (4.2% of India), yield 1–3 t/ha, 3–5-yr harvest cycles. National: ₹28,005 Cr industry, ~14.6 MT production, ~12 million workers, ₹2,500 Cr 2023 furniture exports. No bamboo-specific project IRR is stated in the source. All figures originate in the source diagnostic and its endnotes (NBM, PIB, IBEF, Ken Research, Berchegondi FGD). Fast-moving inputs should be re-verified before external citation.

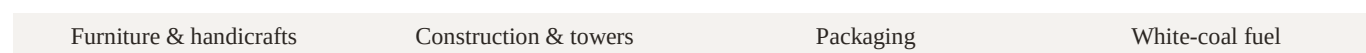
Input / Output Flow

Value Chain Flow • Bamboo-Based Products

INPUTS



OUTPUTS



Source: Berchegondi FGD (Kanker); Jashpur FGD; LCAT synthesis; National Bamboo Mission

B02 Bio-Fibre (Biomass-Based Fibre Manufacturing)

BE • BIO-ECONOMY

The conversion of agricultural residues, plant pseudostems, oilseed straw, bamboo, and natural plant fibres into textile-grade, technical-grade, and composite fibres.

Executive Dashboard

EXECUTIVE DASHBOARD — BIO-FIBRE AT A GLANCE (Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 25,000–50,000 direct rural jobs over 2026–32 from 100–200 cluster decorticator units (5–10 FTE/unit), 20–40 MSME spinning/weaving units (30–60 FTE/unit) and 5–8 industrial composite mills — among the most labour-intensive GETM value chains, with women’s workforce participation typically exceeding 80–90% at cluster tier.

Market & Investment Opportunity. A ₹500–1,200 Cr opportunity envelope (0.5–1% addressable share) across three tracks: cluster decorticator/extraction (₹3–25 lakh/unit), MSME spinning/weaving/composites (₹50 lakh–5 Cr/unit) and industrial-tier composite manufacturing (₹25–150 Cr/unit) for automotive and construction grades.

Market Context. India’s natural-fibre market is USD 5.05 bn (2024), projected to USD 7.28 bn by 2030 (6.3% CAGR); bamboo fibre grows from USD 123 M (2024) to USD 189 M by 2032, and natural-fibre insulation from USD 315 M to USD 636 M by 2034 — with India holding ~22% of the global textile-fibre segment.

Strategic Outcome — a multi-source feedstock hub. Chhattisgarh’s structural advantage is a multi-source feedstock base — 10.9 MMT paddy straw, 1.05 M ha bamboo, emerging niger oilseed (Sogda Jashpur, 14 acres) and pulse/millet residues — anchored in the same forest-, tribal- and agri-belts where rural employment is most needed. The thesis is to convert unmonetised biomass into export-grade fibre using shared FPO-SHG cluster infrastructure with Bio-Feed, Bamboo, RE Manufacturing and Biochar.

Methodology & assumptions.[1] All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.

Executive Dashboard · Bio-Fibre (Biomass-based Fibre Manufacturing) · Chhattisgarh 2026–36

DIRECT RURAL JOBS	INVESTMENT ENVELOPE	NATIONAL MARKET	FEEDSTOCK BASE
25,000–50,000	₹500–1,200 Cr	USD 5.05B → 7.28B	multi-source
cultivation, extraction, spinning, composites (80–90% women)	0.5–1% addressable share of national market	natural fibre by 2030 (6.3% CAGR)	10.9 MMT straw · 1.05M ha bamboo · niger · pulses

2 Contextual Overview

National Context

- **Top-three producer, growing market:** India is among the world’s top three natural-fibre producers; the market grows to USD 7.28 bn by 2030, with high-growth niches in bamboo fibre and natural-fibre insulation and composites.

- **Concentrated capability:** large players (Aditya Birla/Liva, Grasim) capture most farm-gate-to-textile margin — new cluster entrants need niche positioning or FPO-aggregated export channels.

Chhattisgarh Context

- **Multi-source feedstock endowment:** paddy straw, bamboo, niger and pulse/millet residues across three surveyed districts (Rajnandgaon, Kanker, Jashpur), plus a recognised industrial anchor (Bhavya Srishti Udyog, Bemetara).
- **Under-developed processing:** no notified bio-fibre policy and minimal village-tier extraction — raw feedstock flows as low-value waste rather than high-value fibre.
- **First niger evidence:** the Sogda Jashpur FGD records niger (Jatangi) at 5% of village area (14 acres) — the first FGD evidence of an oilseed crop with dual fibre and oil-cake value-chain potential.

3 Demand & Supply Assessment

Supply Analysis

- **Multi-source feedstock:** 10.9 MMT paddy straw, 1.05 M ha bamboo, niger straw and pulse/millet residues, aggregable through FPO-SHG clusters shared with Bio-Feed, Bamboo and Biochar.
- **Extraction spine:** 100–200 cluster decorticator units (banana pseudostem, niger straw, paddy-straw softening, bamboo splitter) feeding 20–40 MSME spinning/composite units.
- **Skills deficit:** India's bamboo-fibre industry estimates a ~5,000-technician deficit in modern extraction — without demonstration units and skilling, feedstock stays low-value.

Demand Dynamics

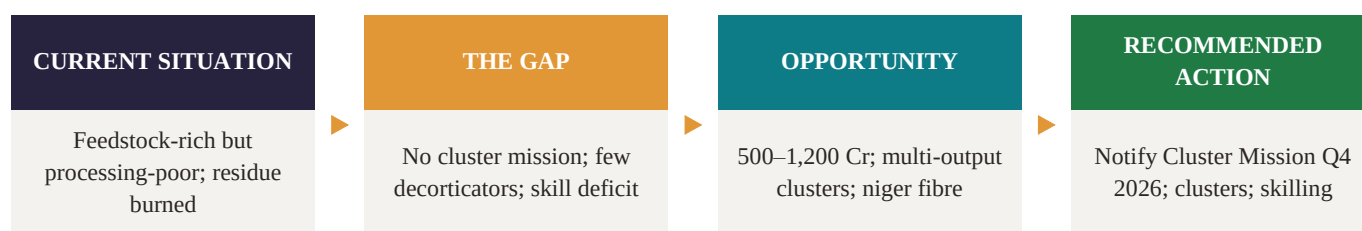
- **Diversified offtake:** apparel brands, automotive composites, construction insulation and bamboo-fibre viscose — with sustainability-driven demand for agri-waste fibres.
- **Niche or export routing:** cluster entrants capture value via niche products (banana-fibre handicrafts, niger-straw insulation, bamboo composites) or FPO-aggregated export channels.

Supply–Demand Gaps

- **Conversion technology gap:** specialised decorticators, enzymatic retting and processing units are concentrated in a few states — a demonstration and skilling gap in CG.
- **Quality & certification gap:** variable cluster-level fibre quality limits offtake to local handicraft markets absent fibre-quality labs and a state certification framework.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Fibre Manufacturing



Source: Agriculture FGDs (Sideswar, Sogda, Sonesarar, Sarudih); Forest FGDs (Barchegondi, Luikona); LCAT synthesis

4 Market Ecosystem for the Value Chain

Bio-fibre converts multi-source biomass (paddy straw, bamboo, niger, pulse residues) into textile-, technical- and composite-grade fibres: primary extraction (decortication, retting, drying, grading) at FPO-SHG clusters; spinning, geotextile and composite manufacturing at MSME tier; and industrial-grade composites for automotive and construction. Midstream FPO-SHG aggregation is shared across Bio-Feed, Bamboo, RE Manufacturing and Biochar, improving unit economics through multi-output cluster economies.

Bio-Fibre Value-Chain Architecture



Market Ecosystem for the Bio-Fibre Value Chain

Inputs & Feedstock	Paddy straw (10.9 MMT) · bamboo (1.05M ha) · niger (Sogda Jashpur) · pulse/millet residues
Producers / Aggregators	FPO-SHG clusters (130+ FPOs, 80–90% women) · Bhavya Srishti Udyog (bamboo anchor)
Processing & QC	100–200 cluster decorticators · 20–40 MSME spinning/composite units · fibre-quality testing labs
Off-takers & Markets	Apparel brands · automotive composites · construction insulation · bamboo-fibre viscose · export
Enablers	Bio-Fibre Cluster Mission (proposed) · National Fibre Policy · PMFME ODOP · KVIC · MSME · CSIDC

5 Community & Stakeholder Insights

Data note. Bio-fibre is community- and SHG-anchored. Field evidence draws on Agriculture FGDs (Sonesarar, Sideswar, Sogda, Sarudih) and Forest FGDs (Berchegoni, Luikona, Sogda) plus a Bio-Manufacturing IDI; women's SHG enterprise interest is explicitly confirmed across sites.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Crop farmers (3 districts)	Paddy straw and rice bran produced at every Agriculture FGD village; niger (Jatangi) at Sogda (14 acres) — feedstock un-monetised.	Aggregate multi-source feedstock via FPO-SHG clusters; monetise straw and niger residue as fibre inputs.
Women's SHGs	Explicit interest in compost, nursery, fodder-pellet and fibre/processing enterprise; 80–90% cluster workforce.	Channel PMFME/KVIC subsidies through FPO-SHG consortia for decorticator and spinning units (women-led).
FPOs (Sideswar)	Strongest institutional architecture in the corpus — active FPO with shareholder addition, 2 SHGs, active extension.	Anchor cluster decorticator units on high-readiness FPOs; use as demonstration/skilling hubs.
Bamboo enterprises (forest belt)	Bamboo enterprise interest across Berchegoni, Sogda, Luikona; industrial anchor at Bemetara.	Integrate bamboo splitter-decorticator units with the bamboo value chain and Bhavya Srishti-class engineering.
MSME processors / buyers	Variable fibre quality limits offtake; conversion-technology and skills gaps.	Build fibre-quality labs, a Bio-Fibre Certification framework and a skilling programme with demonstration units.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Three tracks, shared infrastructure:** a ₹500–1,200 Cr envelope across cluster extraction, MSME spinning/composites and industrial composites — with multi-output cluster economies (shared with Bio-Feed/Bamboo/Biochar) improving each unit's economics.
- **ROI note:** the source gives no single project IRR; ODOP precedents (Hariharpur ₹9 lakh annual revenue, 450 women beneficiaries) indicate viability — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Women-intensive employment:** 25,000–50,000 jobs with 80–90% women participation at cluster tier — among the most jobs-intensive GETM value chains.
- **Tribal-belt fit:** feedstock and enterprise interest concentrate in tribal/forest-belt districts where employment is most needed.

3. Environmental & Climate Resilience

- **Biomass valorisation:** converts un-monetised straw, bamboo and oilseed residue into durable fibre and composites, displacing synthetic materials.
- **Insulation & composites:** natural-fibre insulation and composites substitute higher-carbon materials in construction and automotive.

4. Technical Feasibility

- **Technology & skills gap:** decortication, retting and composite processing require specialised equipment and ~5,000 trained technicians nationally — the binding technical constraint.
- **Demonstration-led:** demonstration units and skilling centres are the decisive enablers to move feedstock from waste to high-value fibre.

7 Success Stories & Proven Models

CASE STUDY 1 · ODOP Fibre Clusters — Mangalam Kalpatharu & Hariharpur

Mangalam Kalpatharu Enterprise (Burhanpur, MP) processes 300–400 banana pseudostems daily into 30–40 kg fibre with 9 employees, while Malawa Kela Resa Kendra (Hariharpur, UP) generates ₹9 lakh annual revenue benefiting 450 women under ODOP — proven cluster-tier fibre-extraction models.

Relevance: *directly transferable templates for CG's 100–200 cluster decorticator units routed through FPO-SHG consortia under PMFME ODOP.*

CASE STUDY 2 · Multi-Source Feedstock Across Three Districts

Sonesarar (250 acres paddy), Sideswar (213 ha paddy/pulses/millet) and Sogda Jashpur (niger at 14 acres, 'biomass sufficient for fibre extraction: Yes') validate a multi-source feedstock base across three districts, anchored by CG's 1.05 M ha of bamboo.

Relevance: *proof of a diversified, de-risked feedstock platform that shares midstream aggregation with Bio-Feed, Bamboo, RE Manufacturing and Biochar.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** minimal village-tier extraction; specialised decortication/retting concentrated in a few states.
- **Solution:** deploy 100–200 cluster decorticators and 20–40 MSME spinning/composite units with demonstration hubs; shared cluster infrastructure with adjacent value chains.

Financial Barriers

- **Barrier:** cluster capex and working-capital gaps; margin capture by vertically-integrated national players.

- **Solution:** route PMFME/KVIC subsidies through FPO-SHG consortia; niche/export positioning for value capture.

Knowledge & Technical Skill Gaps

- **Barrier:** ~5,000-technician national deficit in modern fibre extraction; quality standardisation gap.
- **Solution:** a skilling programme and fibre-quality labs with a Bio-Fibre Certification framework.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Vertically-integrated players (Aditya Birla, Grasim) capture farm-gate-to-textile margin.	Med	Niche positioning (banana fibre, niger insulation, bamboo composites) or FPO-aggregated export channels.	
Production / Climate	Feedstock seasonality; multi-source aggregation complexity.	Med	Multi-source feedstock platform and shared cluster aggregation smooth supply.	
Operational / Supply Chain	Conversion-technology and skills gaps keep feedstock as low-value waste.	High	Demonstration units, ~5,000-technician skilling, and cluster decorticators via FPO-SHG consortia.	
Policy / Governance	No notified bio-fibre policy; no fibre-quality labs or certification.	High	Notify a Bio-Fibre Cluster Mission (nodal: Textiles & Handlooms) with labs and a certification framework.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks (Cluster → Industrial)

Cluster Extraction	MSME Spinning / Composites	Industrial Composites
Decorticators; SHG/FPO tier ₹3–25 lakh/unit 5–10 FTE/unit	Spinning · geotextile · composites ₹50L–5 Cr/unit 30–60 FTE/unit	Automotive/construction grade ₹25–150 Cr/unit high-value integrated

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Bio-Fibre Cluster Mission (Q4 2026) under National Fibre Policy + PMFME ODOP, nodal Textiles & Handlooms, aligned to MSME/KVIC/CSIDC; build fibre-quality labs and certification; route subsidies through FPO-SHG consortia; build shared cluster infrastructure with Bamboo, Bio-Feed and RE Manufacturing.

Private Sector & Investors

- Invest in MSME spinning/composite and industrial composite mills; provide extraction technology, quality systems and offtake (apparel, automotive, construction, viscose); partner via CanvaLoop-style agri-residue sourcing.

Development Agencies & NGOs

- Mobilise women-led FPO-SHG cluster enterprises, build extraction/spinning skills and demonstration units, and facilitate niche/export market linkage.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Bio-Fibre Value Chain
Textiles & Handlooms Department (nodal)		Bio-Fibre Cluster Mission; cluster hub-and-spoke architecture; certification framework.
MSME / PMFME / ODOP		Cluster decorticator and MSME spinning subsidies; ODOP cluster templates.
KVIC		Village-tier fibre-extraction and artisan cluster support.
Industries / CSIDC		Industrial-tier composite manufacturing zones and support.
Agriculture / Forest Departments		Feedstock supply (straw, niger, bamboo) and FPO/Forest cluster mobilisation.
FPOs / SHGs (130+ FPOs, 80–90% women)		Feedstock aggregation, extraction and spinning enterprise.
Fibre-quality labs / BIS liaison		Quality standardisation, testing and Bio-Fibre Certification.
Skilling institutions		~5,000-technician extraction skilling and demonstration units.
NABARD / Financial Institutions		Cluster capex, working capital and credit guarantee.

[1]**Methodology.** Employment: 25,000–50,000 direct rural jobs from 100–200 cluster decorticators (5–10 FTE/unit) + 20–40 MSME spinning/weaving units (30–60 FTE/unit) + 5–8 industrial composite mills over 2026–32; 80–90% women at cluster tier. Investment: ₹500–1,200 Cr envelope (0.5–1% national share) — extraction ₹3–25 lakh; MSME ₹50L–5 Cr; industrial ₹25–150 Cr. Market: natural fibre USD 5.05 bn (2024) → 7.28 bn (2030, 6.3% CAGR); bamboo fibre USD 123 M → 189 M (2032); insulation USD 315 M → 636 M (2034). Feedstock: 10.9 MMT paddy straw + 1.05 M ha bamboo + niger (Sogda 14 acres) + pulse/millet residues. Skills deficit ~5,000 technicians nationally. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow • Bio-Fibre

INPUTS



OUTPUTS

Textile yarn	Geotextiles & insulation	Auto composites	Packaging composites
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Source: Agriculture FGDs (Sideswar, Sogda, Sonesar, Sarudih); Forest FGDs (Berchegondi, Luikona); LCAT synthesis

B03 Bio-Textiles (Natural-Fibre Yarns, Fabrics, Apparel and Home Textiles)

BE • BIO-ECONOMY

The spinning, weaving, knitting, dyeing and finishing of natural and bio-based fibres — organic cotton, tasar (Kosa) silk, hemp, banana, bamboo, pineapple, jute, niger and pulse-residue fibre — into finished yarns, fabrics, apparel and home textiles.

Executive Dashboard

EXECUTIVE DASHBOARD — BIO-TEXTILES AT A GLANCE (Chhattisgarh • GETM 2026–2036)

Direct FTE Employment. 30,000–60,000 direct jobs over 2026–32 across reeling, spinning, weaving, dyeing, apparel manufacturing, design and branding — among the most jobs-intensive value chains in the portfolio, with 60–70% women, applying reeling/spinning (6–12 FTE/unit), power-loom/dyeing (15–40 FTE/unit) and apparel (50–200 FTE/unit) coefficients.

Market & Investment Opportunity. A ₹2,000–5,000 Cr opportunity envelope over GETM 2026–32 across three tracks: village reeling/spinning/handloom clusters (₹5–30 lakh/cluster), MSME power-loom/dyeing/finishing (₹50 lakh–10 Cr/unit) and integrated apparel manufacturing + D2C branding (₹5–50 Cr/unit) — with 50–100 spinning/weaving MSME clusters at scale.

Revenue & Value Capture. The decisive economics are value-addition: raw fibre sells at ₹50–200/kg while finished bio-textile apparel commands ₹500–2,000/kg — a 5–10× multiplier currently captured outside Chhattisgarh. The thesis is to capture that value in-state via integrated spinning + weaving + dyeing + apparel + branding.

Strategic Outcome — heritage-rich, value-poor. CG produces globally renowned Kosa (tasar) silk and hosts tribal handloom clusters (Champa, Janjgir, Raigarh, Bastar) but exports raw silk and fibre out-of-state for finishing, capturing only 10–20% of final value. India's

natural-fibre market (USD 60.42 bn, 2024) grows to USD 108.57 bn by 2032 (7.6% CAGR), and India targets a USD 350 bn textiles-and-apparel industry by 2030 — with eco-fibre the fastest-growing sub-segment (9.2% CAGR, APAC).

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Bio-Textiles · Chhattisgarh 2026–36 (Kosa Silk · Cotton · Bamboo · Banana · Hemp)

DIRECT JOBS	INVESTMENT ENVELOPE	VALUE-ADDITION	NATIONAL MARKET
30,000–60,000	₹2,000–5,000 Cr	5–10×	USD 60.4B → 108.6B
spinning, weaving, dyeing, apparel, branding (60–70% women)	GETM 2026–32 opportunity envelope	raw fibre ₹50–200/kg → apparel ₹500–2,000/kg	natural fibres by 2032 (7.6% CAGR)

2 Contextual Overview

National Context

- **Large market, sustainability pull:** India's natural-fibre market reaches USD 108.57 bn by 2032; Project SU.RE secured commitments from 30 fashion companies to source sustainably, and agri-waste fibre innovators (Canvaloop) supply global brands including Levi's.
- **Policy scaffolding:** Silk Samagra-2, NHDP, PM MITRA, PLI, ATUFS, SFURTI, PMFME and the GI framework provide central support across sericulture, handloom and apparel.

Chhattisgarh Context

- **Distinctive heritage assets:** Kosa tasar silk (Champa, Janjgir-Champa, Raigarh, Korba, Bastar) with GI potential, plus tribal handloom clusters — a premium-positioning anchor unmatched by most states.
- **Value-addition leakage:** raw Kosa silk and fibre are sent to Bhagalpur, Varanasi and Surat for finishing, so CG captures only 10–20% of final textile value.
- **Feedstock & offtake ready:** agri-residue fibre (niger at Sogda; paddy/pulse residue) plus Canvaloop already sourcing 40% of its raw material from CG/MP/HP/S-Gujarat farmer clusters provides a direct in-state offtake pathway.

3 Demand & Supply Assessment

Supply Analysis

- **Fibre & silk base:** Kosa tasar sericulture (Sal/Arjun/Saja host trees), tribal handloom capacity, and upstream bio-fibre (paddy-straw, niger, pulse fibre) from the Bio-Fibre value chain.

- **Processing gap:** absent in-state spinning + weaving + dyeing + apparel infrastructure at MSME scale; fragmented, ageing, informal artisan base.
- **SHG-FPO readiness:** Luikona women interested in a branding-and-packaging unit (YES), Sogda 20 SHGs (highest density) and Berchegondi 50 women interested in enterprise confirm absorptive capacity for finishing enterprise.

Demand Dynamics

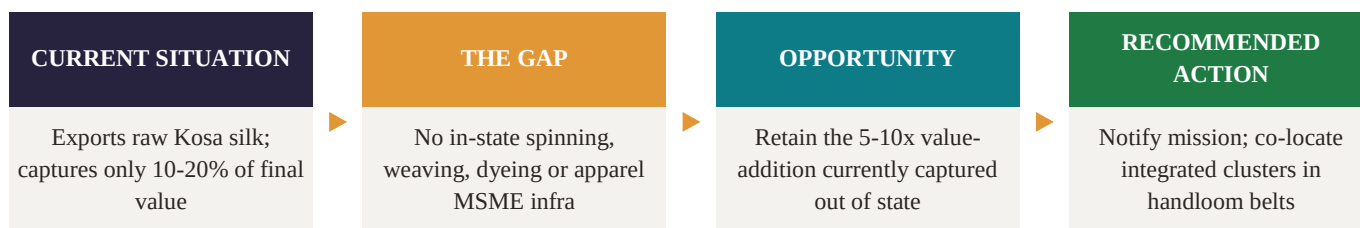
- **Premium sustainable segment:** eco-fibre is the fastest-growing sub-segment; GI-tagged Kosa silk and natural-fibre apparel can occupy premium rather than commodity positioning.
- **Anchored offtake:** Canvaloop (₹3.2 Cr FY22-23 → ₹7–8 Cr FY23-24, ₹18 Cr purchase order FY24-25, Levi's offtake) demonstrates the agri-residue-to-apparel pathway and a CG-anchored partnership.

Supply–Demand Gaps

- **Value leaks out-of-state:** without integrated in-state finishing, the 5–10× value-addition continues to accrue in Bhagalpur/Varanasi/Surat.
- **Brand & design gap:** weak consumer brand identity versus GI competitors (Banarasi, Kanjeevaram, Chanderi, Maheshwari); limited design and e-commerce integration.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Textiles

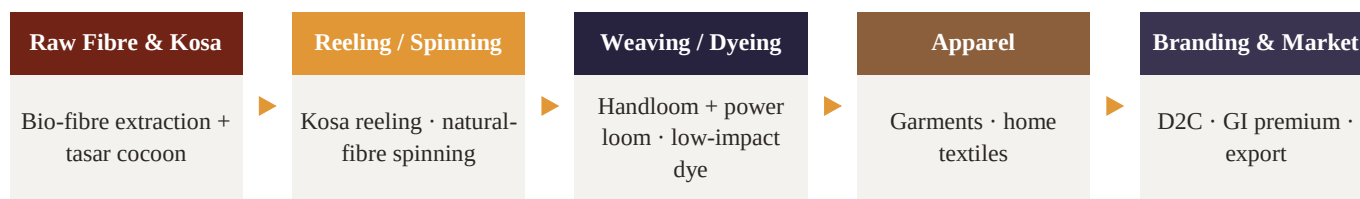


Source: Canvaloop, Chhattisgarh Kosa silk heritage, Project SU.RE, Canaveda

4 Market Ecosystem for the Value Chain

Bio-textiles converts upstream raw fibre (paddy-straw, niger, pulse fibre) and Kosa tasar cocoon into branded finished consumer textiles: village reeling/spinning/handloom clusters; MSME power-loom, dyeing and finishing; and integrated apparel manufacturing with D2C branding — co-locating reeling + spinning + weaving + dyeing + apparel within CG handloom belts to capture the 5–10× value-addition that currently leaks out-of-state.

Bio-Textiles Value-Chain Architecture



Market Ecosystem for the Bio-Textiles Value Chain

Inputs & Fibre	Kosa tasar cocoon · agri-residue / niger fibre · cotton / bamboo / banana / hemp · natural dyes
Producers / Artisans	Tribal tasar reelers · handloom clusters (Champa, Janjgir, Raigarh, Bastar) · SHG-FPO (60–70% women)
Processing & Design	Spinning / weaving / dyeing MSME · apparel manufacturing · NIFT Raipur / Central Silk Board skilling
Off-takers & Markets	D2C brands · Canvaloop / Levi's offtake · GI premium (Champa Kosa) · sustainable-textile export
Enablers	Bio-Textiles Mission (proposed) · Silk Samagra-2 · NHDP · PM MITRA · PLI · ATUFS · SFURTI · GI framework

5 Community & Stakeholder Insights

Data note. *Bio-textiles is heritage- and community-anchored. Field evidence draws on Agriculture FGDs (Sonesarar, Sideswar, Sogda, Sarudih), Forest FGDs (Berchegondi, Sogda, Luikona) and a Bio-Manufacturing IDI, with explicit women's branding/processing enterprise interest.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Kosa silk reelers / sericulture	Tribal reelers export raw silk out-of-state for finishing; ageing, informal, fragmented base.	Modernise reeling (Silk Samagra-2, Central Silk Board), co-locate finishing in-state, and pursue Champa Kosa GI tag.
Tribal handloom artisans	Champa/Janjgir/Raigarh/Bastar clusters capture only the lowest-value tier.	Integrate handloom with spinning/dyeing/apparel via NHDP/SFURTI; design and market linkage through NIFT Raipur.
Women's SHGs (Luikona, Sogda, Berchegondi)	Explicit interest in branding-and-packaging and processing enterprise; 60–70% women workforce.	Anchor finishing/branding enterprise on women's SHG-FPO clusters (PMFME/SFURTI); skilling and D2C support.
Agri-residue farmers / FPOs	Niger and paddy/pulse residue feedstock; Canvaloop sources 40% from regional farmer clusters.	Formalise agri-residue-to-fibre offtake (Canvaloop-style) and FPO aggregation into spinning.
MSME processors / brands	Absent in-state spinning/weaving/dyeing/apparel; weak brand identity.	Notify a Bio-Textiles Mission; build 50–100 MSME clusters

	(PM MITRA/PLI/ATUFS) and a GI-anchored D2C brand.
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6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Value-capture is the case:** capturing the 5–10× raw-to-apparel multiplier in-state (raw ₹50–200/kg → apparel ₹500–2,000/kg) within a ₹2,000–5,000 Cr envelope — the largest value envelope in the bio-manufacturing cluster.
- **ROI note:** the source gives no single project IRR; the Canvaloop growth trajectory and offtake indicate commercial viability — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Women-intensive heritage jobs:** 30,000–60,000 jobs (60–70% women) that revitalise Kosa silk and tribal handloom livelihoods rather than displacing them.
- **Cultural anchor:** GI-tagged Kosa silk provides premium positioning that sustains artisan incomes.

3. Environmental & Climate Resilience

- **Sustainable textiles:** natural and agri-waste fibres, vegetable/low-impact dyeing and zero-waste practices meet export-market sustainability requirements.
- **Circularity:** agri-residue-to-textile pathways divert waste into premium products.

4. Technical Feasibility

- **Modernisation need:** the artisan base needs modern reeling machines, design innovation and quality standardisation — a skilling and technology-upgradation task.
- **Design & branding:** NIFT Raipur, Central Silk Board and Weavers Service Centre partnerships plus D2C/e-commerce are the decisive value enablers.

7 Success Stories & Proven Models

CASE STUDY 1 · Canvaloop — Agri-Residue to Branded Apparel (CG-Anchored Offtake)

Canvaloop, a Surat-based agri-waste-to-textile-fibre pioneer, already sources 40% of its raw material from farmer clusters in CG, MP, HP and South Gujarat, and scaled from ₹3.2 Cr (FY22-23) to ₹7–8 Cr (FY23-24) with an ₹18 Cr purchase order (FY24-25) and Levi's offtake.

Relevance: a proven agri-residue-to-apparel pathway and a direct CG-anchored offtake partnership — the demand-side anchor for in-state finishing.

CASE STUDY 2 · Kosa Tasar Silk Heritage & Champa GI Potential

CG is a leading tasar (Kosa) silk producer with a globally recognised gold-sheened wild silk, tribal sericulture on Sal/Arjun/Saja hosts, and GI potential for Champa Kosa silk — yet raw silk is finished out-of-state, capturing only the lowest value tier.

Relevance: a distinctive premium anchor; GI-tag leverage plus in-state finishing and D2C branding can capture the 5–10× value-addition domestically.

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- Barrier: absent in-state spinning/weaving/dyeing/apparel at MSME scale; value-addition leaks to Bhagalpur/Varanasi/Surat.
- Solution: build 50–100 integrated MSME clusters (PM MITRA/PLI/ATUFS) co-locating reeling + spinning + weaving + dyeing + apparel in CG handloom belts.

Financial Barriers

- Barrier: cluster and apparel capex; fragmented artisan access to finance.
- Solution: route PMFME/SFURTI/NHDP and ATUFS support through FPO-SHG consortia; D2C brand and export offtake for value capture.

Knowledge & Technical Skill Gaps

- Barrier: ageing, informal artisan base with limited modern reeling, design and quality skills; weak branding.
- Solution: skilling with NIFT Raipur/Central Silk Board/Weavers Service Centre; GI-tag leverage and D2C brand development.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Mitigation Strategy
Market / Price	Value-addition leaks out-of-state (raw silk/fibre finished in Bhagalpur/Varanasi/Surat); weak brand identity.	High	Integrated in-state finishing; GI-tag leverage and D2C branding to capture the 5–10× multiplier.
Production / Climate	Fragmented, ageing artisan base with limited modern technology.	Med	Modern reeling/spinning technology and skilling (Silk Samagra-2, NIFT, Central Silk Board).
Operational / Supply Chain	Absent MSME spinning/weaving/dyeing/apparel infrastructure at scale.	High	Build 50–100 integrated MSME clusters (PM MITRA/PLI/ATUFS) co-locating the full chain.
Policy / Governance	No notified Bio-Textiles Mission integrating raw fibre to finished textile.	High	Notify a Bio-Textiles Mission (nodal: Textiles & Handlooms) with GI,

			branding and cluster architecture.
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Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Value-Addition Ladder (Raw Fibre → Branded Apparel)

Village Reeling / Spinning	MSME Power Loom & Dyeing	Apparel + D2C Branding
Kosa reeling + spinning + handloom ₹5–30 lakh/cluster 6–12 FTE, 60–70% women	Weaving + low-impact dyeing ₹50L–10 Cr/unit 15–40 FTE/unit	Garments + branding + export ₹5–50 Cr/unit 5–10× value in-CG

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Bio-Textiles Mission integrating raw fibre to finished textile; build 50–100 MSME clusters (PM MITRA/PLI/ATUFS); pursue Champa Kosa GI; skilling via NIFT Raipur/Central Silk Board; develop a state sustainable-textile D2C brand.

Private Sector & Investors

- Invest in MSME power-loom/dyeing and apparel manufacturing; partner on agri-residue offtake (Canvaloop-style) and D2C/export branding; provide design, technology and market linkage.

Development Agencies & NGOs

- Mobilise women-led SHG-FPO reeling/handloom/branding enterprise, build design and quality-standardisation capacity, and facilitate GI and premium-market linkage.

11 Key Departments & Institutional Alignment

Nodal Department / Institution	Primary Responsibility in the Bio-Textiles Value Chain
Textiles & Handlooms Department (nodal)	Bio-Textiles Mission; integrated raw-fibre-to-apparel cluster architecture; GI and branding.
Central Silk Board / Silk Samagra-2	Tasar (Kosa) sericulture development, reeling modernisation and skilling.
Handloom (NHDP / SFURTI / RMSS)	Tribal handloom cluster support, raw-material supply and weaver welfare.
Industries (PM MITRA / PLI / ATUFS)	MSME power-loom, dyeing, apparel manufacturing and technology upgradation.
NIFT Raipur / Weavers Service Centre	Design innovation, quality standardisation and market linkage.
PMFME / ODOP	Textile micro-enterprise support and district-product cluster development.

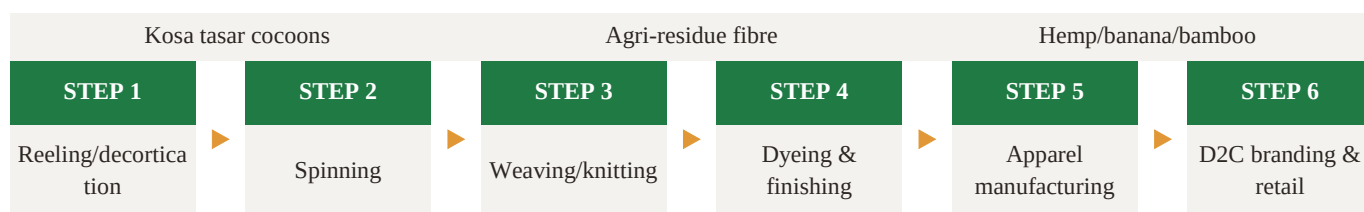
FPOs / SHGs (60–70% women)	Reeling/spinning/finishing/branding enterprise and agri-residue aggregation.
GI Registry	Champa Kosa silk GI registration and premium positioning.
NABARD / Financial Institutions	Cluster and apparel capex, working capital and credit guarantee.

[1]**Methodology.** Employment: 30,000–60,000 direct jobs (60–70% women) from village reeling/spinning clusters (6–12 FTE/unit) + 50–100 MSME power-loom/dyeing units (15–40 FTE/unit) + apparel manufacturing (50–200 FTE/unit) over 2026–32. Investment: ₹2,000–5,000 Cr envelope — clusters ₹5–30 lakh; MSME ₹50L–10 Cr; apparel ₹5–50 Cr. Value-addition: raw fibre ₹50–200/kg → apparel ₹500–2,000/kg (5–10×). Market: natural fibres USD 60.42 bn (2024) → 108.57 bn (2032, 7.6% CAGR); India textiles & apparel target USD 350 bn by 2030; eco-fibre 9.2% CAGR (APAC). Offtake: Canvaloop sources 40% from CG/MP/HP/S-Gujarat clusters; ₹3.2 Cr → ₹7–8 Cr revenue, ₹18 Cr purchase order, Levi’s offtake. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow • Bio-Textiles

INPUTS



OUTPUTS



Source: Canvaloop, Chhattisgarh Kosa silk heritage, Project SU.RE, Canaveda

B04 Bio-Based Feed (Bio-Economy)

BE • BIO-ECONOMY

Processed compound feed for livestock, poultry, and aquaculture — formulated from agricultural residues, oil cakes, pulse by-products, fish-meal alternatives, and emerging bio-protein sources — manufactured at cluster scale in rural Chhattisgarh.

Executive Dashboard

EXECUTIVE DASHBOARD — BIO-BASED FEED AT A GLANCE (Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 15,000–30,000 direct rural jobs over 2026–32 from a deployment of 200–400 cluster-level feed mills and 500–1,000 dealerships — rural mills employ 8–15 FTE/unit, dealerships 2–4 FTE plus 5–10 indirect — concentrated in feedstock aggregation, milling/packaging, distribution, extension advisory and feed-quality testing across the six major paddy-and-livestock districts.

Market & Investment Opportunity. A ₹500–1,500 Cr opportunity envelope (0.5–1% of India’s compound-feed market) across three tracks: cluster feed-mill capex (₹50 lakh–3 Cr mash / ₹5–15 Cr pellet), dealership working capital (₹5–25 lakh/outlet under NLM Entrepreneurship Development + PMFME), and alternative-protein scale-up (Black Soldier Fly, silkworm protein).

Market Context. India’s animal-feed market is ₹1.11 trillion (2024), projected to ₹2.02 trillion by 2033 (6.9% CAGR); compound feed grows from USD 27.23 bn to USD 36.6 bn by 2029 — while at village level feed cost is the #1 ranked livestock and fishery constraint.

Strategic Outcome — connect supply to demand. The same FGDs that flag feed cost as the binding constraint (₹2,000–4,000/HH/month; fish feed ₹50/kg) sit beside villages with abundant un-monetised paddy, pulse and millet residues (10.9 MMT surplus paddy straw). The intervention is not to create demand or build the agricultural base — it is to connect the two, converting feed-cost-as-constraint into feed-enterprise-as-livelihood.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Bio-based Feed · Chhattisgarh 2026–36

DIRECT RURAL JOBS	INVESTMENT ENVELOPE	NATIONAL MARKET	BINDING CONSTRAINT
15,000–30,000	₹500–1,500 Cr	₹1.11T → ₹2.02T	feed cost = #1
cluster feed mills, dealerships, ingredient aggregation	0.5–1% addressable share of national market	animal feed by 2033 (6.9% CAGR)	ranked constraint in livestock & fishery FGDs

2 Contextual Overview

National Context

- **Large, growing market:** India’s animal-feed market (₹1.11 trillion, 2024) grows to ₹2.02 trillion by 2033; compound feed reaches USD 36.6 bn by 2029, with poultry feed the largest share (44–56%).
- **Alternative-protein frontier:** circular alternatives — Black Soldier Fly (Elmentoz processes ~2,000 MT of industrial byproducts monthly) and silkworm-derived protein (Loopworm) — reduce dependence on maize and soybean meal.

Chhattisgarh Context

- **Uniquely clean supply–demand alignment:** the same geographies show feed cost as the #1 livestock/fishery constraint and abundant un-monetised residues — Bargaon (₹2,000–2,500/HH/month across 250 cow-and-goat households), Dashpur (fish feed ₹50/kg for 30 fisher households, ~100 Qtl/yr), alongside Sonesarar (250 acres paddy) and Sideswar (213 ha paddy/pulses/millet).
- **Institutional familiarity:** poultry feed is already a village livelihood (Tumdibod); feed-production-unit and dealership interest is explicitly confirmed — feed enterprise is culturally familiar, lowering adoption risk.
- **Missing middle:** cluster-level formulation, quality testing and certification do not yet exist — the intervention gap.

3 Demand & Supply Assessment

Supply Analysis

- **Feedstock base:** 10.9 MMT surplus paddy straw plus pulse/millet residues, rice bran/husk and oil cakes — currently un-monetised at village level, aggregable through FPO-SHG clusters.
- **Processing formats:** rural mash feed (SHG/FPO staple) scaling to pelletised feed at MSME tier, with alternative-protein (BSF, silkworm) as a circular substitute.
- **Quality gap:** no cluster-level feed-quality testing or certification — the compliance constraint under tightening FSSAI/BIS norms.

Demand Dynamics

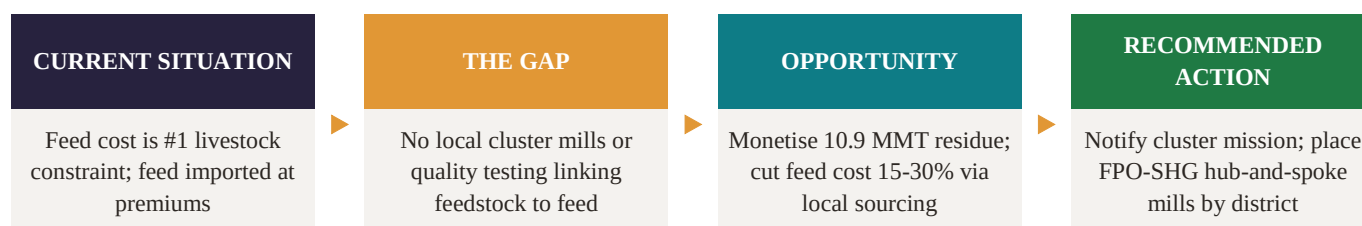
- **Acute, proven demand:** feed cost is the #1 ranked constraint in 2 of 3 livestock FGDs and the #1 cost component in fisheries FGDs (fish selling-price spread ₹120–260/kg depends on feed efficiency).
- **Targeted markets:** tribal and forest-belt districts where large-player distribution is shallow, served by FPO-aggregated direct-to-farmer sales.

Supply–Demand Gaps

- **Disconnection, not scarcity:** demand and feedstock coexist in adjacent villages but are unconnected — cluster hub-and-spoke aggregation is the missing link.
- **Compliance & distribution:** absent testing labs limit offtake to informal buyers; concentrated national players (Godrej Agrovit, Cargill, Suguna, Amrit, Venkateshwara) compress margins.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Bio-Based Feed

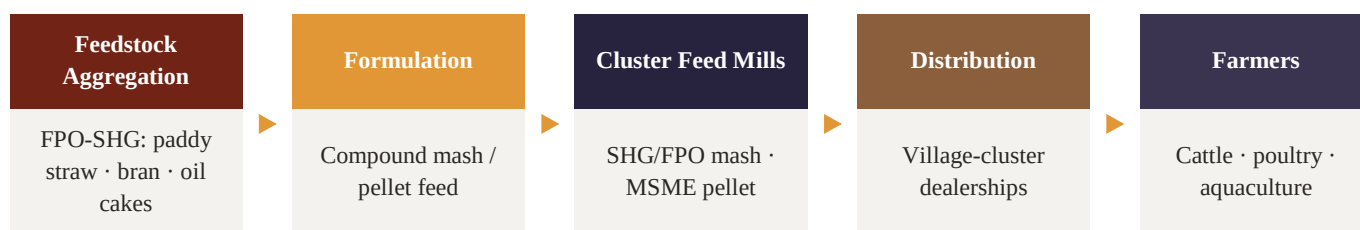


Source: Elmentoz (BSF), Tumdibod poultry-feed FGD, Indian Poultry Alliance-Kwality, Loopworm

4 Market Ecosystem for the Value Chain

Bio-based feed aggregates un-monetised agri-residues, oil cakes and pulse byproducts (FPO-SHG tier), formulates compound mash and pellet feed at cluster mills, and distributes through village-cluster dealerships to livestock, poultry and aquaculture farmers — with alternative-protein (BSF, silkworm) reducing reliance on maize/soybean. It is the most directly community-anchored value chain in the GETM portfolio, connecting feed-cost demand to residue supply in the same geographies.

Bio-based Feed Value-Chain Architecture



Market Ecosystem for the Bio-based Feed Value Chain

Inputs & Feedstock	Agri-residues (10.9 MMT paddy straw) · oil cakes · pulse byproducts · BSF / silkworm alt-protein
Producers / Aggregators	FPO-SHG feedstock aggregators · 130+ FPOs · SHG networks in every FGD village
Processing & QC	Cluster feed mills (₹50L–3 Cr mash · ₹5–15 Cr pellet) · feed-quality testing labs
Off-takers & Markets	Livestock / poultry / aquaculture farmers · village-cluster dealerships · FPO direct-to-farmer
Enablers	National Livestock Mission (Entrepreneurship Dev) · PMFME · PMMSY · FSSAI / BIS · KVK / ITI skilling

5 Community & Stakeholder Insights

Data note. Bio-based feed is deeply community-anchored. Field evidence draws on Livestock/Fishery FGDs (Bargaon-Mathaldabri, Tumdibod, Dashpur) and Agriculture FGDs (Sonesarar, Sideswar) plus a Bio-Manufacturing IDI.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Livestock rearers (Bargaon)	Feed cost ₹2,000–2,500/HH/month is the #1 income barrier across 250 cow-and-goat households; feed-production-unit interest YES.	Deploy cluster feed mills via FPO-SHG consortia (NLM + PMFME); lower feed cost through local residue-based formulation.
Inland fishers (Dashpur)	Fish feed ₹50/kg is the #1 cost component for 30 households (~100 Qtl/yr); selling price ₹120–260/kg hinges on feed efficiency.	Add an aquaculture-feed sub-cluster under PMMSY; FPO-aggregated fish-feed production to cut input cost.

Poultry-feed micro-entrepreneurs (Tumdibod)	Poultry feed already a village livelihood; feed-dealership interest YES.	Support dealership working capital (₹5–25 lakh) and skilling; formalise existing feed enterprise.
Crop farmers (Sonesarar, Sideswar)	Abundant paddy/pulse/millet residues currently un-monetised.	Enable FPO-SHG feedstock aggregation to monetise residues as feed ingredients.
Women's SHGs / FPOs	130+ FPOs and SHG networks provide institutional capacity but lack formulation and testing infrastructure.	Channel capex through FPO-SHG consortia; build feed-quality testing labs and a Bio-Feed Certification framework.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Three investment tracks:** cluster mills, dealerships and alternative-protein scale-up within a ₹500–1,500 Cr envelope — subsidies routed through FPO-SHG consortia address the working-capital gap FGDs document.
- **ROI note:** the source gives no single project IRR; viability rests on cost-saving substitution, NLM/PMFME subsidy and FPO-aggregated direct sales — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Livelihood conversion:** 15,000–30,000 rural jobs turning feed-cost-as-constraint into feed-enterprise-as-livelihood in the same villages that surfaced the problem.
- **Community familiarity:** existing poultry-feed livelihoods and documented skilling willingness lower adoption risk.

3. Environmental & Climate Resilience

- **Residue valorisation:** monetising 10.9 MMT surplus paddy straw diverts residue from burning into productive feed.
- **Circular protein:** BSF and silkworm protein cut dependence on land- and water-intensive maize/soybean meal.

4. Technical Feasibility

- **Field-ready milling:** mash/pellet milling is proven; the constraint is formulation expertise, quality testing and certification, not core technology.
- **Skilling enabler:** KVK/ITI feed-formulation skilling and last-mile Krishi/Kisan Mitra extension are the decisive enablers.

7 Success Stories & Proven Models

CASE STUDY 1 · Feed-Cost Constraint Meets Residue Supply — Bargaon & Sonesarar

Bargaon-Mathaldabri records feed cost of ₹2,000–2,500/HH/month as the binding barrier on livestock livelihoods for 250 households, while adjacent Sonesarar generates residue and bran feedstock from 250 acres of paddy — demand and supply coexisting in neighbouring villages.

Relevance: *the exemplar for cluster hub-and-spoke deployment — an FPO-SHG feed mill connecting residue supply to feed demand in the same geography.*

CASE STUDY 2 · Alternative-Protein Precedents — Elmentoz (BSF) & Loopworm

Elmentoz operates India’s largest BSF-oriented facility, processing ~2,000 MT of industrial byproducts monthly, and Loopworm (2024 launch) produces silkworm-derived protein — commercial precedents for circular alternative-protein feed.

Relevance: *the Track-3 template for MSME-tier alternative-protein scale-up that reduces maize/soybean dependence and raw-material price volatility.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no cluster-level formulation, quality-testing or certification infrastructure.
- **Solution:** cluster feed mills (hub-and-spoke) plus state feed-testing labs and a Chhattisgarh Bio-Feed Certification framework.

Financial Barriers

- **Barrier:** working-capital gap at mill and dealership tier; margin competition from concentrated national players.
- **Solution:** route NLM/PMFME capex through FPO-SHG consortia; target tribal/forest-belt markets with FPO-aggregated direct sales.

Knowledge & Technical Skill Gaps

- **Barrier:** absent feed-formulation and ingredient-quality skills at cluster level.
- **Solution:** a Chhattisgarh Bio-Feed Skills Programme via KVKs, agricultural universities and ITIs; leverage Krishi/Kisan Mitra extension.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Concentrated national players (Godrej Agrovet, Cargill, Suguna) compress rural distribution margins.	Med	Target shallow-distribution tribal/forest-belt markets; FPO-aggregated direct-to-farmer sales.	
Production / Climate	Maize/soybean price volatility (weather, pests, food competition) raises feed cost.	Med	Substitute agri-residues, oil cakes, BSF and pulse byproducts; invest in formulation and testing.	

Operational Supply Chain /	Feedstock and demand coexist but are unconnected; no cluster aggregation.	High	Cluster hub-and-spoke feed mills via FPO-SHG consortia connecting residue supply to feed demand.
Policy Governance /	Tightening FSSAI/BIS feed-safety norms without state labs limit offtake to informal buyers.	High	Notify a Bio-Feed Cluster Mission (nodal: Animal Husbandry & Dairying) with testing labs and certification.

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks (Cluster → Alt-protein)

Cluster Feed Mills	Feed Dealerships	Alt-protein Scale-up
Mash feed; SHG/FPO tier ₹50L–3 Cr/unit 8–15 FTE/unit	Last-mile distribution ₹5–25 lakh/outlet 2–4 FTE + 5–10 indirect	BSF / silkworm protein (MSME) ₹5–15 Cr/unit circular, high-value

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Bio-Feed Cluster Mission (Q4 2026) under NLM Entrepreneurship Development, nodal Animal Husbandry & Dairying, aligned to PMMSY for aquaculture feed; build feed-testing labs and certification; route NLM/PMFME capex through FPO-SHG consortia; launch a Bio-Feed Skills Programme.

Private Sector & Investors

- Invest in cluster/MSME feed mills and alternative-protein (BSF, silkworm) scale-up; provide formulation technology, quality systems and offtake; partner on dealership distribution.

Development Agencies & NGOs

- Mobilise FPO-SHG feedstock aggregation, build formulation and extension capacity, and structure working-capital and direct-to-farmer sales models in tribal/forest-belt districts.

11 Key Departments & Institutional Alignment

Nodal Department / Institution	Primary Responsibility in the Bio-Feed Value Chain
Dept. of Animal Husbandry & Dairying (nodal)	Bio-Feed Cluster Mission; NLM Entrepreneurship Development; feed-cluster hub-and-spoke architecture.
Fisheries Department / PMMSY	Aquaculture-feed sub-cluster and fish-feed cost reduction.
Industries / PMFME / CSIDC	Micro-enterprise credit-linked subsidy and MSME pellet-feed support.

Agriculture Department	Residue/feedstock supply, Krishi Mitra extension and FPO linkage.
FPOs / SHGs (130+ FPOs)	Feedstock aggregation, mill/dealership operation and direct-to-farmer sales.
Feed-testing labs / FSSAI-BIS liaison	Feed-safety compliance, quality testing and Bio-Feed Certification.
KVKs / Agricultural Universities / ITIs	Feed-formulation, mill-operations and extension skilling.
NABARD / Financial Institutions	AIF, working capital and credit guarantee for mills and dealerships.
Livestock/Fishery communities FGD	Demand articulation and enterprise participation (Bargaon, Tumdibod, Dashpur).

[1]**Methodology.** Employment: 15,000–30,000 direct rural jobs from 200–400 cluster feed mills (8–15 FTE/unit) + 500–1,000 dealerships (2–4 FTE + 5–10 indirect) over 2026–32. Investment: ₹500–1,500 Cr envelope (0.5–1% of national compound-feed market) — mills ₹50L–3 Cr (mash) / ₹5–15 Cr (pellet); dealerships ₹5–25 lakh. Market: India animal feed ₹1.11T (2024) → ₹2.02T (2033, 6.9% CAGR); compound feed USD 27.23 bn → 36.6 bn (2029). Feedstock: 10.9 MMT surplus paddy straw + pulse/millet residues + rice bran/husk + oil cakes. FGD demand: feed cost ₹2,000–4,000/HH/month; fish feed ₹50/kg; fish price ₹120–260/kg. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Bio-Feed (Bio-Economy)

INPUTS



OUTPUTS



Source: Elmentoz (BSF), Tumdibod poultry-feed FGD, Indian Poultry Alliance-Kwality, Loopworm

B05 Nutraceutical Value Chain

BE · BIO-ECONOMY

A strategic industrial intervention to build the "industrial middle" — GMP-certified extraction hubs, quality labs, and digital traceability — that converts Chhattisgarh's raw forest botanicals into standardised, high-margin nutraceutical ingredients and finished products.

Executive Dashboard

EXECUTIVE DASHBOARD — NUTRACEUTICALS AT A GLANCE (Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 18,000+ formal FTE jobs across primary processing, GMP mega-hubs and quality labs — with all 35 Tier-3 clusters legally owned by SHGs/Van Dhan and SC/ST and women employment preferences enforced under IDP 2024–30.

Market & Investment Opportunity. A ₹600 Cr capital outlay over ten years (Phase 1 ₹120 Cr / Phase 2 ₹260 Cr / Phase 3 ₹220 Cr) to build the missing 'Industrial Middle': 35 SHG-led primary clusters (₹140 Cr), 5 GMP mega-hubs (₹210 Cr, PPP), 18 district quality labs (₹63 Cr), a Digital Material Passport + R&D (₹37 Cr) and working capital/skills/food parks (₹150 Cr) — leveraging IDP 2024–30 Thrust-Sector incentives (100% Net SGST reimbursement up to 12 years; ₹50–200 Cr capital subsidies; a dedicated Raipur Pharma Park).

Revenue Potential. ₹3,800 Cr annual revenue by 2036 from a ~₹200 Cr raw-trade economy today (~19×), by capturing the 10×–22× 'Botanical Multiplier' — raw dried herbs at ₹30–60/kg becoming GMP-compliant bioactive ingredients at ₹800–2,400/kg — that currently leaks to Gujarat and Maharashtra.

Strategic Outcome — the constraint is governance, not capital. CG has the biology (44% forest cover, 1,525 MAP species, 65,000 MT annual yield) but is missing the Industrial Middle. A prior 2005–2010 MAP pilot failed on execution and quality discipline, not finance — the current design corrects this via a Digital Material Passport (quality from the forest floor), clustered aggregation, and GMP-discipline pharma PPPs.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Nutraceuticals · Chhattisgarh 2026–36 (Forest Wealth → Botanical Sovereignty)

FORMAL FTE JOBS	CAPITAL OUTLAY	ANNUAL REVENUE	BOTANICAL MULTIPLIER
18,000+	₹600 Cr	₹3,800 Cr	10–22×
primary processing, GMP hubs and quality labs	over 10 years (Ph1 ₹120 / Ph2 ₹260 / Ph3 ₹220 Cr)	target by 2036 vs ~₹200 Cr today (~19×)	₹30–60/kg raw → ₹800–2,400/kg GMP extract

2 Contextual Overview

National Context

- **Large, fast-growing market:** India's nutraceutical market is USD 38.77 bn (2025), projected to USD 84.99 bn by 2033 (10.3% CAGR); the global market expands toward USD 1.12 trillion by 2034, with acute demand for standardised, traceable, heavy-metal-free extracts.
- **India's botanical base:** world-leading millet (~43% of global output) and turmeric (~75% share) production, with AYUSH/herbal exports reaching USD 651 M in 2023–24.

Chhattisgarh Context

- **Exceptional ecological foundation:** ~44% forest cover, 1,525 documented MAP species and 65,000 MT annual yield, with high concentrations of Ashwagandha, Giloy and Amla across Bastar, Surguja and Korba.
- **The structural paradox (value leakage):** despite 65,000 MT of potent biomass, the sector earns only ₹180–220 Cr/yr — 85–90% of MAP produce sold unprocessed, under 5% formally certified — because CG operates strictly as an 'Input Supplier'.
- **Policy tailwind:** IDP 2024–30 designates herbal/pharma a Thrust Sector, unlocking capital subsidies, interest subsidies and Net SGST reimbursement plus a dedicated Raipur Pharma Park.

3 Demand & Supply Assessment

Supply Analysis

- **Resource base:** 65,000 MT annual MAP yield, 10,270 ha under cultivation (Bastar alone ~2,100 ha), and a tribal NTFP workforce already mobilised under CGMFPFED and Van Dhan.
- **Missing Industrial Middle:** no GMP-certified extraction hubs, quality labs or digital traceability — the value-adding tier that the ₹600 Cr intervention builds.
- **Quality discipline:** under 5% of produce is formally certified; the Digital Material Passport enforces quality from the forest floor to correct the prior pilot's failure mode.

Demand Dynamics

- **B2B pull for standardised extracts:** national pharma/nutraceutical manufacturers face an acute shortage of standardised, traceable, heavy-metal-free extracts — the demand CG is positioned to supply.
- **Premium capture:** the 10×–22× multiplier (₹30–60/kg raw → ₹800–2,400/kg extract) is the value CG must retain in-state.

Supply–Demand Gaps

- **Execution, not finance:** the 2005–2010 pilot proved buy-back, distillation and subsidy convergence can be assembled; it failed on harvest-stage quality, sub-scale acreage and extension that stopped at planting.
- **Fragmentation & middlemen:** trade is fragmented and middlemen-dominated, with no GMP infrastructure — the reason value leaks to Gujarat/Maharashtra.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Nutraceutical

CURRENT SITUATION	THE GAP	OPPORTUNITY	RECOMMENDED ACTION
65,000 MT biomass yields only Rs 180-220 Cr; 85-90% sold raw	Zero pharma-grade GMP hubs; <5% certified; no traceability	Retain the 5x-15x processing premium; reach Rs 3,800 Cr in-state	Build 35 clusters, 5 GMP mega-hubs, 18 labs + CG-BIO passport

Source: Turmeric/Curcumin national model, Van Dhan Kendras (CGMFPPED), Patanjali-class Amla sourcing

4 Market Ecosystem for the Value Chain

The nutraceutical value chain builds the ‘Industrial Middle’ between forest and market: tribal collection (CGMFPPED, Van Dhan), SHG-led primary processing (35 drying/grading clusters), GMP bioactive extraction (5 mega-hubs via pharma PPP), and quality/traceability (18 NABL labs plus a Digital Material Passport) feeding B2B pharma/nutraceutical manufacturers and AYUSH exports — converting a raw-supplier economy into a high-margin extraction vertical.

Nutraceutical Value-Chain Architecture (Building the 'Industrial Middle')

Forest Collection	SHG Primary Processing	GMP Extraction	Quality & Traceability	B2B Market
Tribal NTFP · CGMFPPED · Van Dhan	35 clusters: drying · grading sheds	5 mega-hubs: bioactive extraction (PPP)	18 labs · Digital Material Passport	Pharma / nutraceutical · AYUSH export

Market Ecosystem for the Nutraceutical Value Chain

Inputs & Resource	1,525 MAP species · 65,000 MT annual yield · 10,270 ha cultivation (Bastar ~2,100 ha) · 44% forest cover
Producers / Aggregators	Tribal collectors · Bihaan SHGs · Van Dhan Kendras · FPOs · CGMFPPED (SC/ST + women preference)
Industrial Middle	35 SHG primary clusters · 5 GMP mega-hubs · 18 quality labs (NABL) · Digital Material Passport · Raipur Pharma Park
Off-takers & Markets	B2B pharma / nutraceutical manufacturers · AYUSH & herbal exports · clean-label ingredient buyers
Enablers	IDP 2024–30 Thrust Sector (100% Net SGST, ₹50–200 Cr subsidy) · CGMFPPED · PMFME · State FDA / NABL

5 Community & Stakeholder Insights

Data note. *Nutraceuticals is anchored in tribal forest communities. Field and institutional evidence covers tribal MAP collectors, Bihaan SHGs and Van Dhan Kendras, pharma anchor partners, and the lessons of the 2005–2010 NHM MAP pilot (Bandora, Tilda).*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Tribal MAP collectors	Sell raw herbs at ₹30–60/kg with no processing; 85–90% of produce unprocessed; value leaks out-of-state.	Route collection through CGMFPFED/Van Dhan with SC/ST and women employment preference; SHG-owned primary processing to retain value.
Bihaan SHGs / Van Dhan Kendras	Aggregation is sub-scale and post-harvest quality inconsistent (the prior pilot's failure).	Establish 35 SHG-led primary clusters with drying/grading sheds and clustered 50+ acre aggregation; extension through harvest, not just planting.
Pharma anchor firms (PPP)	Face an acute shortage of standardised, traceable, heavy-metal-free extracts.	Develop 5 GMP mega-hubs via PPP with pharma anchors enforcing post-harvest accountability and GMP discipline.
Quality/regulatory institutions	Under 5% of produce is formally certified; no traceability.	Deploy 18 NABL district quality labs and a Digital Material Passport (blockchain) enforcing quality from the forest floor.
MSME entrepreneurs / investors	Missing Industrial Middle deters formal investment despite strong incentives.	Leverage IDP 2024–30 Thrust-Sector incentives (100% Net SGST, ₹50–200 Cr subsidy) and the Raipur Pharma Park.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Value capture is the case:** a ₹600 Cr intervention converts a ₹200 Cr raw-trade economy into ₹3,800 Cr (revenue architecture: ₹1,800 Cr / ₹1,550 Cr / ₹450 Cr streams) by retaining the 10×–22× multiplier in-state.
- **Incentive leverage:** IDP 2024–30 Thrust-Sector incentives (Net SGST reimbursement, capital and interest subsidies) materially de-risk the GMP-hub capex — the source states no single project IRR.

2. Social Benefits

- **Tribal, women-inclusive ownership:** 18,000+ formal jobs with SHG/Van Dhan legal ownership of all 35 primary clusters and enforced SC/ST and women employment preference.

- **Livelihood formalisation:** connects tribal NTFP collectors directly to the formal national nutraceutical supply chain.

3. Environmental & Climate Resilience

- **Sustainable forest valorisation:** monetises the forest floor's botanical wealth within sustainable harvest limits, adding value without expanding extraction.
- **Clean-label alignment:** traceable, heavy-metal-free extracts meet rising clean-label and preventive-healthcare demand.

4. Technical Feasibility

- **GMP + traceability:** GMP extraction, NABL labs and a Digital Material Passport are the technical core — proven technologies whose absence is the binding gap.
- **Execution discipline:** the design's central lesson is that governance and post-harvest quality discipline, not technology or capital, determine success.

7 Success Stories & Proven Models

CASE STUDY 1 · The 2005–2010 MAP Pilot — Why Execution, Not Finance, Is the Constraint

Between 2005–2010 the Horticulture Department (under NHM) ran an MAP cultivation drive (lemongrass, vetiver, stevia) with distillation units, NGO partners and herbal-company buy-back — the Bandora (~6 acres) and Tilda units show the institutional template works. It failed not for lack of finance but on inconsistent post-harvest quality, weak market access and inadequate plot-level maintenance after planting.

Relevance: *the design correction — a Digital Material Passport (quality from the forest floor), 50+ acre clustered aggregation, and GMP-discipline pharma PPPs forcing post-harvest accountability — solves precisely the three failure modes.*

CASE STUDY 2 · The Botanical Multiplier — ₹30–60/kg to ₹800–2,400/kg

The same forest economy that yields ₹30–60/kg for raw dried herbs can, through standardised extraction and GMP-compliant processing, yield purified bioactives commanding ₹800–2,400/kg in the B2B pharmaceutical market — a 10×–22× multiplier currently captured in Gujarat and Maharashtra.

Relevance: *the core investment logic: building the Industrial Middle retains this multiplier in-state, turning a ₹200 Cr raw-supplier economy into a ₹3,800 Cr extraction vertical.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no GMP extraction hubs, quality labs or traceability; sub-scale, fragmented aggregation.
- **Solution:** build 35 SHG primary clusters, 5 GMP mega-hubs, 18 NABL labs and a Digital Material Passport, anchored by the Raipur Pharma Park.

Financial Barriers

- **Barrier:** formal investment deterred by the missing Industrial Middle despite strong incentives.
- **Solution:** leverage IDP 2024–30 Thrust-Sector incentives (100% Net SGST, ₹50–200 Cr subsidy), PMFME convergence and PPP capital for GMP hubs.

Knowledge & Technical Skill Gaps

- **Barrier:** harvest-stage quality discipline and post-harvest extension gaps (the prior pilot's failure).
- **Solution:** extension through harvest and post-harvest, GMP skilling, and DMP-enforced quality from the forest floor.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	Value leaks out-of-state (Gujarat/Maharashtra capture the 10×–22× multiplier); fragmented middlemen trade.	High	Build in-state GMP extraction and B2B linkage; retain the multiplier via the Industrial Middle.	
Production / Climate	Inconsistent post-harvest quality and sub-scale acreage (prior pilot failure).	High	Digital Material Passport quality enforcement; 50+ acre clustered aggregation; extension through harvest.	
Operational / Supply Chain	No GMP hubs, labs or traceability; under 5% formal certification.	High	35 SHG clusters + 5 GMP hubs + 18 NABL labs + DMP; Raipur Pharma Park anchoring.	
Policy Governance	Governance and execution discipline are the binding constraint, not capital.	Med	Pharma-PPP GMP discipline, SHG/Van Dhan ownership and IDP 2024–30 incentive convergence.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

₹600 Cr Investment Tiers (Building the Industrial Middle)

Tier-3 Primary Clusters	Tier-1 GMP Mega-Hubs	Quality Labs + DMP + WC
35 SHG drying/grading sheds ₹140 Cr <i>Bihaan / Van Dhan-owned</i>	5 extraction hubs via PPP ₹210 Cr <i>private pharma anchors</i>	18 labs + blockchain passport ₹250 Cr <i>traceability + skills + R&D</i>

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Build the Industrial Middle (35 SHG clusters, 5 GMP hubs, 18 NABL labs, Digital Material Passport, Raipur Pharma Park); enforce SHG/Van Dhan ownership and SC/ST-women preference; deploy IDP 2024–30 Thrust-Sector incentives; route collection via CGMFPPED/Van Dhan.

Private Sector & Investors

- Anchor GMP mega-hubs via PPP; provide extraction technology, GMP discipline and B2B/export offtake; enforce post-harvest accountability and standardised, traceable, heavy-metal-free extracts.

Development Agencies & NGOs

- Mobilise and skill tribal collectors and SHGs, build harvest-through-post-harvest extension and quality discipline, and structure clustered 50+ acre aggregation and buy-back.

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Nutraceutical Value Chain
Industries Department (IDP 2024–30)		Thrust-Sector incentives (Net SGST, capital subsidy), Raipur Pharma Park, GMP-hub PPP facilitation.
Forest Department CGMFPPED	/	Sustainable MAP collection, Van Dhan procurement and resource governance.
Tribal Welfare Department		Van Dhan Kendras, tribal collector mobilisation and CFR/IFR linkage.
Panchayat & Rural Development (Bihaan)		SHG-led primary clusters, aggregation and enterprise ownership.
State FDA / NABL labs		18 district quality labs, spectroscopy testing and GMP certification.
Digital Material Passport authority		Blockchain traceability and quality enforcement from the forest floor.
Horticulture Department		MAP cultivation, agronomy and post-harvest extension (correcting the 2005–2010 gaps).
PMFME / MSME		Micro-enterprise convergence, skills and food-park support.
Pharma anchor firms (PPP)		GMP extraction mega-hubs, post-harvest accountability and B2B/export offtake.

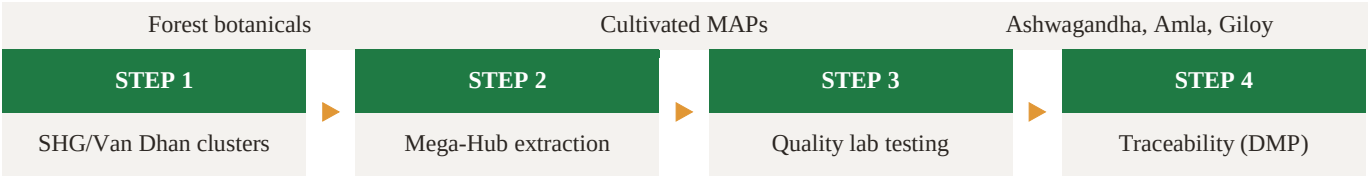
[1]**Methodology.** Employment: 18,000+ formal FTE across primary processing, 5 GMP mega-hubs and 18 quality labs; all 35 Tier-3 clusters SHG/Van-Dhan-owned with SC/ST-women preference. Investment: ₹600 Cr over 10 years — Tier-3 clusters ₹140 Cr (35), GMP mega-hubs ₹210 Cr (5, PPP), quality labs ₹63 Cr (18), DMP+R&D ₹37 Cr, working capital/skills/food parks

₹150 Cr (Ph1 ₹120 / Ph2 ₹260 / Ph3 ₹220 Cr). Revenue: ₹3,800 Cr by 2036 (from ~₹200 Cr; streams ₹1,800 Cr / ₹1,550 Cr / ₹450 Cr) capturing the 10×–22× multiplier (₹30–60/kg → ₹800–2,400/kg). Resource: 44% forest cover, 1,525 MAP species, 65,000 MT yield, 10,270 ha cultivation (Bastar ~2,100 ha). Market: India nutraceuticals USD 38.77 bn (2025) → 84.99 bn (2033, 10.3% CAGR). No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow • Nutraceutical

INPUTS



OUTPUTS



Source: Turmeric/Curcumin national model, Van Dhan Kendras (CGMFPPED), Patanjali-class Amla sourcing

B06 Sustainable Ecotourism

BE • BIO-ECONOMY

Community-based, nature, wildlife, cultural and heritage tourism that converts Chhattisgarh's forest and tribal endowment into a community-led, women-anchored rural economy.

Executive Dashboard

EXECUTIVE DASHBOARD — SUSTAINABLE ECOTOURISM AT A GLANCE
(Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 75,000–150,000 direct rural jobs from a 2030 deployment of 5,000–10,000 community homestays, 500–1,000 cluster-tier enterprises and 20–40 premium eco-resorts — the most labour-intensive value chain in the GETM portfolio per rupee invested, with women’s participation typically exceeding 50–60%. Kerala’s Responsible Tourism Mission benchmark registered 25,000 micro-enterprises supporting 1.5 million households.

Market & Investment Opportunity. A ₹2,000–4,000 Cr opportunity envelope (a realistic 3–5% national share by 2030) across three tracks: community homestays/guiding (₹2–15 lakh/unit, SHG/Van Samiti tier), destination-cluster infrastructure (₹50 lakh–15 Cr under PRASHAD and Swadesh Darshan 2.0) and premium eco-resorts (₹10–100 Cr/asset).

Market Context. India’s ecotourism market is USD 14 bn (2024), projected to USD 51.2 bn by 2034 (9.7% CAGR); the broader sustainable-tourism segment grows from INR 329 bn (2023) toward INR 2.24 trillion by 2030 — yet Chhattisgarh captures less than 2% of national ecotourism revenue today.

Strategic Outcome — an under-leveraged endowment. CG has the highest forest cover among major states (44%, ~12% of India’s forest area), three tiger reserves, Chitrakote Falls, Kanger Valley National Park and distinctive tribal heritage — yet remains sub-scale. The Luikona (Jashpur) FGD records the highest forest-dependent household income in the corpus (₹30,000–40,000/HH/yr), anchoring a community-led, women-anchored, tribal-inclusive ecotourism opportunity.

Methodology & assumptions.[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Sustainable Ecotourism · Chhattisgarh 2026–36

DIRECT RURAL JOBS	INVESTMENT ENVELOPE	NATIONAL MARKET	CG CAPTURE TODAY
75,000–150,000	₹2,000–4,000 Cr	USD 14B → 51.2B	<2%
homestays, guiding, hospitality, F&B (50–60% women)	3–5% national share addressable by 2030	ecotourism by 2034 (9.7% CAGR)	of national ecotourism revenue · highest forest cover (44%)

2 Contextual Overview

National Context

- **Large, fast-growing market:** India’s ecotourism reaches USD 51.2 bn by 2034 (9.7% CAGR); tourism supports ~5% of GDP and over 48 million jobs (1 in 14 positions).

- **Proven community model:** Kerala's Responsible Tourism Mission registered 25,000 micro-enterprises supporting 1.5 million households — the template for community-tier registration and benefit retention.

Chhattisgarh Context

- **Exceptional endowment:** 44% forest cover, three tiger reserves (Indravati, Achanakmar, Udanti-Sitanadi), Kanger Valley/Indravati/Guru Ghasidas national parks, Chitrakote Falls, Boramdeo, Sirpur and Mainpat — plus distinctive Bastariya, Kamar, Muria and Halba tribal heritage.
- **Under-capture:** despite this, CG earns under 2% of national ecotourism revenue, with informal employment dominant and no notified state mission.
- **Highest community readiness:** Luikona (₹30–40K/HH/yr, 300 forest-dependent households, 9 SHGs) and Berchegondi (Van Samiti since 2006, 92 IFR titles, 40 youth + 50 women interested) provide the strongest institutional base in the corpus.

3 Demand & Supply Assessment

Supply Analysis

- **Community enterprise base:** 5,000–10,000 potential homestays plus guiding, cuisine, artisan and transport enterprises anchored on Van Samiti–SHG–PRI institutions; documented precedents include Chitrakote Adventure Camp (SHG-run) and Bastar tribal homestays.
- **Destination infrastructure:** interpretation centres, eco-transport, sanitation and digital booking under PRASHAD and Swadesh Darshan 2.0 (MP's Eco Circuit was approved at INR 93.76 Cr as a benchmark).
- **Readiness triangulation:** Sogda (20 SHGs), Luikona (9 SHGs) and Berchegondi (8 SHG/CLFs) form a forest-tier network; Sogda and Luikona FGDs explicitly estimate 20–25 additional village jobs each.

Demand Dynamics

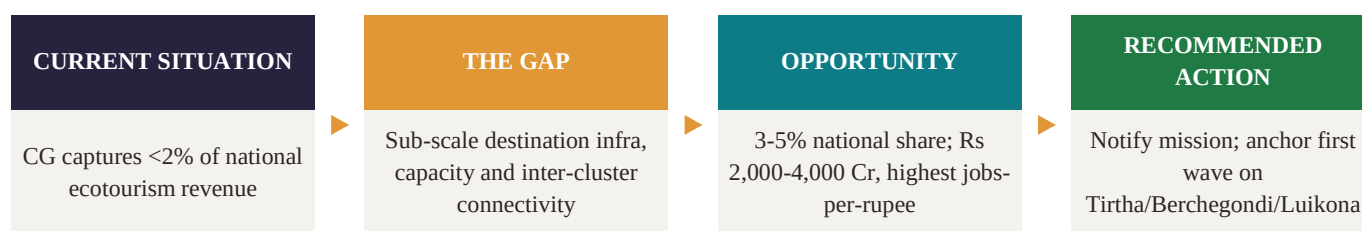
- **Premium experiential demand:** nature, wildlife, cultural and forest-based experiential travel, plus a premium eco-resort segment (₹10–100 Cr assets) drawing domestic metros.
- **Complementary income:** ecotourism revenue addition of ₹20–50K/HH/yr in tier-1 sites layers onto existing NTFP income rather than displacing it.

Supply–Demand Gaps

- **Perception & connectivity:** a Red Corridor security-perception overhang and 200+ km distances from Raipur airport constrain demand — requiring geographic sequencing and UDAN airport upgrades.
- **Benefit-leakage & capacity:** rapid scale-up without community capacity risks cultural commodification and benefit leakage — mitigated by Kerala-style community-tier registration and carrying-capacity caps.

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Sustainable Ecotourism



Source: Chitrakote CBT Village 2024, Kerala Responsible Tourism Mission, Snow Leopard Conservancy/Spiti Ecosphere

4 Market Ecosystem for the Value Chain

Sustainable ecotourism converts CG's natural and cultural endowment into a community-led economy: Van Samiti-SHG-PRI homestays, guiding and cuisine enterprises; destination-cluster infrastructure (interpretation, eco-transport, sanitation, digital booking) under PRASHAD/Swadesh Darshan 2.0; and premium private eco-resorts — organised into five priority circuits and sequenced geographically to manage the tribal-region security overhang, with women's participation exceeding 50–60%.

Sustainable Ecotourism Value-Chain Architecture



Market Ecosystem for the Sustainable Ecotourism Value Chain

Assets & Endowment	44% forest cover · 3 tiger reserves · Chitrakote Falls · Kanger Valley NP · tribal heritage · Van Samitis/IFR
Community Producers	SHG/Van Samiti homestays · guides · artisans · cuisine · transport (50–60% women)
Destination Infrastructure	Interpretation centres · eco-transport · digital booking · PRASHAD / Swadesh Darshan 2.0 clusters
Off-takers & Markets	Domestic tourists · eco-travellers · OTA / travel-trade channels · premium eco-resort guests
Enablers	Ecotourism Mission (proposed) · Tourism / Forest / Tribal Welfare / PRIs · National Ecotourism Policy 2022 · UDAN

5 Community & Stakeholder Insights

Data note. *Ecotourism is community- and women-anchored. Field evidence draws on Forest Management FGDs (Luikona, Berchegondi, Sogda) with the strongest institutional readiness in the corpus, plus documented CG community-tourism precedents.*

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
Forest communities (Luikona, Jashpur)	₹30–40K/HH/yr forest income (highest in corpus); 300 forest-dependent households; 9 SHGs.	Anchor first-wave homestay/guiding deployment here; layer ₹20–50K/HH/yr tourism income onto existing NTFP earnings.
Van Samiti (Berchegondi, Kanker)	Active since 2006, 92 IFR titles, 40 youth + 50 women interested — strongest CBT governance readiness.	Route PRASHAD/Swadesh Darshan capex through Van Samiti–SHG–PRI consortia; use as a proof-of-concept village.
Women’s SHGs (Sogda, forest belt)	20 SHGs (highest density); branding/processing enterprise interest confirmed.	Support artisan, cuisine and branding enterprises; women-led hospitality and guiding cadres.
Bastar Paryatan Samiti (Tirtha)	Operational SHG-run camping (largest capacity in CG) — a Bastar proof-of-concept.	Sequence Bastar tribal circuits last, after Mainpat/Sirpur/Bhoramdeo, as security and connectivity mature.
Private eco-resort investors	Premium demand exists but connectivity (200+ km from Raipur) and perception constrain it.	UDAN upgrades (Jagdalpur/Ambikapur); carrying-capacity permit caps and no-influencer marketing protocols.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Jobs-intensive per rupee:** the ₹2,000–4,000 Cr envelope is the most labour-intensive in the portfolio, with community tracks (₹2–15 lakh/homestay) delivering the highest jobs-per-rupee.
- **ROI note:** the source gives no single project IRR; Kerala RTM (25,000 enterprises, 1.5M households) evidences viability — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Women-anchored, tribal-inclusive:** 75,000–150,000 jobs with 50–60% women participation, layering tourism income onto NTFP earnings without displacing forest livelihoods.
- **Institutional readiness:** Van Samiti/IFR governance and dense SHG networks lower deployment risk.

3. Environmental & Climate Resilience

- **Conservation-aligned:** nature- and forest-based tourism monetises intact ecosystems, incentivising conservation over extraction.
- **Carrying-capacity discipline:** permit caps in tiger reserves and tribal villages prevent over-tourism erosion of the assets.

4. Technical Feasibility

- **Low-tech, capacity-led:** the constraint is community capacity, connectivity and marketing, not technology — homestay and guiding models are well-established.
- **Digital enablement:** digital booking, interpretation and responsible-marketing protocols are the decisive enablers.

7 Success Stories & Proven Models

CASE STUDY 1 · Luikona (Jashpur) — Highest Forest Income in the Corpus

The Luikona Forest Management FGD documents 300 forest-dependent households earning ₹30,000–40,000/HH/yr — the highest forest income in the entire GETM corpus — with 9 SHGs and confirmed enterprise interest.

Relevance: *the highest-readiness Jashpur anchor for first-wave community-based tourism, where a ₹20–50K/HH/yr tourism-income addition layers onto an already-strong NTFP base.*

CASE STUDY 2 · Chitrakote Village (Bastar) — Best Community-Based Tourism Village 2024

Adjacent to Chitrakote Falls, the village won India's most prestigious national community-tourism award in 2024. It is community-anchored, hosts the largest camping capacity in Chhattisgarh through the adjacent Tirtha Bastar Paryatan Samiti SHG, and is integrated with the Chitrakote Adventure Camp managed by Unexplored Bastar; community capacity was built through TECA programmes.

Relevance: *Chitrakote is the flagship state brand anchor, and the Tirtha SHG operating model is directly transferable to Mainpat, Sirpur, Boramdeo, Luikona and Berchegondi.*

CASE STUDY 3 · Jashpur Eco-Tourism Model — Community-Owned District Blueprint

Built around a community-led eco-tourism approach, Jashpur has emerged as one of Chhattisgarh's most promising sustainable tourism destinations by integrating eco-friendly homestays, tribal culture, adventure tourism and local livelihoods. The district has developed nine eco-friendly homestays, trained women's SHGs in hospitality and tribal youth as trekking guides and eco-tourism facilitators, and positioned the Jashpur Jamboree as its flagship tourism festival.

Adventure tourism initiatives — including the Tribal Alpine Expedition — and the promotion of cultural and religious landmarks such as Madheshwar Mountain have further strengthened its tourism identity.

Relevance: *a scalable model for community-owned eco-tourism, replicable across Mainpat, Kanger Valley, Tamor Pingla, Satrenga and other tribal landscapes by combining homestays, SHG-led enterprises, cultural experiences and nature-based tourism under a single community-managed framework.*

CASE STUDY 4 · Kerala Responsible Tourism Mission — The State-Tier Reference Model

Kerala's state-run Responsible Tourism Mission registered more than 25,000 micro-enterprises — from canoe guides to artisan workshops — supporting 1.5 million households, under a state-tier framework spanning hospitality, guiding, F&B, transport and cultural enterprise. It demonstrates community-tier registration that retains benefit locally and prevents leakage to external operators.

Relevance: *the operational template for the proposed CG Ecotourism Mission — a community-tier consortium and registration architecture adapted to CG's tribal-heritage and forest-belt context — and the model for routing PRASHAD/Swadesh Darshan capex through Van Samiti-SHG-PRI consortia rather than private operators.*

CASE STUDY 5 · Snow Leopard Conservancy + Spiti Ecosphere (Ladakh-Himachal Pradesh)

The Conservancy engages 500+ community members through homestays, guiding and craft cooperatives; wildlife-watching guests generate up to 30% of participating families' annual household income, and retaliatory predator killings have halved in key valleys.

Further documented Chhattisgarh and adjacent-state templates include the Bastar Tribal Homestay (₹4,500/night), Aamcho Laadi's 30+ year track record, Agora Eco Tourism's cultural-respect protocols, and Madhya Pradesh's 100,000-foreign-tourist tiger-reserve revenue model.

Relevance: the 30%-of-household-income benchmark validates the Luikona ₹30–40K baseline plus an ecotourism addition, and the model is directly transferable to the Indravati, Achanakmar and Udanti-Sitanadi tiger reserves.

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** connectivity — most premium sites are 200+ km from Raipur airport; limited last-mile transport.
- **Solution:** UDAN upgrades at Jagdalpur/Ambikapur, hub-and-spoke circuit connectivity and Swadesh Darshan 2.0 destination infrastructure.

Financial Barriers

- **Barrier:** benefit-leakage to private operators; community capex access.
- **Solution:** route PRASHAD/Swadesh Darshan/Dekho Apna Desh capex through Van Samiti–SHG–PRI consortia (Kerala RTM model).

Knowledge & Technical Skill Gaps

- **Barrier:** community-capacity and over-tourism risks; security perception overhang.
- **Solution:** capacity-building, carrying-capacity permit caps, no-influencer/photography protocols, and geographic sequencing (Mainpat/Sirpur/Bhoramdeo first, Bastar last).

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Mitigation Strategy
Market / Price	Security-perception overhang in Red Corridor districts limits demand.	High	Geographic sequencing — Mainpat/Sirpur/Bhoramdeo/Mahanadi-Sihawa first; Kanker, Jashpur, then Bastar as conditions mature.
Production / Climate	Over-tourism and carrying-capacity risk erodes the assets.	Med	Carrying-capacity permit caps in tiger reserves/tribal villages; no-influencer marketing and photography protocols.
Operational / Supply Chain	Connectivity — 200+ km from Raipur airport; weak last-mile.	High	UDAN upgrades (Jagdalpur/Ambikapur); hub-and-spoke and Swadesh Darshan 2.0 infrastructure.
Policy / Governance	No notified ecotourism mission; benefit-leakage to private operators.	High	Notify an Ecotourism Mission (nodal: Tourism) routing capex through Van Samiti–SHG–PRI consortia.

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tracks (Community → Premium)

Community Homestays	Destination Clusters	Premium Eco-resorts
SHG / Van Samiti tier ₹2–15 lakh/unit 50–60% women	PRASHAD / Swadesh Darshan 2.0 ₹50L–15 Cr/cluster interpretation, transport	Private boutique lodges ₹10–100 Cr/asset wildlife camps, heritage

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Sustainable Ecotourism Mission (Q4 2026) under Swadesh Darshan 2.0 + PRASHAD + National Ecotourism Policy 2022, nodal Tourism with Forest/Tribal Welfare/PRI; deploy five priority circuits; anchor on Luikona, Berchegondi and Tirtha; route capex through community consortia.

Private Sector & Investors

- Invest in premium eco-resorts, destination clusters and digital booking/marketing; partner with community enterprises for hospitality, guiding and F&B; support UDAN-linked connectivity.

Development Agencies & NGOs

- Mobilise Van Samiti–SHG–PRI consortia, build hospitality/guiding/enterprise capacity, and implement carrying-capacity and responsible-tourism protocols (Kerala RTM model).

11 Key Departments & Institutional Alignment

Nodal Institution	Department /	Primary Responsibility in the Ecotourism Value Chain
Tourism Department (nodal)		Ecotourism Mission; five priority circuits; PRASHAD/Swadesh Darshan 2.0 destination infrastructure; branding.
Forest Department		Tiger-reserve/national-park access, carrying-capacity permits and eco-development committees.
Tribal Welfare Department		Tribal-heritage tourism, Van Samiti/IFR linkage and community enterprise.
Panchayati Raj Institutions (PRIs)		Village-tier tourism governance and Van Samiti–SHG–PRI consortia.
Women's SHGs / Bihaan (SRLM)		Homestay, cuisine, artisan and guiding enterprise (50–60% women).
Civil Aviation / UDAN		Jagdalpur/Ambikapur airport upgrades and last-mile connectivity.
Culture / Archaeology		Heritage sites (Sirpur, Bhoramdeo) interpretation and conservation.

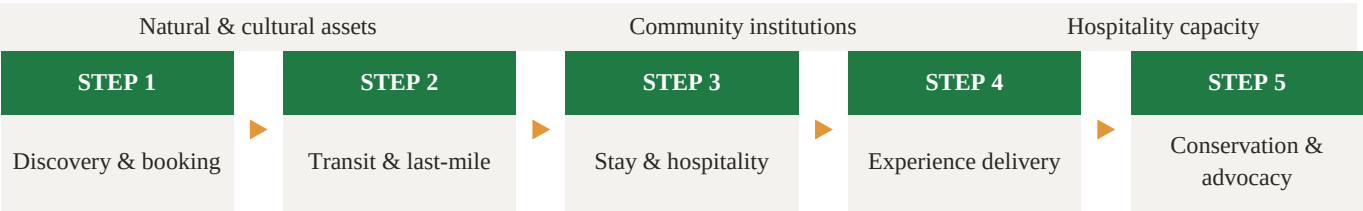
Private eco-resort operators	Premium lodge and wildlife-camp investment and responsible-tourism practice.
NABARD / Financial Institutions	Community-enterprise and cluster capex, working capital and credit.

[1]**Methodology.** Employment: 75,000–150,000 direct rural jobs from 5,000–10,000 homestays + 500–1,000 cluster enterprises + 20–40 premium eco-resorts (2030 deployment); women’s participation 50–60%. Investment: ₹2,000–4,000 Cr envelope (3–5% national share) — homestays ₹2–15 lakh; clusters ₹50L–15 Cr; resorts ₹10–100 Cr. Market: India ecotourism USD 14 bn (2024) → 51.2 bn (2034, 9.7% CAGR); sustainable tourism INR 329 bn (2023) → 2.24 trillion (2030). Assets: 44% forest cover, 3 tiger reserves, Chitrakote Falls, Kanger Valley NP, tribal heritage. FGD income: Luikona ₹30–40K/HH/yr (highest in corpus); Berchegondi Van Samiti (2006), 92 IFR, 40 youth + 50 women. Kerala RTM benchmark: 25,000 enterprises, 1.5M households. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Eco-Tourism

INPUTS



OUTPUTS

Visitor revenue	Rural jobs & income	Conservation finance
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Source: Chitrakote CBT Village 2024, Kerala Responsible Tourism Mission, Snow Leopard Conservancy/Spiti Ecosphere

B07 Sustainable Housing

BE · BIO-ECONOMY

Design and construction of residential buildings using bamboo, compressed stabilised earth blocks, bio-fibre insulation, paddy-straw board and rice-husk cement — the downstream demand-aggregation value chain for Chhattisgarh's bio-economy.

Executive Dashboard

EXECUTIVE DASHBOARD — SUSTAINABLE HOUSING AT A GLANCE
(Chhattisgarh · GETM 2026–2036)

Direct FTE Employment. 50,000–100,000 direct rural jobs across material production, masonry, technical supervision and skilled trades — CG’s most jobs-multiplicative downstream bioeconomy application — from 200–500 village production units, 50–100 mechanised cluster units and 30–50% bio-material substitution in PMAY-G delivery, using CSEB (4–6 FTE/unit), bamboo (6–10 FTE) and paddy-straw board (10–20 FTE) coefficients.

Market & Investment Opportunity. A ₹2,500–6,000 Cr opportunity envelope (2–3% national share) across three tiers: village production units (₹3–50 lakh), MSME mechanised plants (₹50 lakh–15 Cr) and integrated developer-tier PMAY-G clusters (₹25–500 Cr) — anchored by AVEI’s CSEB template (14,000+ trainees) and the HDFC/IFC/SBI/PNB green-building-finance ecosystem.

Housing-Finance Anchor. PMAY-G has completed 2.82 crore rural houses (Aug 2025) with a ₹54,500 Cr FY2024–25 allocation against a 4.12 crore target, plus 2 crore additional houses through FY2028–29 (₹3 lakh Cr) and PMAY-U 2.0 (₹10 lakh Cr, 1 crore urban houses). Converting 30–50% of CG’s PMAY-G delivery to bio-materials means ~5–10 lakh houses.

Strategic Outcome — the downstream demand sink. Sustainable housing converts all four upstream CG bioeconomy value chains (Bamboo, Bio-Fibre, Agri-Residue, Bio-Inputs) into finished assets at the scale of India’s largest housing-finance flow. India’s green-building-materials market grows from USD 13.86 bn (2024) to USD 39.01 bn by 2033 (11.28% CAGR), with India holding the world’s 2nd-largest registered green-building footprint (10 bn+ sq ft, IGBC).

Methodology & assumptions.^[1] *All headline metrics are derived from the source value-chain document; formulas, coefficients and data gaps are detailed in the footnote below.*

Executive Dashboard · Sustainable Housing · Chhattisgarh 2026–36 (Bamboo · Earth · Bio-Fibre · Agri-Residue)

DIRECT RURAL JOBS	INVESTMENT ENVELOPE	MATERIALS MARKET	PMAY-G ANCHOR
50,000–100,000	₹2,500–6,000 Cr	USD 13.86B → 39B	5–10 lakh houses
material production, masonry, supervision, trades	2–3% national share addressable	green building materials by 2033 (11.28% CAGR)	30–50% bio-material substitution in CG delivery

2 Contextual Overview

National Context

- **Large housing-finance flow:** PMAY-G (2.82 crore houses completed, ₹54,500 Cr FY24-25; +2 crore through FY2028-29 at ₹3 lakh Cr) and PMAY-U 2.0 (₹10 lakh Cr, 1 crore urban) provide the demand anchor.
- **Growing green-materials market:** USD 13.86 bn (2024) to USD 39.01 bn by 2033 (11.28% CAGR); India's 10 bn+ sq ft IGBC footprint is the world's 2nd-largest.

Chhattisgarh Context

- **Material-endowment-rich:** 1.05 M ha bamboo (4.2% national), 10.9 MMT surplus paddy straw, abundant clay/earth, and the Bemetara Bhavya Srishti Udyog world-record bamboo tower as an industrial proof-of-concept.
- **Execution-poor:** no notified state Sustainable Housing Mission and no integration of bio-materials into PMAY-G delivery at scale; existing activity concentrated in the Bemetara cluster.
- **Universal FGD interest:** bamboo enterprise interest is confirmed across all three Forest FGD villages (Berchegondi, Sogda, Luikona), with universal residue burning providing paddy-straw-board feedstock.

3 Demand & Supply Assessment

Supply Analysis

- **Bio-material spine:** CSEB (compressed stabilised earth blocks), structural bamboo, paddy-straw board, rice-husk cement and bio-fibre insulation — converting four upstream value chains into construction materials.
- **Deployment structure:** 200–500 village production units and 50–100 mechanised cluster units, co-located with PMAY-G cluster delivery sites.
- **Skills deficit:** CSEB, bamboo structural and rice-husk-cement work need specialised skills — only ~500–1,000 trained masons exist in CG against AVEI's 14,000-trainee national benchmark.

Demand Dynamics

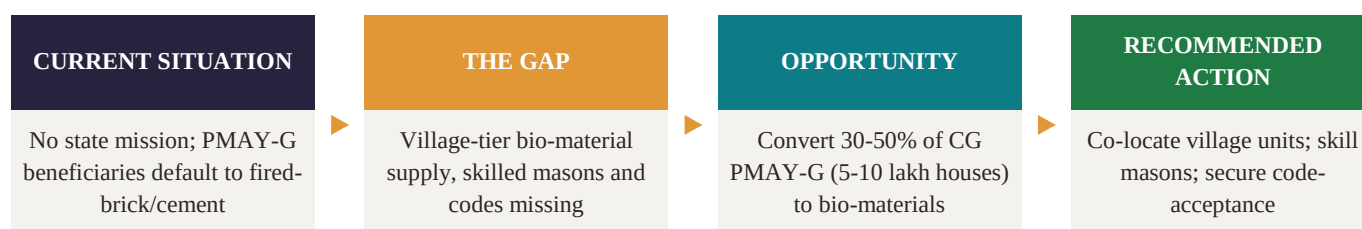
- **PMAY-G/U demand:** converting 30–50% of CG PMAY-G delivery to bio-materials means ~5–10 lakh houses, plus PMAY-U 2.0 affordable green housing.
- **Green-finance pull:** IGBC/GRIHA-rated projects recover 3–8% incremental green cost through 20–30% lower operating costs within 5–7 years, supported by HDFC/IFC/SBI/PNB green finance.

Supply–Demand Gaps

- **Substitution default risk:** PMAY-G's ₹1.20–1.30 lakh/unit DBT makes conventional fired-brick + cement + tin-sheet the path of least resistance absent local bio-material supply and skilled masons.
- **Code-acceptance gap:** CG building codes are written around fired-brick/cement/steel; bio-materials need explicit BIS/BMTPC/IS code acceptance (pending in CG).

Demand & Gap Assessment

Demand → Gap → Opportunity → Action · Sustainable Housing



Source: Auroville Earth Institute (AVEI), Bhavya Srishti Udyog Bemetara, Gujarat HI CSEB reconstruction

4 Market Ecosystem for the Value Chain

Sustainable housing is the downstream demand-aggregation value chain that converts CG's four upstream bioeconomy chains (Bamboo, Bio-Fibre, Agri-Residue, Bio-Inputs) into finished assets: village production units (CSEB, bamboo, paddy-straw board) co-located with PMAY-G clusters; MSME mechanised plants; and integrated developer-tier delivery — anchored on PMAY-G/U housing finance, the AVEI CSEB template, and the green-building-finance ecosystem, with skilling and code-acceptance as the enabling conditions.

Sustainable Housing Value-Chain Architecture



Market Ecosystem for the Sustainable Housing Value Chain

Upstream Materials	1.05M ha bamboo · 10.9 MMT paddy straw · clay/earth · Bio-Fibre + Bio-Inputs value chains · Bemetara anchor
Producers / Masons	Village CSEB/bamboo/straw-board units · trained masons · SHG-FPO · Bhavya Srishti Udyog
Processing & Skilling	MSME mechanised plants · skilling centres (AVEI / BMTPC / CBRI / IIT-M) · IGBC/GRIHA certification
Off-takers & Markets	PMAY-G cluster delivery · PMAY-U 2.0 · private green housing · green-building-finance ecosystem
Enablers	Sustainable Housing Mission (proposed) · PMAY-G / PMAY-U 2.0 · ECBC / Eco-Niwas · BMTPC / BIS code acceptance

5 Community & Stakeholder Insights

Data note. Sustainable housing is anchored on PMAY-eligible households and bio-material supply. Field evidence draws on Forest Management FGDs (Berchegondi, Sogda, Luikona) with universal bamboo-enterprise interest, plus AVEI and Bhavya Srishti industrial benchmarks.

Stakeholder Group	Ground Insights & Core Needs	Recommended Policy Action
PMAY-G beneficiaries	₹1.20–1.30 lakh/unit DBT makes conventional construction the default; 60% of targets reserved for SC/ST (matching CG’s profile).	Co-locate village CSEB/bamboo/straw-board units with PMAY-G clusters; awareness and mason availability at village tier.
Forest communities (Berchegondi, Sogda, Luikona)	Bamboo enterprise interest universal; Berchegondi ‘no bamboo left due to excess harvest’ signals demand.	Integrate structural-bamboo supply with the Bamboo value chain and sustainable harvest management.
Masons / skilled trades	Only ~500–1,000 trained masons in CG vs AVEI’s 14,000-trainee benchmark.	Build 3–5 Sustainable Housing Skilling Centres with AVEI/BMTPC/CBRI Roorkee/IIT-Madras.
MSME producers	Absent mechanised CSEB/engineered-bamboo/board capacity at scale.	Support MSME mechanised plants (₹50L–15 Cr) through green-building finance and cluster subsidy.
Developers / financiers	Green-cost premium and code-acceptance uncertainty deter investment.	Enact BIS/BMTPC/IS code acceptance; GRIHA/IGBC incentives and FAR benefits; HDFC/IFC/SBI/PNB finance.

6 Triple-Bottom-Line & Feasibility

1. Economic Feasibility & ROI

- **Jobs-multiplicative:** the ₹2,500–6,000 Cr envelope delivers 50,000–100,000 jobs while absorbing four upstream value chains — the portfolio’s strongest demand-sink economics.
- **ROI note:** the source gives no single project IRR; IGBC-rated projects recover 3–8% green cost via 20–30% operating savings in 5–7 years — any IRR figure would be an analyst estimate.

2. Social Benefits

- **Coal-transition and tribal jobs:** employment concentrated in coal-transition, forest-belt and tribal-belt districts, aligned with PMAY-G’s SC/ST reservation.
- **Asset creation:** durable, climate-appropriate homes for the rural poor at PMAY-G scale.

3. Environmental & Climate Resilience

- **Low-embodied-carbon materials:** CSEB, bamboo, paddy-straw board and rice-husk cement cut embodied carbon versus fired brick and cement.
- **Residue valorisation:** converts 10.9 MMT surplus paddy straw and bamboo into building materials, diverting residue from burning.

4. Technical Feasibility

- **Proven technology:** AVEI's 36-year CSEB template (14,000+ trainees, 95 countries) and Bhavya Srishti's bamboo engineering are proven — the gap is local skilling and code acceptance.
- **Enabling conditions:** skilling centres and BIS/BMTPC code acceptance are the decisive enablers, not core technology.

7 Success Stories & Proven Models

CASE STUDY 1 · Auroville Earth Institute (AVEI) — The CSEB Template

AVEI, HUDCO-founded, documents a 36-year operational benchmark with 14,000+ trainees from 95 countries; its HI CSEB technology received Gujarat, Tamil Nadu and Iranian government approval post-2001 earthquake reconstruction.

Relevance: *the technology-and-training template for CG's village CSEB units and skilling centres; its code-acceptance path is the precedent for pending CG BIS/BMTPC approval.*

CASE STUDY 2 · Bhavya Srishti Udyog (Bemetara) — Industrial Bamboo Proof-of-Concept

The Bemetara Bhavya Srishti Udyog world-record bamboo tower provides CG's Tier-3 industrial proof-of-concept for structural-bamboo construction, anchoring the state's 1.05 M ha bamboo endowment.

Relevance: *demonstrates in-state industrial bamboo capability that can supply structural components to PMAY-G cluster delivery and MSME producers.*

8 Overcoming Value-Chain Implementation Bottlenecks

Infrastructure Gaps

- **Barrier:** no village-tier bio-material supply co-located with PMAY-G clusters; limited mechanised capacity.
- **Solution:** 200–500 village production units and 50–100 mechanised cluster units co-located with PMAY-G delivery.

Financial Barriers

- **Barrier:** ₹1.20–1.30 lakh/unit DBT favours conventional construction; green-cost premium.
- **Solution:** green-building finance (HDFC/IFC/SBI/PNB), GRIHA/IGBC incentives and FAR benefits; cluster subsidy for producers.

Knowledge & Technical Skill Gaps

- **Barrier:** ~500–1,000 trained masons only; pending code acceptance.
- **Solution:** 3–5 Sustainable Housing Skilling Centres (AVEI/BMTPC/CBRI/IIT-M); BIS/BMTPC/IS code acceptance for bio-materials.

9 Perceived Risks & Mitigation Strategy

Risk Category	Identified Perceived Risk	Severity	Actionable Strategy	Mitigation
Market / Price	₹1.20–1.30 lakh/unit DBT makes conventional fired-brick/cement/tin the default choice.	High	Co-locate village bio-material production with PMAY-G clusters; awareness and skilled-mason availability.	
Production / Climate	Bamboo over-harvest signals (Berchegondi ‘no bamboo left’) threaten supply.	Med	Integrate sustainable-harvest bamboo supply with the Bamboo value chain.	
Operational / Supply Chain	~500–1,000 trained masons only; skills gap in CSEB/bamboo/rice-husk cement.	High	3–5 Sustainable Housing Skilling Centres with AVEI/BMTPC/CBRI/IIT-Madras.	
Policy / Governance	CG codes written around fired-brick/cement/steel; bio-material code-acceptance pending.	High	BIS/BMTPC/IS code acceptance; notify a Sustainable Housing Mission with GRIHA/IGBC incentives.	

Severity ratings are assigned by the analyst from the qualitative weight the source places on each risk; they are directional, not quantified.

Three Investment Tiers (Village → Developer)

Village Production Units	MSME Mechanised	Integrated Developer
CSEB / bamboo / straw board ₹3–50 lakh/unit 4–20 FTE/unit	Mechanised CSEB / eng. bamboo ₹50L–15 Cr/unit 5,000–15,000 blocks/day	PMAY-G cluster delivery ₹25–500 Cr/project 1,000–10,000 houses

10 Stakeholder Matrix & Action Domains

State Government / Public Sector

- Notify a Chhattisgarh Sustainable Housing Mission integrating bio-materials into PMAY-G delivery; co-locate village production units with clusters; build 3–5 skilling centres; secure BIS/BMTPC/IS code acceptance; offer GRIHA/IGBC and FAR incentives.

Private Sector & Investors

- Invest in MSME mechanised plants and integrated developer-tier PMAY-G/U delivery; provide engineered bamboo, CSEB and board materials; access green-building finance (HDFC/IFC/SBI/PNB).

Development Agencies & NGOs

- Mobilise SHG-FPO village production units, deliver mason skilling (AVEI/BMTPC), and build community awareness for bio-material substitution at PMAY-G village tier.

11 Key Departments & Institutional Alignment

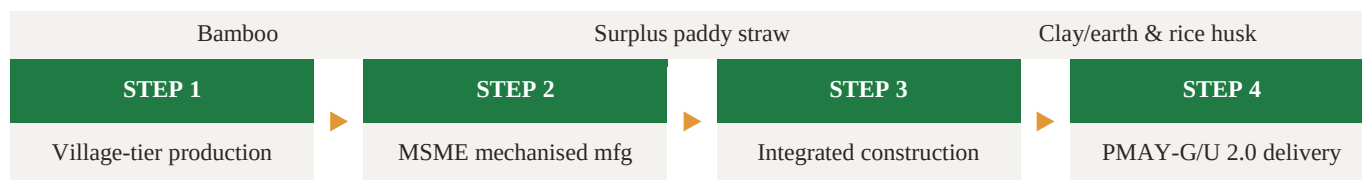
Nodal Department / Institution	Primary Responsibility in the Sustainable Housing Value Chain
Sustainable Housing Mission (proposed)	Integrate bio-materials into PMAY-G; village-unit co-location; skilling and code-acceptance coordination.
Rural Development (PMAY-G)	Rural housing delivery, DBT and cluster-conversion to bio-materials.
Housing & Urban Development (PMAY-U 2.0)	Affordable urban green housing and IGBC/GRIHA project delivery.
Forest Department / Bamboo Mission	Sustainable structural-bamboo supply and the Bamboo value-chain linkage.
Industries / MSME / CSIDC	MSME mechanised CSEB/engineered-bamboo/board plants and cluster support.
Skilling institutions (AVEI/BMTPC/CBRI/IIT-M)	Mason and technical-supervision skilling centres.
BIS / BMTPC	Code acceptance for CSEB, structural bamboo, paddy-straw board and bio-fibre insulation.
SHGs / FPOs	Village production units and PMAY-G-linked material supply.
Green-finance institutions (HDFC/IFC/SBI/PNB/HUDCO/SIDBI)	Green-building debt finance, refinancing and green bonds.

[1]**Methodology.** Employment: 50,000–100,000 direct rural jobs from 200–500 village production units (CSEB 4–6 FTE, bamboo 6–10 FTE, board 10–20 FTE), 50–100 mechanised cluster units and on-site PMAY-G construction (4–8 person-weeks/unit) over 2026–32. Investment: ₹2,500–6,000 Cr envelope (2–3% national share) — village ₹3–50 lakh; MSME ₹50L–15 Cr; developer ₹25–500 Cr. Anchor: PMAY-G 2.82 crore completed (Aug 2025), ₹54,500 Cr FY24-25, 4.12 crore target, ₹1.20–1.30 lakh/unit DBT; +2 crore through FY2028-29 (₹3 lakh Cr); PMAY-U 2.0 ₹10 lakh Cr / 1 crore. Substitution: 30–50% of CG PMAY-G = ~5–10 lakh houses. Market: green building materials USD 13.86 bn (2024) → 39.01 bn (2033, 11.28% CAGR). Benchmarks: AVEI 14,000+ trainees; CG trained masons ~500–1,000. No single project IRR is stated in the source. All figures originate in the source diagnostic. Fast-moving inputs should be re-verified before external citation.

Input / Output Flow

Value Chain Flow · Sustainable Housing

INPUTS



OUTPUTS



Source: Auroville Earth Institute (AVEI), Bhavya Srishti Udyog Bemetara, Gujarat HI CSEB reconstruction



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