IMPACT INVESTORS COUNCIL

CLIMATE POLICY INITIATIVE

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GREEN INVESTMENT OPPORTUNITIES IN INDIA

About Impact Investors Council (IIC)

The Impact Investors Council (IIC) is India's preeminent member-based, not-for-profit industry body set up to strengthen impact investing in the country. IIC's key areas of activity and effort include advocacy and policy support, research, and publications in addition to a strong focus on impact measurement and management. IIC is supported by 60 investors and ecosystem partners.

About Climate Policy Initiative (CPI)

Climate Policy Initiative (CPI) is an analysis and advisory organization with deep expertise in finance and policy. CPI's mission is to help governments, businesses, and financial institutions drive economic growth while addressing climate change. CPI's vision is to build a sustainable, resilient, and inclusive global economy.

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FOREWORD

The world faces a deficit in climate investments, and the gap has been increasing by the order of a trillion dollar every year. The India-led G20 Leaders' Declaration stated that the developing world would need USD 5.9 trillion until 2030 to achieve their Nationally Determined Contributions (NDCs) out of which USD 4 trillion is required only for clean energy transition to meet the zero-emission goal. In addition, India is one of the major climate vulnerable countries in the world, and therefore India is committed to scale up climate investments through clean energy transition and shift to a low-carbon economy in Services, Industry and Agriculture.

The Global Landscape of Climate Finance Report 2021 Report published by Climate Policy Initiative (CPI) states the total climate investments are at USD 850 – 950 billion against a requirement of USD 4.5 -5 trillion annually; and in India, the total climate investments for FY 2019 and FY 2020 were of USD 44 billion annually while India needs USD 160 billion as stated in its NDCs to meet the Paris Agreement goals.

The world cannot meet its climate goals without adequate investments in developing countries (including India) and therefore, there is a need to channelise global capital from developed to developing countries. Given India's current scale of emissions and growth trajectory, it may not be possible for the world to meet its climate goals if climate investments are not materialised in India.

In light of the above, India presents a huge green investment opportunity for global investors across critical sectors such as cleantech, clean energy, clean transportation, electrical vehicles, industrial decarbonisation, water, nature-based solutions etc. which could drive green growth in India.

While the high-level numbers on climate investments required in India are well acknowledged, this report is an attempt by Impact Investors Council (IIC) and Climate Policy Initiative (CPI), to delve deeper and identify climate-oriented sectors in both mitigation and adaptation which offer potential investment opportunities across green value chains in products, technologies, and services. With the right set of enabling policies and incentives, these critical climate investment sectors have the potential to scale up significantly.

This report endeavours to provide adequate investment information to global strategic and financial investors on the scale of green investment opportunities in India. We hope that this report will pave the path to direct global green capital to India.

Dhruba Purkayastha
India Director
Climate Policy Initiative

Girish Aivalli
Chief Executive Officer
Impact Investors Council

MESSAGE FROM NEEV FUND

When it comes to tackling climate change, the world is rapidly moving from ambition to action, with India being on the fore front as a climate change leader.

Adaptation of processes used in sectors such as traditional agriculture, waste management, through technology & process improvements is the way forward to mitigate & adapt to climate change. Along with process adaptations, India's increasing confidence in alternative green sources of energy such as green hydrogen can make the country a potential game changer in the race of achieving net-zero emissions.

Through increasing policy impetus, growing consumer awareness, technology innovations and international trends, we not only see the larger traditional players paving the way, but also exciting and promising emerging enterprises playing a significant role in this global energy transition.

The current climate conscious environment supports the cause of sustainable investing, and hence we see immense opportunity for private capital to play a catalysing role in not just climate mitigation but also adaptation centric efforts.

We believe this report will outline key insights for those looking to match the growing spirit of innovation with a befitting financial support.

Akshay Panth
Chief Investment Officer
Neev Funds

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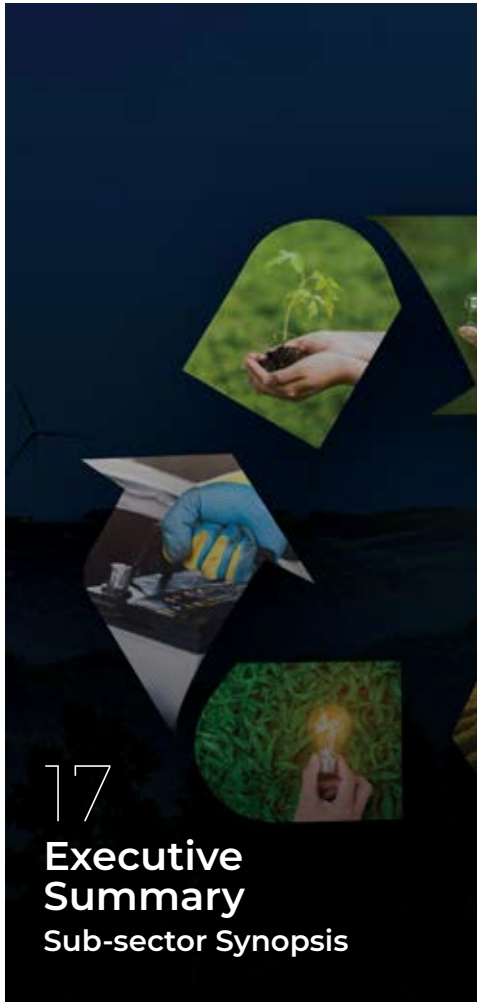
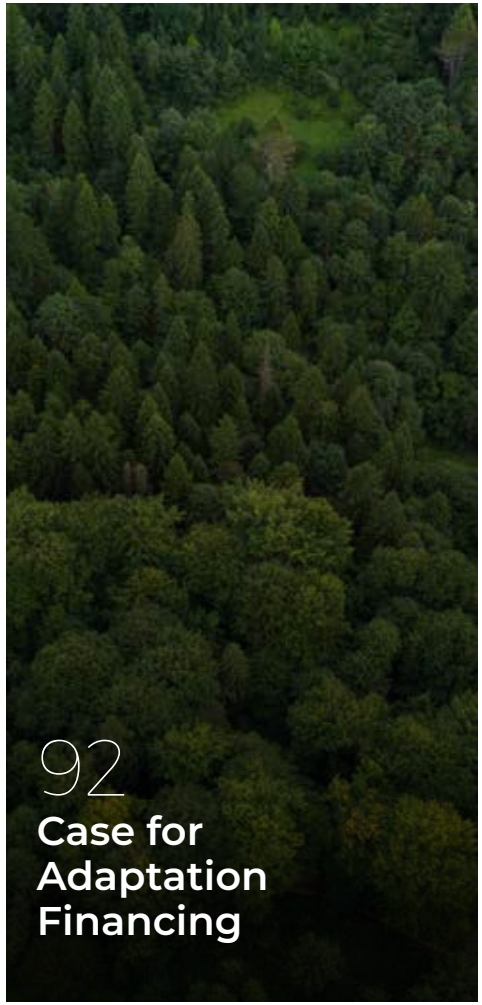
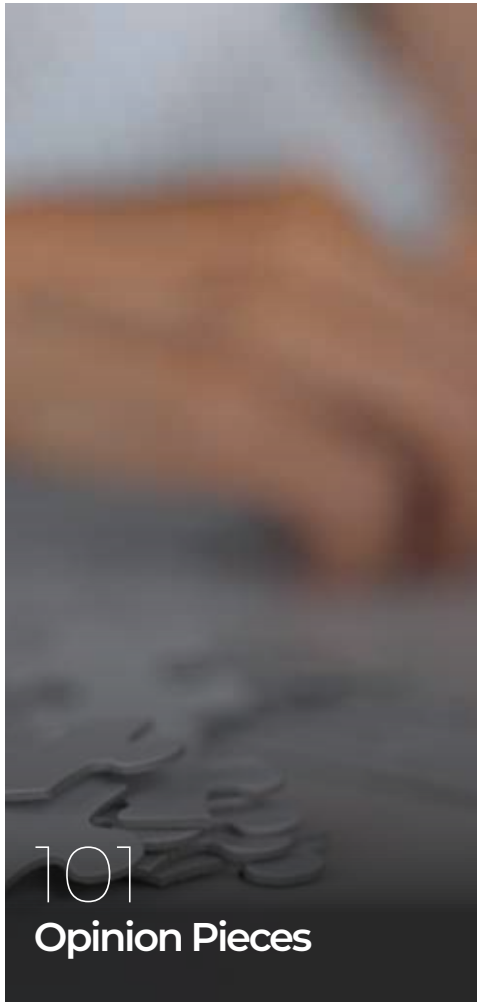






Acronyms and Abbreviations

ACC	Advanced Cell Chemistry
ADB	Asian Development Bank
AI	Artificial Intelligence
BESS	Battery Energy Storage Systems
BMS	Battery Management Systems
CCfD	Carbon Contract for Differences
CEA	Central Electricity Authority of India
CO_2	Carbon dioxide
CSA	Climate Smart Agriculture
CSO	Civil Society Organisations
CSR	Corporate Social Responsibility
CSS	Cross Subsidy Surcharge
CTF	Clean Technology Fund
DFI	Development Financial Institutions
ED	Electricity Duty
EIB	European Investment Bank
EPR	Extended Producer Responsibility
ESS	Energy Storage Systems
FCDO	Foreign, Commonwealth and Development Office
FMCG	Fast Moving Consumer Goods
FPO	Farmer Producer Organisation
G-H2	Green Hydrogen
GDP	Gross Domestic Product
GESP	Global Energy Storage Programs
GHGs	Greenhouse Gasses
GWh	Gigawatt-hour
GoI	Government of India
H4D	Hydrogen for Development Partnership
IDB	Inter-American Development Bank
IFC	International Finance Corporation
IoT	Internet of Things
IREDA	Indian Renewable Energy Development Agency
ISTS	Inter-state transmission charges
KWh	Kilowatt-hour
LABs	Lead Acid Batteries
LIBs	Lithium-ion Batteries
MeitY	Ministry of Electronics and Information Technology
MMT	Million Metric Tons
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change of India
MoHUA	Ministry of Housing and Urban Affairs
MoU	Memorandum of Understanding
MWh	Megawatt-hour
NAPCC	National Action Plan on Climate Change
NDCs	Nationally Determined Contributions
NGHM	The National Green Hydrogen Mission
NGO	Non-governmental organization
NMSA	National Mission for Sustainable Agriculture
NZE	Net Zero Emissions
PE	Private Equity
PFC	Power Finance Corporation
PLI	Product-linked Incentive Scheme
PPP	Public Private Partnerships
PRAS	Primary Reserve Ancillary Services
PSL	Priority Sector Lending
PSUs	Public Sector Undertakings
PtX	Power-to-X
R&D	Research & Development
RD&D	Research, Development & Demonstration
RE	Renewable Energy
REC	Rural Electrification Corporation
RTC	Round-the-Clock Power
SAPCCs	State Action Plans on Climate Change
SDG	Sustainable Development Goals
SECI	Solar Energy Corporation Of India
SHGs	Self Help Groups
SIGHT	Strategic Interventions for Green Hydrogen Transition
SME	Small and medium-sized enterprises
SOP	Standard Operating Procedure
SSA	Stationary Storage Applications
ToD	Time of day pricing
TPDDL	Tata Power Delhi Distribution Limited
ULB	Urban Local Bodies
VC	Venture Capital
VGF	Viability Gap Funding

INTRODUCTION

Introduction

India's significant greenhouse gas emissions, high vulnerability to the impacts of climate change and fast-paced development require for rapid innovation systems and timely, adequate, and targeted financial resources to unlock and bring climate action into the mainstream. The same also has to scale up and accelerate sustainable development.

Limited climate related investments continue to be one of the biggest barriers to achieving India's ambitious emissions reduction targets, with estimates indicating that **India could face an investment shortfall of $3.5 trillion in achieving its net-zero target[1].** Public finance will be largely insufficient, requiring the private sector to play a crucial role in closing the financing gap and accelerating green finance[2].

India's investment requirement is significant for transitioning to a low carbon and resilient economy

$170 billion

Required per year to meet India's Nationally Determined Contributions (NDCs) targets by 2030.

Source: *Climate Policy Initiative, 2022*

3.5 - 6% of GDP

Required in green investments until 2050 to decarbonise the Indian economy.

Source : *McKinsey, 2022*

Additionally, annual investments of about 2.5% of India's GDP would be required until 2030 solely to address the infrastructure gap caused due to climate events.

Source: *Reserve Bank of India, 2023*

The business case for enabling low-carbon and resilient growth, while pursuing sustainable growth, continues to strengthen, creating an array of opportunities that are already being explored by various investors at different stages[3]. The rationale behind such opportunities is backed by a series of high-level assessments around the green investment climate, and existing challenges and approaches to unlocking investments in green solutions and technologies at scale.

Recognising the immense potential that the green investment space holds for funders and enterprises in India, this report attempts to bring together global and national perspectives on green investment opportunities, as well as the knowledge and expertise of funders and sector experts to present an analysis of:

- Green investment opportunities, which have the potential to be replicated or/and scaled in the short-to-medium term and best suited financing mechanisms for each;
- Financing requirements for replicating or/and scaling these opportunities wherein funders can play a significant role.

The in-depth assessments of priority green sectors and deep dives of green technologies and solutions within these elucidate their:

- Contribution to climate action;
- Green investment landscape; and
- Actionable pathways for financing them at scale.

Green investment opportunities encompass multiple sectors, sub-sectors and technologies across the areas of climate change mitigation and adaptation, and sustainable development goals. This report refers to key green technologies and solutions listed by the International Energy Agency and United Nations Environment Programme. These include:

Green Investment Sectors

Energy and Feedstock Transformation

Generation, transmission, distribution and storage of energy and feedstock from renewable sources

Transport

Shift to low-carbon modes of transportation

Waste and Circular Economy

Efficient use and reuse of materials and waste to reduce demand and GHG emissions

Land Use and Oceans

Management of land use changes and oceanic temperatures to reduce GHG emissions into the atmosphere

Water

Conservation and sustainable management of water resources to ensure water security

Health

Improvement of food security, health infrastructure and services to adapt to the impacts of climate change

Climate Change Forecasting and Monitoring

Protection of people, infrastructure and ecosystems from climate hazards with planning and early warning systems and technologies

Industry

Technologies and processes for low-carbon and sustainable manufacturing of industrial materials and products

CO_2 Management

Reduction of CO_2 in the atmosphere using technologies and natural climate solutions

Buildings

Reduction of energy consumption in buildings by using technological and design efficiency measures

Food, Agriculture and Livestock

Initiatives to reduce emissions from agriculture and livestock and help the sector adapt to the impacts of climate change

Marines, Fisheries and Coastal Zones

Protection of marine and coastal ecosystems from the impacts of climate change

Forestry

Protection of and increase in forest cover for carbon sequestration, ecosystem protection and livelihood generation

Sources: *International Energy Agency* & *United Nations Environment Programme*

Green finance and investments

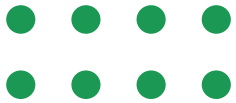
While there is no singular definition of 'green' in the context of finance and investments, this paper understands green finance and investments as 'finance and investments focused on climate action and environmental objectives necessary to support sustainability, and in particular, aspects such as biodiversity and resource conservation.'

Green financing focuses on increasing levels of financial flows from various sources such as banking, micro-credit, insurance and investment, from public, private and not-for-profit sectors to:

- Better manage climate and environmental, and associated social risks; and
- Adopt opportunities that ensure both a decent rate of return, and climate and environmental benefits.

Green sectors, sub-sectors, and technologies and solutions within these have been selected based on their relevance in the Indian investment ecosystem and their potential for scaling in the short-to-medium term.

Recognising the growing importance of climate adaptation and the opportunities arising from it, this study also attempts to emphasise the case for financing adaptation activities. This includes sectors such as healthcare, water, infrastructure resilience, and climate change forecasting and monitoring, which currently do not see private sector financing and engagement at scale, but have immense potential for business opportunities in the form of products, technologies and services.



APPROACH AND METHODOLOGY

Overall Approach

Identify high-potential investment opportunities

Map landscape of green sectors, sub-sectors and technologies / solutions

Select technologies / solutions that have high investment potential for deep-dive analysis

Selection criteria: Climate impact, maturity and commercial readiness, investment activity, financial sustainability, enabling environment, scalability

Research

Detailed assessment of selected investment opportunities

Consultations with stakeholders to understand the current state and expected trajectory of the sector

Assessment areas: Value chain components, key players, policy environment, investment trends and potential, capital requirements, investment barriers

Analysis and recommendations

Analyse investment gaps and barriers and identify opportunities for interventions by different types of stakeholders

Recommend specific actions for policy-makers and investors to unlock green investments

Recommendations for: Policy-makers, regulators, investors and lenders

Validation

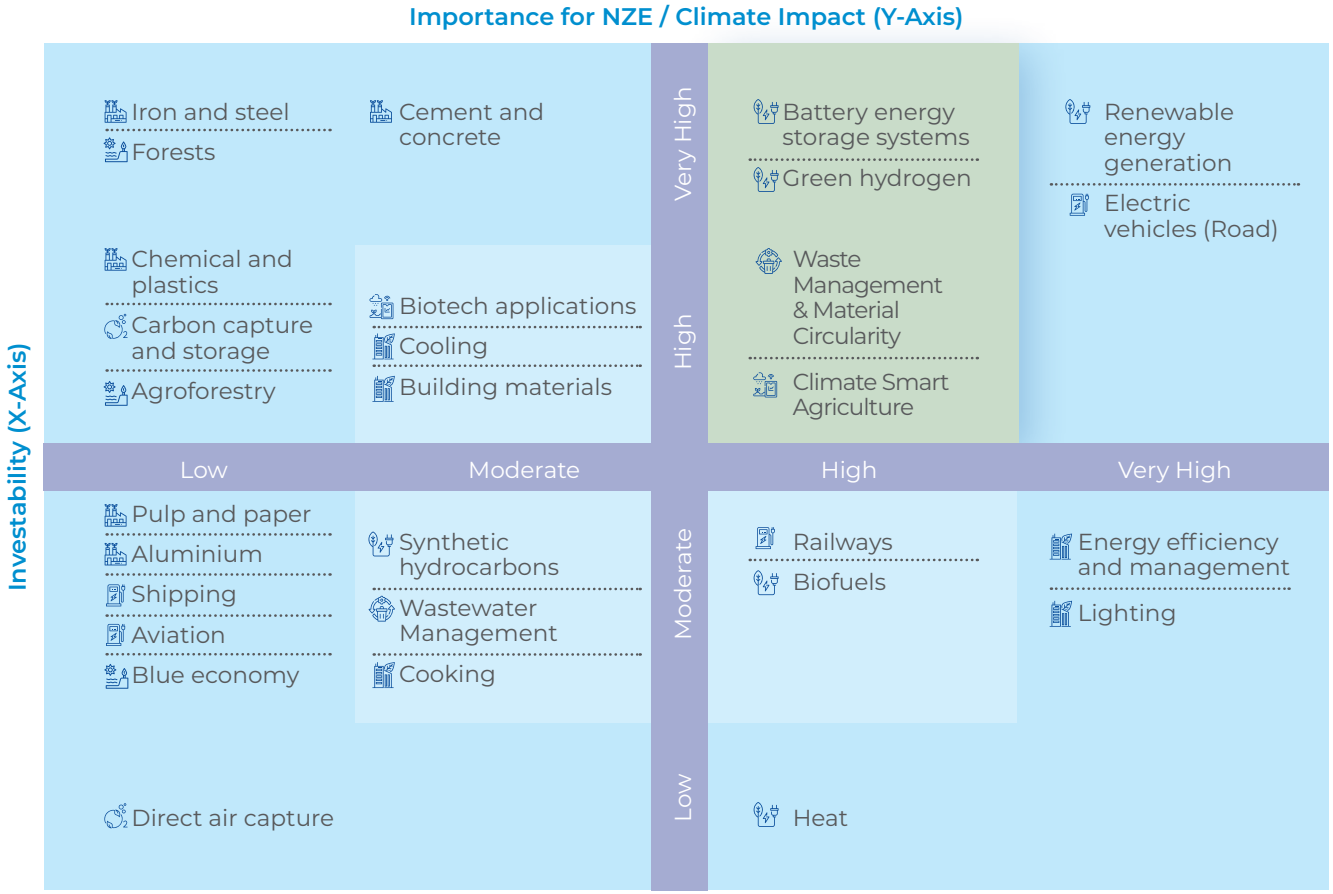
Validate assumptions, analysis and recommendations with stakeholders

Validated by: Industry and independent subject experts

Identifying Investment Opportunities: Mapping Green Sub-sectors

All sub-sectors within the green investment sectors were analysed and then selected on the basis of two metrics: their importance for India's net-zero emissions (NZE) target or climate impact, and their 'investability' (see below for definition of metrics). The accompanying graph maps these selected sub-sectors. Of these, four sub-sectors (in the green shaded cells) were then chosen for a deep-dive analysis: **Battery Energy Storage Systems, Green Hydrogen, Waste Management & Material Circularity, and Climate Smart Agriculture.** Each of these sub-sectors have:

1. High to very-high relevance for India's NZE ambitions and sustainable development;
2. High investment potential, but are in early stages of development. They require strategic interventions to address investment barriers and scale up commercial investments.



Source: Authors, 2023

Legend: Green Investment Sectors

- Energy and Feedstock Transformation
- Food, Agriculture and Livestock
- Transport
- Land Use and Oceans
- Industry
- Waste and Circular Economy
- Buildings
- CO_2 Management

Note: Of the 13 sectors introduced before, five sectors under climate adaptation have been excluded from this analysis due to low-investability (low financial sustainability/ high dependence on public finance). The sector 'Food, Agriculture and Livestock' has overlapping mitigation and adaptation benefits. Here we use the term, 'Climate Smart Agriculture', to collectively refer to investable opportunities in this space.

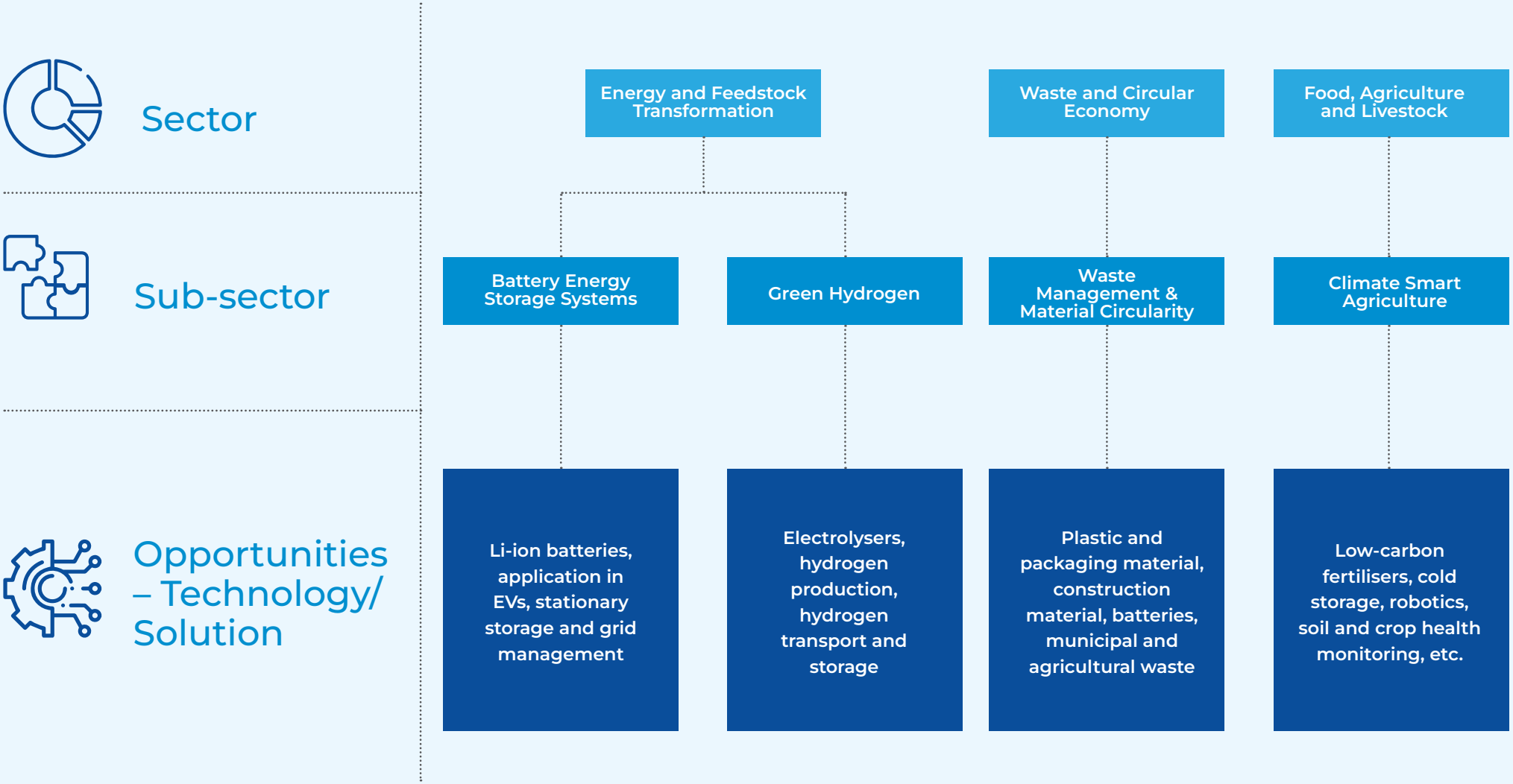
Definition of Metrics:

Importance for NZE / Climate Impact: Measure of the impact of the sub-sector on India's GHG emissions.

Investability: A compound measure of the sub-sector's maturity (technological and commercial readiness levels), enabling environment (supporting policies and regulations) and level of investment activity in recent years.

Identifying Investment Opportunities: Technologies and Solutions

Each of the chosen sub-sectors has several technologies and solutions which present suitable investment opportunities for a wide range of investors. Again, based on climate impact and investability, key technologies and solutions were identified and selected for deep-dive analysis. The figure below shows these opportunity spaces and the sub-sector and sector to which they belong.



EXECUTIVE SUMMARY

Sub-sector Synopsis

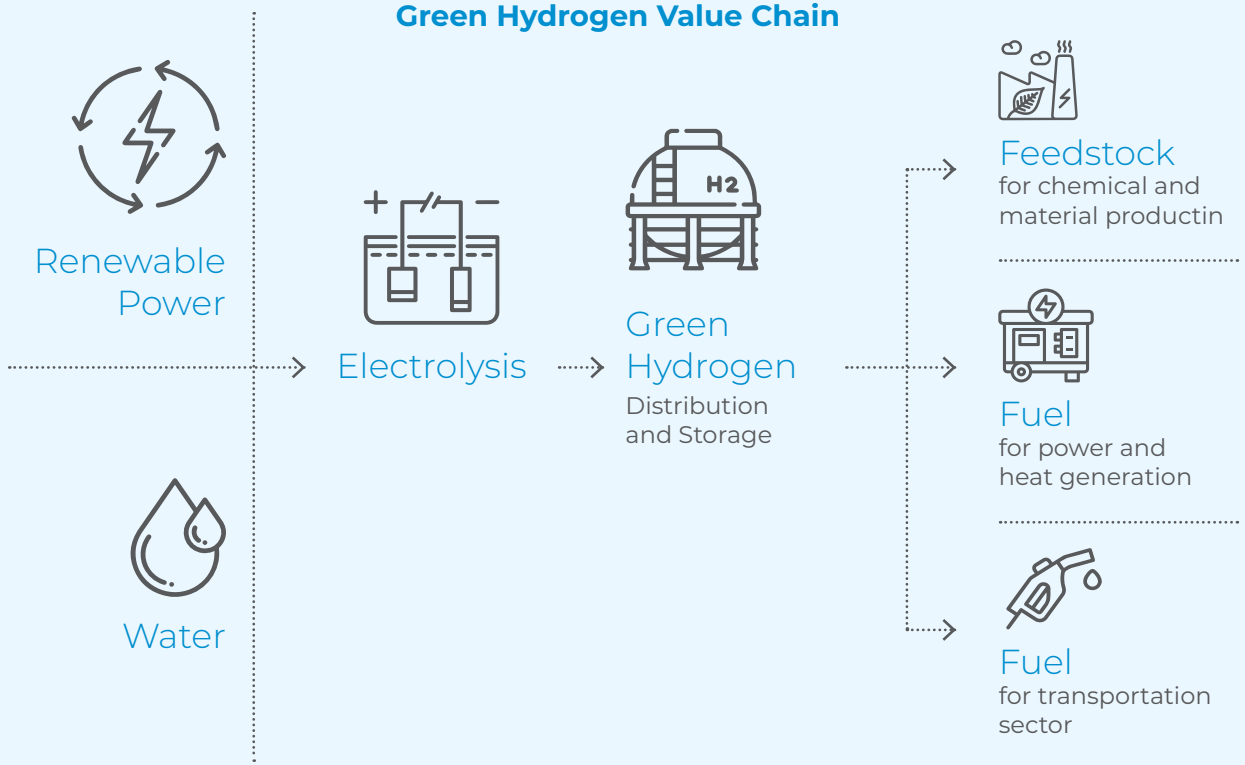
Green Hydrogen

Green Hydrogen: Unlocking its Pivotal Role in India's Decarbonisation Journey

India is at a crucial juncture, striving to harmonise economic growth with sustainability. Industries like oil refineries, fertilisers, steel, and shipping, which are substantial users of grey hydrogen, are now presented with a significant opportunity to transition towards green hydrogen, thereby reducing their carbon emissions. **The adoption of green hydrogen is slated to enable India to cumulatively abate 3.6 gigatonnes of CO_2 emissions by 2050[1].**

Green hydrogen (G-H2), produced by using **clean energy** has been seeing policy impetus as well as active interest from the real and financial sector with investments expected to reach **~$97 billion** by 2030[2] with oil refineries, fertilisers and gas blending driving demand in the short-term[3]. Despite this promising story, the pressing challenge of making G-H2 economically viable for application sectors remains.

Green Hydrogen Value Chain



Source: *Alfa Laval*

The Cost Conundrum: An Opportunity Waiting

Reducing the current cost of G-H2, which is above $4/kg, to approximately $2/kg[4] is imperative for achieving economic viability for end-users. **There is an opportunity to mobilise increased investments in the sector to foster innovation and build economies of scale in green hydrogen production.** This cost reduction trajectory can be led by increased investments in two key cost components[5]:

- Renewable energy production
- Electrolyser manufacturing

Building the Value Chain

As India aspires to become a global hub for G-H2 production, we witness a spur of activities across the value chain with:

- Startups and SMEs developing **electrolyser technologies** and **G-H2 production facilities**
- Large corporate announcing **large-scale, integrated G-H2 projects**

Strategic partnerships are abound as enterprises are collaborating to work across different business models.

Business Model Variables

RE	G-H2 Production	Transportation	Storage
• On-site generation • Off-site generation with transmission	• Centralised production (hubs, valleys) • Decentralised production (on-site)	• Pipelines (high volume) • Trucks (short distances) • Ships (long distances)	• Salt caverns, rock caverns, Depleted oil and gas fields (large volume, long term) • Tanks (small volume, short/long distance transport)

Given the evolving nature of the sector and requirement for large capacities, technical and financial assistance are critical for building a sustainable value chain and aligning with policy directives.

Policy's Impetus

Recent initiatives like The National Green Hydrogen Mission, G-H2 Standards, and incentives to drive electrolyser manufacturing and G-H2 production, have outlined the government's clear priority to build scale for the G-H2 sector with a target of achieving 5 MMT/annum G-H2 production capacity by 2030[6]. **This momentum calls for a complementary set of demand-side incentives that can bolster** local demand for G-H2 which will be critical towards the segment's growth.

A Case for 'Green' Finance

India's journey towards clean energy and industrial transition positions the green hydrogen segment to draw capital that can **support innovation, build supporting infrastructure and invest in project capacities that together hold the potential to build a sustainable domestic value chain.**

Recommendations for Policy and Finance

Introduction of demand-side offtake mandates

Concessional capital towards electrolyser manufacturing and G-H2 production facilities

Patient capital for startups and SMEs across the value chain

Investments in storage, transport, and hub infrastructure

Technical assistance for project development and implementation

Risk mitigation and de-risking mechanisms for crowding-in commercial capital

Battery Energy Storage Systems

Supporting India's Renewable Energy Goals

India's transition to the adoption of clean energy for both industry and transport requires sustainable and scalable solutions for storing energy. **Battery energy storage systems (BESS)** emerges as a vital solution in this space.

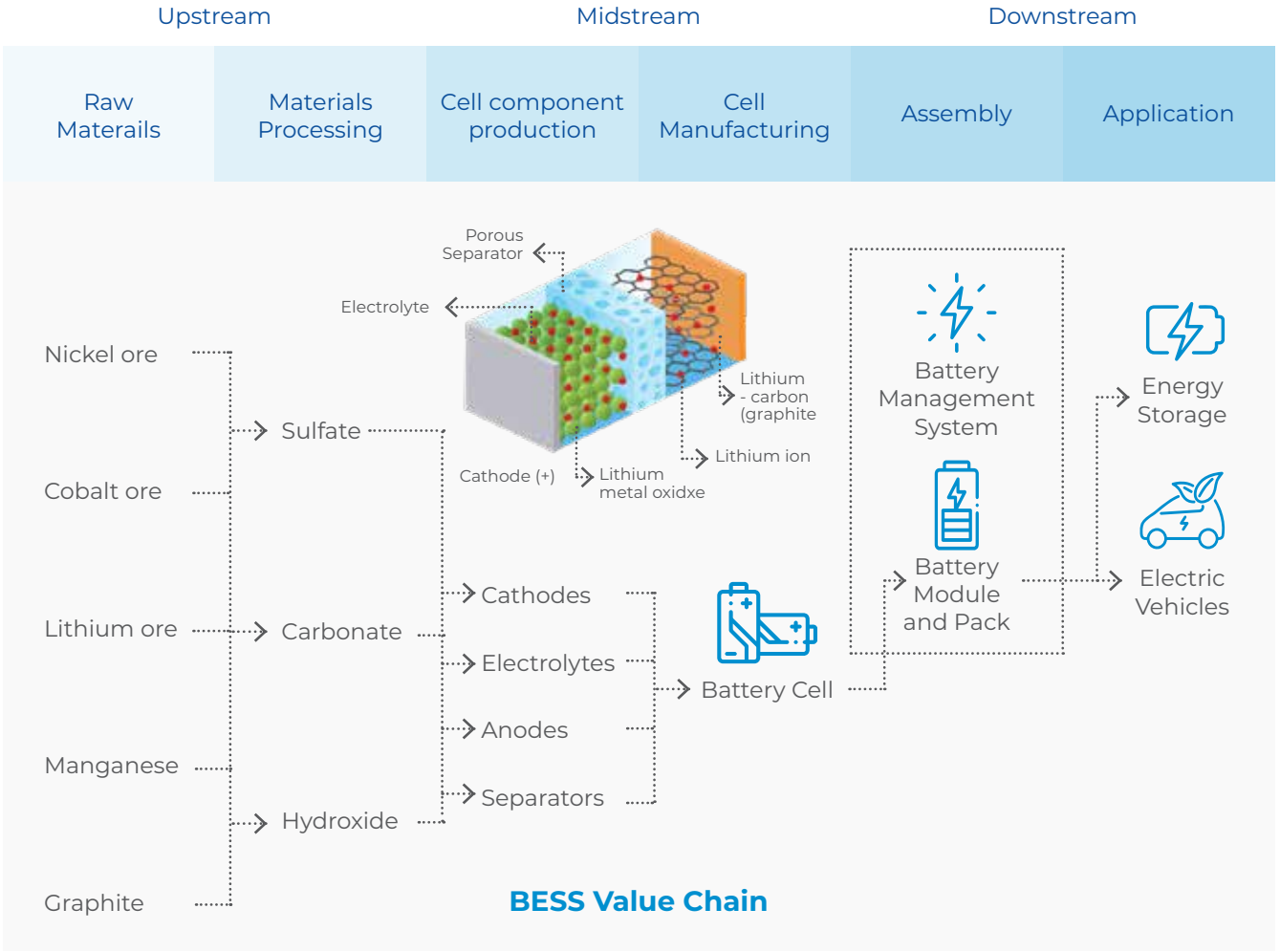
Within the realm of BESS, various battery chemistries play distinctive roles with **lithium-ion batteries (LIBs) racing past** lead acid batteries (LABs) because of superior performance.

LIBs: Powering India's Energy Transition

With high energy density, extended lifespan, low maintenance requirements and rapidly declining costs, LIBs find applications in several areas - stationary storage, electric vehicles (EVs) and grid management services[1].

Across a scale of conservative to accelerated cases, the annual demand for batteries is expected to be **~106 GWh - 260 GWh by 2030,** respectively[2]. The India Battery Market, in the accelerated scenario, could surpass **$15 billion,** and in the conservative scenario, could amount to **$6 billion**[3].

This surging demand necessitates building a self sustainable value chain right from **cell manufacturing** to **deploying battery technologies** for applications.



Source: *L.E.K*

Even as lithium-ion battery storage technologies gain traction, there is scope for research and development (R&D) in alternative advanced chemistry batteries.

Innovation

Scale

Policy Boost

- The **National Framework for Energy Storage Systems launched**
- PLI scheme of $2.4 billion - **National Program on Advanced Cell Chemistry (ACC) Battery Storage** for promotion of domestic cell manufacturing[4]
- **Viability Gap Funding Scheme** extending funding support for development of BESS projects[5]
- **The Faster Adoption and Manufacturing of Electric Vehicles (FAME)** schemes incentivise adoption and manufacturing of EVs [6]

These policies outline the pathway for commercial investments to support scale and innovation across the value chain.

Collaboration and Capital

The high capital requirements, innovative technologies and multiple applications across sectors, warrant the need for public and private sector players to invest in and build technical and financial capacity across the value chain.

Given the perceived complexity of technologies and deployment towards large-scale projects, there is an opportunity to develop **strategic alliances and collaborations, facilitate knowledge-sharing and mobilise low cost capital towards enterprises.**

A single BESS asset holds the promise of multiple value streams as the market for energy storage systems continues to grow. With technology advancements and increased policy support, the sector is poised to receive domestic and international capital, which can unleash the full potential of BESS.

Recommendations for Policy and Finance

- Policies to include BESS in energy systems planning and clarification on remuneration schemes for multiple services
- Facilitating knowledge building, technical advisory & strategic collaborations
- Low cost consumer finance for EVs
- Patient capital to support innovative cell chemistries
- Low-cost financing for developers for stationary storage projects
- Risk mitigation and de-risking mechanisms for crowding-in commercial capital
- Investment towards battery recycling solutions

Climate Smart Agriculture

Climate Change and Agriculture: Close Interplay

Agriculture is both, a sector most impacted by climate change, as well as an important source of greenhouse gas (GHG) emissions. In light of this, the **adoption of climate smart agriculture (CSA) practices becomes not just a choice but a compelling imperative**

14% of nation's total GHG emissions.[1]

Driving Climate Mitigation & Adaptation

- Climate resilient seeds & Low CO_2 fertilisers
- Soil & crop health monitoring
- Robotic agriculture
- Food processing & harvesting technologies
- Cold storage

These high impact solutions stand to benefit by increasing investments that build their scale and ability to ease on-ground adoption.

While climate-resilient practices are essential, farmers are more likely to embrace them when they have the financial means to access and adopt the solutions and can see their tangible benefits, such as enhanced income and reduced farm losses.

This presents an opportunity for philanthropic capital and development finance to enable the on-ground deployment of CSA solutions through capacity building of enterprises and farmers.

As technological innovations come up, there is a case for impact investors to develop a sector focussed investment strategy.

An Untapped Opportunity

With increasing government initiatives, openness of farmers to technology adoption and increased venture capital (VC) interest, agtech in India has thrived over the last few years. From 2018 to 2021, VCs invested **$1.6 billion,** with an additional **$1.2 billion in 2022 across 114 deals.**[2]

In 2022, **over 60% of investments went to downstream agtech** firms,[3] highlighting an **untapped opportunity** for investors to bring capital to on-farm and closer-to-farm CSA solutions.

CSA solutions also hold the potential to equip investors and lenders with the much-needed farm level data insights, driving home their **multidimensional impact** as well as ability to build economical gains across the value chain.

Mobilising Capital for India's Priority Sector

Providing timely support through concessional capital in the form of grants, equity, or debt can eventually lead to transformation of many emerging enterprises, which are building innovative solutions, into attractive investment opportunities.

Deploying patient capital, leveraging blended finance structures and adopting a holistic approach to build capacity for solution providers as well as users could pave the way for a climate focussed and financially viable investment approach for India's priority sector.

Recommendations for policy and finance

- Building capacity & awareness programmes for farmers
- Deploying patient capital to CSA focussed enterprises
- Enabling affordable and accessible finance for farmers
- Developing and enabling access to agricultural insurance products
- Enhancing credit and risk mitigation structures to commercial lenders

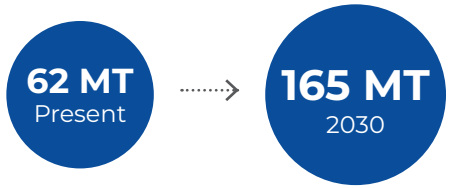
Waste Management & Material Circularity

Managing Waste: India's Surmounting Challenge

India's **increasing population** and its diverse forms of waste make the waste management process carried out by local municipal authorities very complex. The unorganised and informal nature of waste collection and segregation warrant the emergence of innovative solutions and enterprises that process waste.

Therein lies an opportunity to invest in a sector converging between climate action and social impact.

Municipal waste generated annually[1]



Growing Demand for Waste Management Solutions

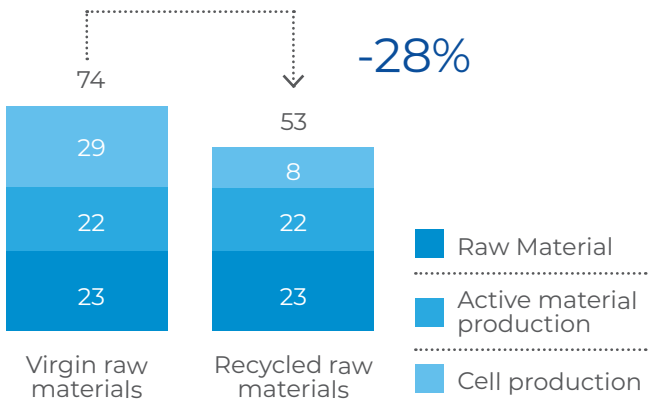
Given the underlying waste generating industries such as of **Electric Vehicles (EV)s, consumer electronics, packaging and construction continue to grow,** the Indian market for a **circular economy practices is pegged at growing to $45 billion by 2030[2].**

Despite this promising outlook, investments in waste management solutions are yet to gain traction. As per IIC's analysis, startup enterprises in this sector attracted only $159 million in equity investments between 2020 and 2022. This highlights a substantial untapped opportunity to invest in innovation and scale that can bring efficiency to the waste management process across diverse streams. Within this ambit, one space, viz, **battery recycling,** stands out for its increasing relevance and demand potential in India's clean energy transition.

Battery Recycling: A Special Mention

An increasing demand for Lithium (Li) batteries across various applications such as **EVs, grid storage, and electronic devices drives demand for battery recycling solutions.** The growing demand for lithium raw materials and battery recycling makes a compelling case for low-cost early-stage capital to support the development and scale up of such solutions.

Total CO_2 emissions from battery cell production



Source: *Battery recycling takes the driver's seat - Mckinsey*

An Increasing Policy Priority

National policies such as the EPR and Battery Management Rules encourage waste management practices by waste producers giving impetus to an increasing demand for such solutions. As local municipal authorities recognise the imperative to manage waste sustainably, there is a case for supporting private enterprises who build value linkages.

A Case for Development & Commercial Finance

The sector holds high potential for **low cost concessional capital** to build technical and technological capacity across the value chain and foster ecosystem collaborations as well as crowd-in commercial capital.

The high demand outlook, growing application industries and technological innovations create a fertile space for more **impact investments to build capacity of early and growth-stage enterprises.**

These comprehensive approaches, deployed at scale, are pivotal for nurturing the waste management ecosystem, ensuring its sustainability and long-term impact.

Recommendations for policy and finance

- Building capacity programmes for the unorganised waste picker workforce
- Preparing technical and project level guidance for implementing waste management projects
- Facilitating strategic collaborations and partnerships
- Deploying early-stage capital to foster R&D efforts and build technological innovations
- Enhancing credit and de-risking mechanisms to commercial lenders

A Glimpse of Sectoral Needs

Having explored the four sectors in brief, we can comprehend their pivotal roles in achieving decarbonisation, facilitating clean energy transition, and transforming India's priority industries. These emerging sectors are still in their nascent stages, offering not only significant investment opportunities, but also demanding support from both the public and private sectors to achieve scale. Within the scope of our report, each of these emerging sectors, albeit at varying stages of maturity, shares a common need for specific interventions. This section outlines the areas where essential interventions are imperative to drive progress in India's sustainable development journey.

Nourish the Entire Value Chain

- Invest in supply-side interventions & build economies of scale
- Enable demand creation across application areas

Enable Technical Assistance

- Earmark funds for technical assistance in addition to direct financial investments
- Ensure efficiency of operations and effectiveness of impact

Explore Blended Finance Structures

- Explore blending of different forms of capital to support emerging solutions with high potential for long-term growth.

Nurture Innovation

- Invest in early and growth-stage enterprises for building commercially viable businesses
- Provide patient capital, commensurate with the developing stage of the sector

Strengthen the ecosystem

- Build cross-linkages for technical and financial synergies between ecosystem players including civil society and government organisations
- Foster public and private partnerships for innovation and commercialisation of green technologies and solutions

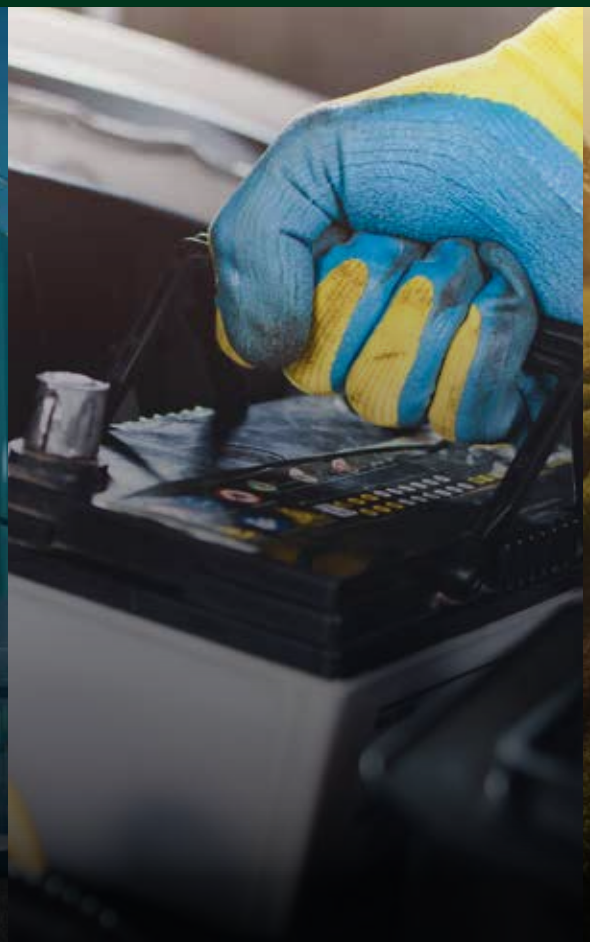
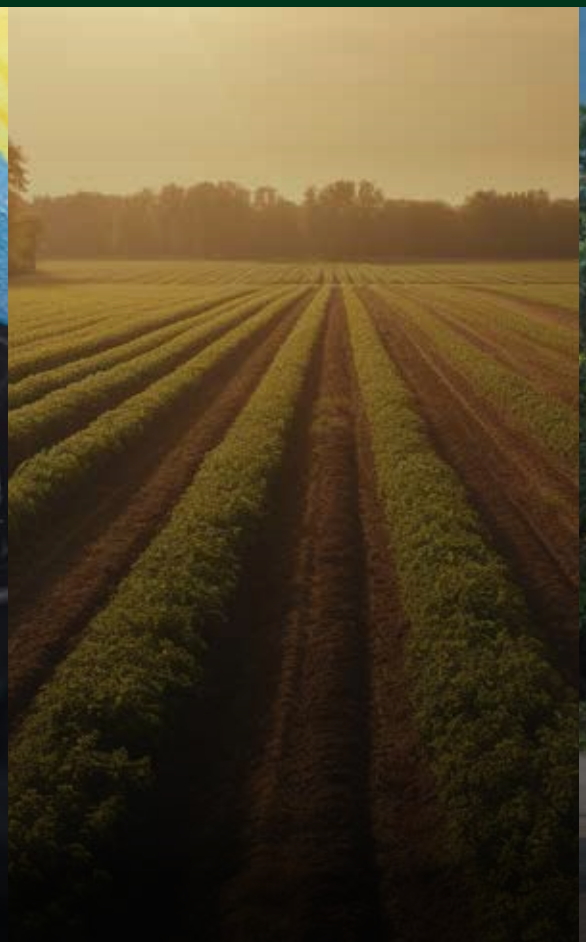
Align with Policy

- Develop an investment strategy to complement policy and regulatory enablers

In the following sections, we will delve deeper into each sectors for a comprehensive understanding of their investment potential and their contribution to reducing climate impact.

Green Investment Opportunities

SUB-SECTOR DEEP DIVES


Energy and Industry Transformation:

GREEN HYDROGEN

THE KEY TO DECARBONISATION

Replacement for carbon-intensive grey hydrogen

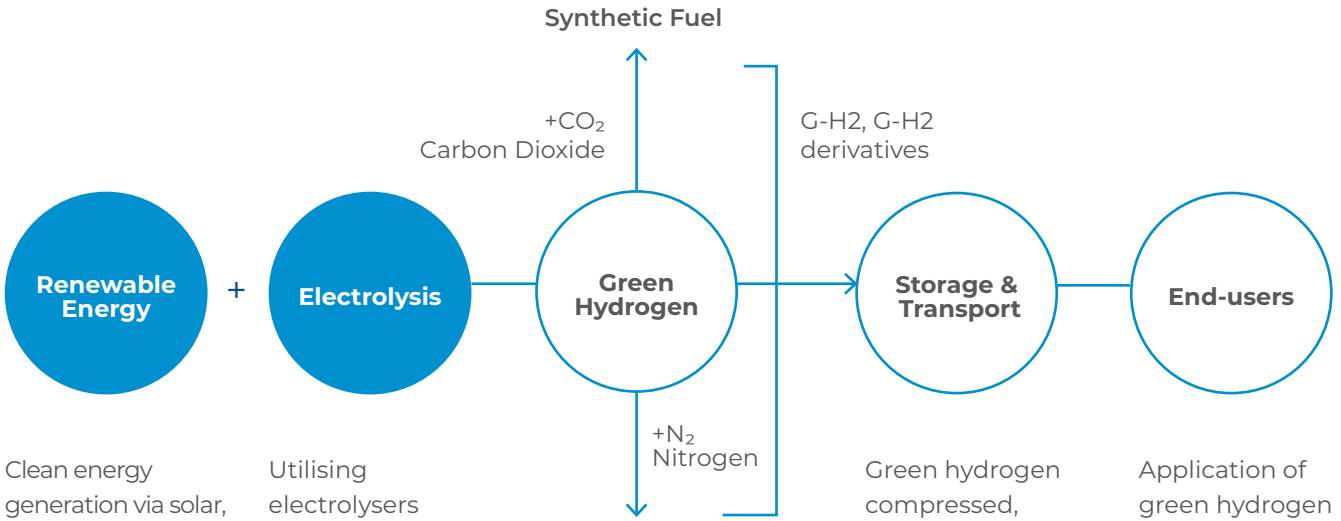
High potential to abate CO_2: 3.6 GT by 2050[1]

Scope for application: Fertilisers, refining and steel among others

The Potential of Green Hydrogen: A Path to Decarbonisation

Grey hydrogen finds application in industrial uses such as refineries and as feedstock to produce ammonia and methanol[2]. Green hydrogen (G-H2), a low-carbon alternative, can play a **critical role in enabling deep decarbonisation of many sectors such as steel, fertilisers, refining, and maritime shipping, which are a major contributor of CO_2 emissions.**

Green Hydrogen Value Chain



Clean energy generation via solar, hydro & wind

Key Players: Adani Green, ACME Solar, Greenko, ReNew, Avaada Energy, NTPC

Utilising electrolysers to split water into oxygen & hydrogen

Key Players: h2e Power, NewTrace, Ohmium, NTPC

Key Players Greenko, Avaada Energy, Hygenco, NTPC, Oil India, ONGC

Green hydrogen compressed, stored & transported via shipping, pipelines and trucks

Key Players: C&E Midstream (CEM), Linde Engineering

Application of green hydrogen to industry, transport, heating, power generation, energy storage

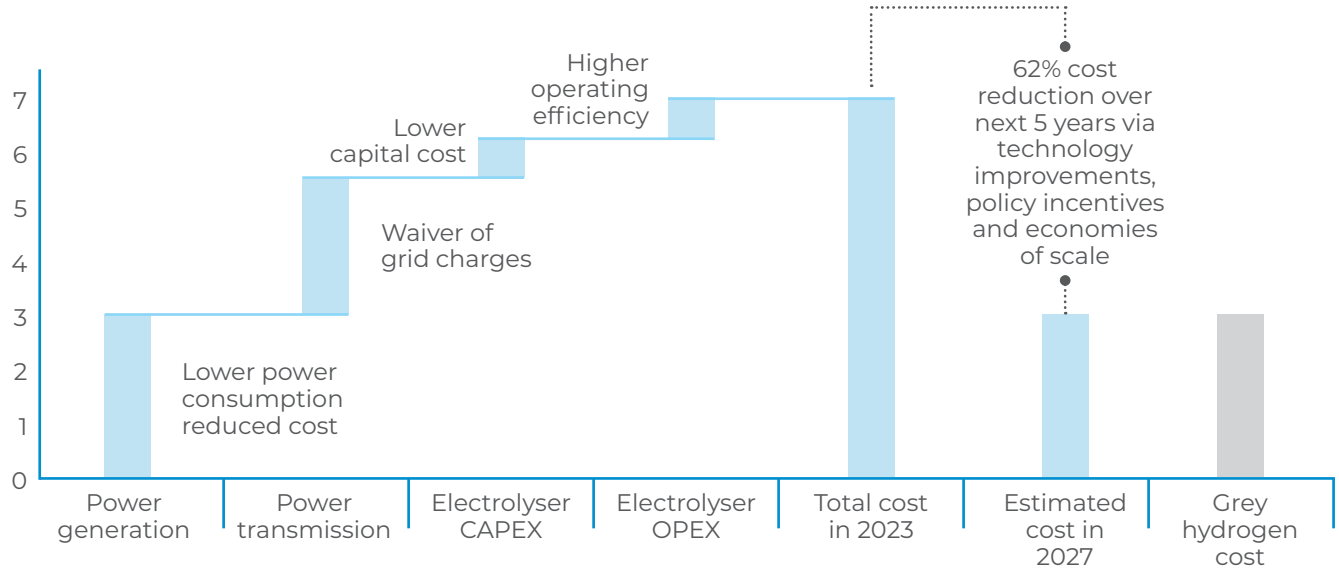
Short-term Applications: Fertilisers, Oil Refineries, Gas Blending

Source: Authors, 2023

Decoding the G-H2 Sector

- Hydrogen is an existing fuel/feedstock for several critical industrial sectors. G-H2 made from renewable sources accounts for less than 1% of global production[3] but holds great potential for scale given its pivotal role in decarbonising the economy and is the **second most important decarbonisation lever after electrification and renewable energy (RE).**
- Market demand is currently in nascent stages but significant interest from **public sector undertakings (PSUs), early-stage startups and SMEs, as well as large corporates,** active across the G-H2 value chain, hold promise to provide value to several end-use sectors, especially with **increasing policy impetus to scaling up G-H2.**
- Key imperatives to build the supply chain for G-H2 would entail greater investment towards **renewable energy production, electrolyser manufacturing and G-H2 production.**

G-H2 costs 2-3 times more than Grey Hydrogen[4]



Source: *Bridge to India Research*

Electricity and Electrolysers: Driving the long-term price trajectory of G-H2

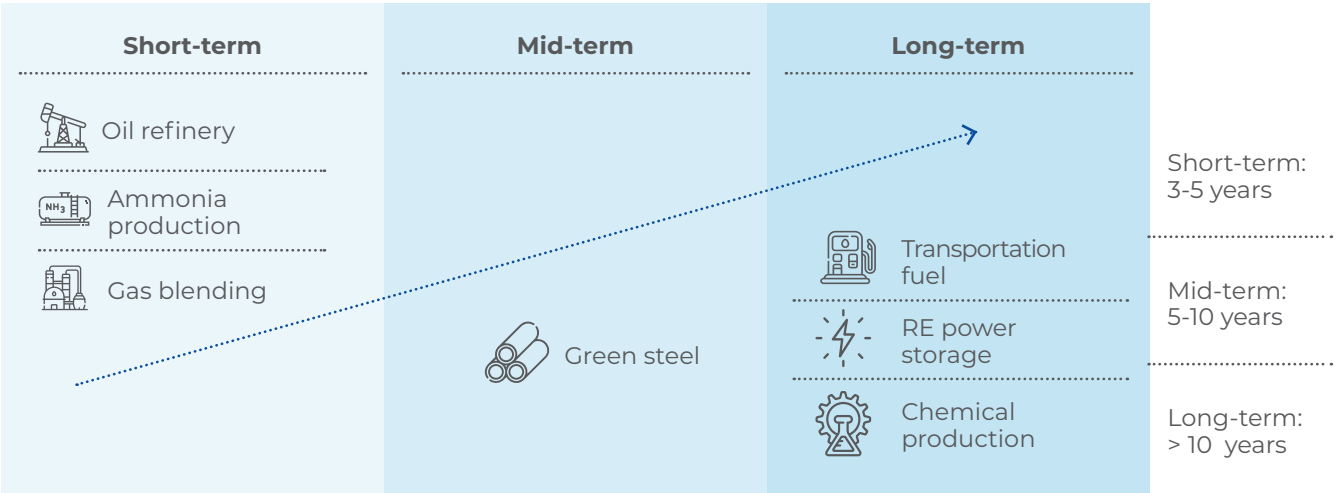
Key cost components: electricity, electrolysers, and storage & transport. The cost structure is*:

- **Electrolyser plants:** $475–750/KWh
- **Electricity cost:** $40–60/MWh
- **Operational expenses:** 3–5% of capex
- **Storage and transportation:** $1–2/kg
- **Capacity utilisation:** 18–32%.

Overall, depending on the electrolyser technology, cost of RE supply and the mode of hydrogen storage and transport, the total cost of delivered G-H2 ranges at $4-9/kg. It is expected to reach ~$2/kg by 2030[5].

*Refer Annexure: G-H2 production cost components

Demand to grow more than fourfold by 2050, representing 10% of global demand[6]



Source: *Green hydrogen: Hype or game changer? (A 2022 CRISIL Report)*

This table shows expected sectoral demand and investment potential by 2030[7].

Demand Areas	Estimated Annual Consumption of G-H2 (by 2030)	G-H2 Investment Potential ($)
Oil refining	1.8 MMT	32.5 billion
Gas blending	0.54 MMT	9.7 billion
Fertiliser industry	1.32 MMT	28.5 billion
Exports (G-H2 & Ammonia)	1.25 MMT	26.9 billion
Others*	0.1 MMT	1.7 billion

*Others comprise of the steel, methanol and transportation industries

Key Trends

Renewable Energy

Increasing RE penetration. Focus on energy storage for supply of round-the-clock power.

G-H2 Production

Investments in decentralised production and centralised hydrogen hubs and valleys. Partnerships being formed between ecosystem players.

Electrolyser Production

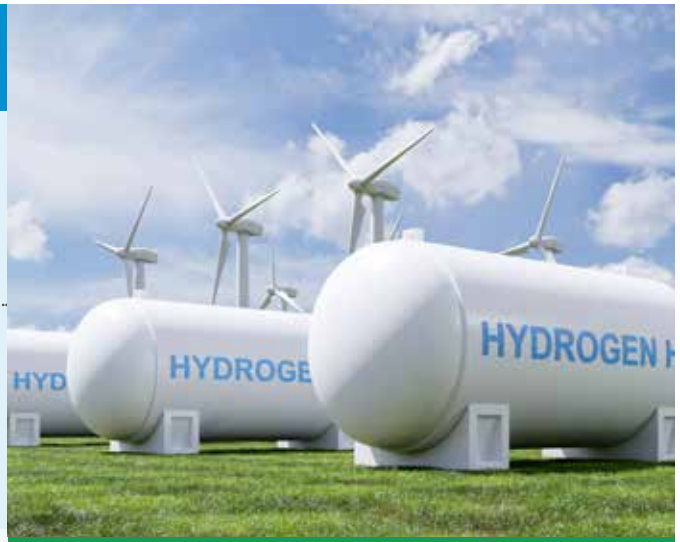
Tie-ups between international manufacturers and domestic G-H2 producers. Domestic manufacturing in early stages but scaling up.

Storage & Transport

Facilities yet to be fully developed. Scope for innovation and scale to emerge.

End-users

Early adopters: Oil refineries, ammonia producers & natural gas blending[8]. Large private conglomerates such as Reliance, Adani and L&T, and PSUs such as NTPC and IOCL have planned billion dollar investments in G-H2 production[9]. **Companies** focusing on creating **market linkages** and finding **export markets** to sell G-H2 and its derivatives.



G-H2 Demand Landscape at a Glance

- G-H2 with its high decarbonisation impact finds applications across several major high carbon emitting sectors.
- Currently **cost of production of G-H2 is high** (>$4/kg), making it economically unviable for consumption in end-use sectors.
- **Investments in scaling up RE, electrolyser manufacturing, G-H2 production, and transport and storage infrastructure needed** to drive down costs and build value chain.
- Near term projects to rely upon **strategic partnerships** and **synergic collaborations** to develop and strengthen supply chain.

Policy Initiatives: Paving the Way for India's G-H2 Pathway

2021

National Hydrogen Mission[10]

Making India a global hub for manufacturing electrolysers while creating domestic demand and undertaking R&D activities.

2022

Green Hydrogen/ Ammonia Policy[11]

Enabling access to low-cost RE for G-H2 production via measures such as open access, banking of unconsumed RE, waiver of inter-state transmission charges, etc.

2023

National Hydrogen Mission[12]

Launching a comprehensive policy framework for creating an enabling ecosystem for G-H2 deployment in the country and achieving at least 5 MMT/annum G-H2 production capacity and associated 125 GW of RE capacity by 2030.

Green Hydrogen Standards[13]

Establishing emission thresholds for 'green' category hydrogen production in recently defined Green Hydrogen Standard by the Ministry of New and Renewable Energy (MNRE).

Landmark Policy: The National Green Hydrogen Mission (NGHM)[14]

The overarching objective of the NGHM is to **achieve at least 5 MMT/annum G-H2 production capacity and associated 125 GW of RE capacity by 2030.**

As part of the **Strategic Interventions for Green Hydrogen Transition (SIGHT) programme,** under the NGHM, GoI has announced supply-side financial incentives for two types of activities:

- **Component I:** Financial incentives for **electrolyser manufacturing** in India. Total **capital outlay of ₹4,440 crore (~$622 million) allocated to provide viability gap funding.** Base incentive of ₹4,440/kW announced – to be tapered down over 5 years – and awarded based on a competitive bidding process.

- **Component II:** Financial incentives for **G-H2 production** in India. Total **capital outlay of ₹13,050 crore (~$2 billion) until 2030 allocated to provide viability gap funding.** Incentives capped at ₹50/kg in the first year, ₹40/kg in the second year, and ₹30/kg in the third year.

Green Hydrogen Standards 2023[15]

Definition

A well-to-gate emission (i.e., including water treatment, electrolysis, gas purification, drying and compression of hydrogen) of not more than 2 kg CO_2 equivalent/kg H_2.

Approach

A detailed **methodology for measurement, reporting, monitoring, on-site verification, and certification** of G-H2 and its derivatives to be specified by the MNRE, with the Bureau of Energy Efficiency (BEE) being the **nodal authority** for monitoring, verification and certification of G-H2 production projects.

Impact on Industry

- Provides industry with a criteria for defining G-H2 based on the emissions footprint, compared to alternatives.

- Enables development of processes for monitoring, evaluation, verification and certification of G-H2 projects.

Summary of the Policy's Catalysing Role

- Policy measures collectively reflect government's commitment to support the **development of G-H2 sector** in the country.
- Current policy and regulatory interventions focused on incentivising private investments by **defining standards and providing supply-side incentives.**
- **Demand-side interventions needed** to create lead markets and drive investments across the value chain.

The Funding Initiatives

As policy interventions continue, the sector has been seeing investments in enterprises engaged across the value chain, including large-scale projects as well as cost effective innovation. Given the evolving nature of technologies involved, increasing sources and quantum of funding hold potential to build the sector.

	Development Finance Institutions (DFIs) Pledge Investment Support to GoI			Equity Investments Support Innovation		
	European Investment Bank	THE WORLD BANK	ADB ASIAN DEVELOPMENT BANK	NEEV FUND	Aavishkaar CAPITAL SEQUOIA	Gruhas
	European Investment Bank	**World Bank**	**Asian Development Bank**	**The Neev Fund**	**Aavishkaar Capital, Sequoia Capital**	**Gruhas**
Amount	**€1 billion loan facility**	**$1.5 billion loan**	**$20-$25 billion loan over 5 years**	**$25 million towards Hygenco**	**$5.65 million towards NewTrace**	**$2.4 million towards Ossus Biorenewables**
Use of Proceeds	Establishing large-scale G-H2 hubs and projects[16].	Scaling renewables, G-H2, stimulating climate finance[17].	Supporting transport, energy transition, carbon markets, G-H2, circular economy[18].	Early-stage capital support for green hydrogen production facilities[19].	Early-stage capital support for commercial deployment of innovative, low cost electrolyser technology[20].	Early-stage capital support towards innovative G-H2 production process with waste carbon as input[21].
	Debt Financing			Equity Financing		

Sector Level Challenges to Scaling Investments

While the sector has been seeing investments across the value chain, it remains characterised by challenges that limit funding at scale. These include:

- **High cost of production:** Current cost of G-H2 production above $5/kg (largely as per cost of RE and electrolysers), against $1–2/kg for grey hydrogen[22].
- **Supply chains yet to be established:** Large scale addition of RE capacity, modernised electricity grids, hydrogen pipelines and storage facilities at an evolving stage.
- **Lack of visibility regarding demand:** Restricted foresight into forthcoming G-H2 demand, influenced by cost economics and the absence of government mandates.

Investment Risks for Electrolyser Manufacturing

- **Supply chain linkages:** Most metals and minerals (nickel, platinum group metals and rare earth metals like lanthanum, yttrium and zirconium)[23] required for manufacturing electrolysers concentrated in specific geographies, presenting supply chain risk to manufacturers.
- **Supply–demand gap:** Technological innovations to build efficiency and reduce costs, still at an evolving stage, with further investments hampered by ambiguity over demand offtake.

Investment Risks for G-H2 Production

- **Off-take risk**: Absence of long-term offtake contracts (specifying both price and volume) with strong counter-parties leading to uncertainty of revenues[24] .
- **Project completion risk:** G-H2 projects require integration of various technologies and are faced with significant risks during early development and construction phases[25].
- **Infrastructure development:** Underdeveloped infrastructure for G-H2 transportation and storage infrastructure as well as grid infrastructure for absorbing increasing levels of RE.

Essential Funding Avenues to Drive Down Costs

- **Investments in supporting infrastructure** (e.g., electricity grids, RE, hydrogen transport and storage systems, manufacturing hubs) **needed in parallel** from both public and private sectors.
- G-H2 prices are determined largely by the cost of electrolysers and RE. Therefore, a substantial imperative exists to establish electrolyser manufacturing, either through the utilisation of existing technologies **to achieve scalability** or the innovation of novel ones **and to lower RE costs to further lower production costs.**

Emerging Business Models: Investment Announcements by the Industry

The initiatives listed indicate emergence of business model strategies that seek to address various investment risks and barriers arising from the need for technology demonstration and the development of functioning market and value chain for G-H2 and its derivatives.

Announcements

NTPC[26]

To develop a G-H2 hub in Andhra Pradesh consisting of RE, G-H2 and ammonia production, and manufacturing of clean technologies.Hub to cater to domestic and international demand.

ACME Group[27]

Agreement with Tata Steel Special Economic Zone in Odisha to set up a large-scale G-H2 and ammonia production plants. Access to Gopalpur Port Facility for transport and exports to international markets.

Amplus Solar[28]

MoU with state government of Andhra Pradesh to set up multiple decentralised G-H2 plants for consumption in multiple industries.

Hygenco[29]

G-H2 offtake agreement with Jindal Stainless to build, own and operate a multi-megawatt G-H2 facility. India's first long-term off-take agreement.

Larsen & Toubro[30]

Joint venture with industry majors ReNew and Indian Oil Corporation to undertake large-scale investments in G-H2 and derivatives.

Key Features

Large-scale centralised model, combining investments in critical supporting infrastructure, manufacturing and deployment to capitalise on synergies and minimise costs.

Moderate-scale centralised production model. Leverages existing infrastructure for storage, logistics and exports.

Small-scale decentralised production model to supply G-H2 to multiple off-takers closer to consumption centers. Reduced need for transportation.

Assured off-take of green hydrogen to manage demand (price and volume) risk.

Strategic partnerships with industry players leveraging expertise. Co-investments for risk sharing and scaling up investments.

Business Model Variables

RE Generation
On-site Generation
Off-site Generation with Transmission

G-H2 Production
Centralised & Decentralised Production

Transportation
Pipelines, Trucks, Ships

Storage
Salt & Rock Caverns, Depleted Oil Fields, Tanks

Case Study – How a DFI is Driving G-H2 Projects[31]

Overview

- KfW launched the world's first G-H2 financing platform and set up the **PtX Development Fund and PtX Growth Fund.**
- PtX (Power to X) means turning renewable energy like solar and wind into hydrogen.
- Germany has allocated €550 million for G-H2 in developing countries and €300 million for European company projects.
- The PtX Development Fund aids local value chains and hydrogen use in developing nations.
- The PtX Growth Fund supports international G-H2 market expansion with European company involvement.

Impact Created

- KfW Group's PtX Platform offers **funding and financial advisory** for large-scale PtX projects outside Europe, acting as both a funding platform and advisor.
- It offers **tailored financing** (grants, debt, equity) to boost bankability in non-EU industrial PtX projects, supporting green hydrogen projects worldwide.
- It enables **knowledge-sharing** by allowing German and Germany-affiliated companies to invest in non-European Union (EU)/European Free Trade Association (EFTA) PtX projects.

How the Platform Works

The two funds launch regular calls for expressions of interest (EoIs) for qualified applicants

The applicants apply for grant financing by the funds and an optional/ additional KfW-financing (grant, equity, debt)

In accordance with the ministries, KfW selects projects that receive the grants after a selection process based on a clearly defined criteria

KfW provides a customised and financing package, potentially consisting of grants, equity and debt financing

The Financing Structure[32]

Project Funding through the PtX - Platform

Source: *KfW*

Other Instances of Support Extended by DFIs

World Bank & IFC[33]:

Offer **strategy & policy development, legal & regulatory framework build-up, capacity building** support to emerging G-H2 economies.

World Bank's Hydrogen for Development (H4D) Partnership[34]:

H4D drives substantial hydrogen investment from public and private sectors, fostering capacity, regulations, and technology rollout for low-carbon hydrogen in developing nations.

United Nations' Green Climate Fund (GCF)[35]:

Joined hands with IDB for **first regional fund** to promote electric mobility (e-mobility) and G-H2 in Latin America and the Caribbean.

European Investment Bank[36]:

Supports G-H2 projects via its funding platform, **InnovFin Energy Demonstration Projects,** to help finance innovative first-of-a-kind demonstration projects

Inter-American Development Bank (IDB)[37]:

Provides **pre-feasibility studies, legal advice to governments.**

The aforementioned case studies exemplify a DFI's role in funding G-H2 projects via financial and technical assistance. It underscores the essential role of development finance in advancing the G-H2 value chain.

Case Study – The UK–India Partnership for Advancing Electrolyser Manufacturing in India[38]

The following case study exemplifies the critical role of partnerships in fostering the development of the Indian G-H2 ecosystem. This illustrative example showcases the transformative power of collaboration between countries in driving sustainable solutions for our energy needs and how the government can forge more such partnerships to build the supply chain and disseminate knowledge and expertise among the stakeholders.

Programme

Accelerating Smart Power and Renewable Energy in India

Entities involved

A bilateral programme between the **Foreign, Commonwealth and Development Office (FCDO)** and the **Ministry of Power** and the **MNRE**

Objective

To support the state government of Tamil Nadu to understand the value chain for electrolyser manufacturing via an assessment study.

Project description

- Analyse production chain for localising electrolyser manufacturing.
- Provide actionable policy recommendations to enable and facilitate electrolyser manufacturing, fostering a favourable investment environment in Tamil Nadu.
- Enhance knowledge and skills in electrolyser manufacturing, empowering local companies to participate in the G-H2 industry.

Expected outcome

Improved investment environment in Tamil Nadu and enhanced knowledge and skills in electrolyser manufacturing.

Investor Preview: A Snapshot of the Landscape

Country Priority	**High**	• Government aspiration to position India as a global hub for the production, usage, and export of green hydrogen • Achieve 5 MMT/annum green hydrogen production capacity by 2030[39] • Support the development of green hydrogen infrastructure
Policy environment	**Supportive**	• Supply-side financial incentives announced to promote commercial production of green hydrogen and electrolyser manufacturing • Budget outlay of ₹19,744 crore (~$2.38 billion) prescribed[40] • Emission standards prescribed • Scope to implement demand-side interventions for assurance of demand offtake
Mitigation potential	**High**	• Scope to abate 3.6 $GtCO_2$ by 2050[41] • Second most important decarbonisation lever for the economy after electrification with clean energy • Critical for decarbonising several transport and industrial sectors such as steel, ammonia, methanol, shipping, etc. • Zero-carbon hydrogen (counting direct Scope I and II emissions) possible using electrolysis
Technology complexity	**Moderate to High**	**Technology readiness** — **Moderate to High**
Commercial readiness	**Moderate**	• High scope of application across major high carbon emitting sectors • Demand expected to pick up with reduction in input costs and introduction of economic incentives for application sectors • Investments in storage, transportation and hub infrastructure required to support the predicted demand • Large volumes of investment announcements by large players and investments in SMEs being observed
Enterprise types	• Startups and SMEs deploying technologies across the value chain • Large corporations setting up integrated projects	
Investment / Funding suitability	**Equity & Debt Capital**	• Towards large-scale integrated projects being implemented by MSMEs
	Early-Stage Equity & Grant Capital	• Towards startups and SMEs across the value chain

*Please note that the ratings provided on a "High to Low" scale here are subjective, based on the authors' analysis and stakeholder inputs, and may not precisely mirror the market reality.

What is Needed: A Systemic Approach

Reducing Input Costs

Increasing capacity of RE and electrolysers to in turn achieve economies of scale

Assuring Demand Off-take

Demand-side incentives or policy mandates to ensure long-term consistent offtake

Developing Value Chain

Focus on upstream, midstream and downstream linkages

Fostering Innovation

Building technological advancements to enhance efficiency and reduce cost of production processes

Fostering Collaborations

Collaborations and ecosystem partnerships between different value chain players

What is Needed: Policy

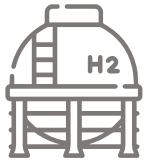
The successful advancement of the G-H2 sector hinges on a synergistic partnership between the government and the private sector. While the government sets the policy framework and provides a conducive ecosystem, the private sector brings innovation, expertise, and investment to drive tangible outcomes. This collaboration creates a dynamic environment where policy incentives and market-driven solutions converge, accelerating the adoption of G-H2 technologies. The following section highlights the policy interventions that the government should execute to build the G-H2 ecosystem in the country.

Defining sectoral transition pathway and setting decarbonisation targets

Develop sector-specific net-zero emissions (NZE) pathways and set interim and long-term decarbonisation targets.

DFIs, Industry, Academia

Advisory support for developing sectoral low-carbon transition roadmaps/ pathways (at national and sub-national levels).



Harmonising hydrogen standards and certification schemes

Harmonise G-H2 production, handling and safety standards with global norms to facilitate trade. Develop certification processes and quality standards for G-H2 projects.

DFIs & Philanthropic Foundations

Knowledge-sharing resources, international best practices, guiding principles and certification standards for G-H2 projects.

Introducing demand-side incentives/ mandates

Hydrogen Purchase Obligations (HPOs) for firm demand from end-user sectors. Green public procurement to create demand for green products such as steel.

DFIs

Advisory support for identifying suitable policy and fiscal instruments and developing guidelines/ frameworks to create G-H2 demand.

Supporting infrastructure

Investments in hubs, ports, storage and transportation infrastructure for G-H2 and its derivatives.

DFIs & Industry Bodies

Project preparation advisory and technical support. Facilitating public-private projects and co-financing of infrastructure projects.

Carbon pricing mechanisms and Carbon Contract for Differences (CCfDs)

Well designed national carbon market can help level the playing field between green and conventional technologies. CCfDs for unviable projects in the initial stages of market development.

DFIs

Technical assistance and financial support for development of the national carbon market and for CCfD programmes for high-emitting, hard-to-abate sectors.

What is Needed: Capital

Building upon policy interventions, there is immense scope for private capital inflows to build financial as well as technical capacity for the sector. The following section highlights the interventions that ecosystem players can implement by advancing capital support.

Financial and Technical Assistance for Ecosystem Building

Challenges

High cost of green hydrogen

Nature of support

Supporting innovation and scale-up of electrolyser manufacturing

Intervention*

R&D Funding and Technical Assistance for Startups and SMEs

- Dedicated R&D funding and early-stage technical, knowledge sharing and mentorship support to startups engaged in electrolyser manufacturing.
- Collaboration with industry bodies for creating knowledge-sharing centres to help SMEs gain technical assistance, further fostering R&D.

Financing Programmes for Commercialisation of Technologies

- Public–private partnerships for setting up demonstration funds to support innovative technologies cross the valley of death and reach
- Investment funds with flexibility to extend grant/equity/debt/ hybrid financing instrument to support early and growth-stage enterprises.

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations, Incubators, Accelerators

Supporting actors:

Think Tanks, Industry Associations

Financing actors:

Corporates, DFIs, Philanthropic Foundations, Impact Investors (VCs), PE, NBFCs

Challenges

High cost of green hydrogen

Nature of support

Lowering the cost of Round-the-Clock (RTC) renewable power and scale production of G-H2

Intervention*

Blended Finance for RE, BESS and G-H2 Projects

- Use of concessional finance to provide low-cost, long-term financing for RTC (RE + Energy Storage Systems) and G-H2 production projects.

Credit Risk Mitigation

- Risk mitigation instruments such as credit guarantees and first loss default guarantee to improve risk appetite of lenders of RE + ESS and G-H2 projects.

Actors Involved

Financing actors:

DFIs, Commercial Banks

What is Needed: **Capital**

Financial and Technical Assistance for Ecosystem Building

Challenges

High cost of green hydrogen

Nature of support

Technical assistance and advisory support to G-H2 projects

Intervention*

Technical Assistance / Project Preparatory Facility for Project Developers

- Technical advisory (sharing best practices, standards and guidelines) and financial assistance (for undertaking technical feasibility studies, impact assessment, etc.) to project developers for development and implementation of pilot projects across G-H2 value chain.
- Extend financial advisory to financing intermediaries for pre-investment feasibility studies and designing of financial structures.

Market Access Platform for Value Chain Entities

- Platform linking upstream, midstream and downstream players with prospective funders, enabling price discovery and fostering partnerships.

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Implementing actors:

Industry Associations, Think Tanks, Consulting Firms

Challenges

High cost of green hydrogen

Nature of support

Investments in G-H2 storage and transport infrastructure

Intervention*

Infrastructure Fund/Financing Facility

- A public–private partnership fund / financing facility to undertake investments in hubs, and pilot and commercial scale transportation and storage projects.

Actors Involved

Financing actors:

DFIs, Corporates, Impact Investors (VCs), PEs, Commercial Banks

*Note: Some of the interventions proposed here may have already been put into action, however, given the scope of application, the table suggests actions for implementation at scale.

Energy Transformation

BATTERY ENERGY STORAGE SYSTEMS

Fuelling the Clean Energy Transition

- Scaling robustness for RE projects
- Integral to EV Charging Infrastructure
- Building a reliable and robust clean energy system

The case for Lithium-Ion Batteries

Within ESS, electrochemical storage, specifically lithium-ion batteries (LIBs), has emerged as a rapidly expanding domain due to its applications in stationary storage, transportation and power grid management. These storage systems are valuable towards ensuring stability of the electricity grid, enhancing the integration of renewable energy sources and scaling up deployment of EVs. LIBs offer distinct advantages, including high power and energy density, extended operational lifespan, and reduced maintenance costs[1].

Understanding the BESS Value Chain

Material Sourcing

Mining critical minerals like lithium, cobalt and nickel

Cell Component Manufacturing

Manufacturing/ chemical processing of components like anodes, cathodes, electrodes, separators & casings

Players: Himadri, Epsilon Carbon, Allox

Cell Manufacturing

Manufacturing cells from cell components

Players: Log9 Materials, Godi Energy, Amara Raja, e-TRNL

Battery Pack Manufacturing & Assembling

Configuring cells into battery packs and battery modules

Players: Amara Raja, Exide, Log9 Materials, Cygni Energy

Deploying

Project developers engaged in integration and deployment of batteries across different applications.

Key Players: Greenko, Fluence India ReNew Power

Stationary Storage Applications (SSAs)

BESS improves integration of variable utility-scale RE and enables provision of Round-the-Clock (RTC) power.

It reduces RE curtailment through distributed-scale and off-grid RE systems for commercial, industrial and residential (behind-the-metre) applications.

Improves RE dispatchability, firmness and penetration, ensuring stable power supply.

e-Mobility

Application in EVs (2Ws, 3Ws and 4Ws) and supporting infrastructure (battery-as-a-service, battery swapping, RE + BESS charging stations).

Grid Management & Ancillary Services

BESS can improve grid resilience and power system flexibility through peak load management and energy arbitrage.

It can provide ancillary services such as frequency response, voltage control, black start, etc., to maintain grid reliability and power quality. It also optimises transmission capacity and reduces network congestion.

*We have excluded consumer electronics from the possible applications since our focus is on sectors with a climate impact.

Source: Authors, 2023

Leveraging BESS for India's Green Transition

BESS is critical for India to ensure a **sustainable scale up** of key climate impact sectors such as RE and clean mobility.

LIBs are gaining prominence over lead acid batteries (LABs) given their **more superior performance and rapidly declining costs.**

Alternate cell chemistries are being developed (such as sodium-ion batteries), indicating an opportunity to explore, invest and develop **an ecosystem for alternative cell chemistries**[2]**.**

Deployment of LIBs is mainly expected in **stationary storage and transportation,** and high-value utilisation in **ancillary services.**

The LIB Demand Outlook: A Multi-Billion Dollar Opportunity

LIB Demand Potential[6] (GWh/Year)	Electric Vehicles (GWh/Year)			Stationary Storage & Other Grid Applications (GWh/Year)			Market Potential[7] ($ billion/Year)		
	2022	2026	2030	2022	2026	2030	2022	2026	2030
Conservative*	4	20	46	0	10	46	1	3	6
Accelerated**	11	51	130	0	25	128	2	6	15

*Assumes battery demand rises in line with the most conservative expert forecasts

**Assumes the current policy momentum for EVs, renewables, and other end-use applications

India aims to have EV sales accounting for 30% of private cars, 70% for commercial vehicles and 80% for 2Ws and 3Ws by 2030[3].

Rules mandating a shift from diesel gensets to cleaner energy, thus promoting energy storage systems[4].

Need for ESS to integrate variable RE. Recently discovered hybrid RE + BESS tariffs stand competitive against new thermal power[5].

BESS: Other Drivers

Rapidly declining costs: LIB costs have fallen over 90% in the last decade[8] and are expected to fall further to $100/kWh by 2023 and $58/kWh by 2030[9].

Strengthening policy & regulatory environment: This has been good news for application of BESS in stationary storage and grid management.

Roll-back of net-metering policies: This has led to reduction of credits for sending excess energy back to the grid. It incentivises energy storage and maximisation of self-consumption in distributed applications[10].

Repurposing of EV battery packs for second-life application: This has resulted in second life application in energy storage services that thereby adding salvage value and improving life cycle economics[11].

Emerging Industry Trends

Cell Component Manufacturing	Cell Manufacturing	Battery Pack Manufacturing & Assembling	Deployment
Expected to pick up pace as cell manufacturing scales up.	**Cells:** **65% of total cost** [12] Currently large dependence on imports. Domestic production capacities/ Gigafactories being established. New cell chemistries being developed.	**Batteries:** **15% of total cost**[13] Battery pack manufacturers & assemblers moving from LABs to LIBs. Backward integration noted as they move towards cell production.	SMEs and large project developers deploying batteries in various applications. Massive scale up in deployment expected over next few years.

Key Trends

Source: Authors, 2023

Decoding the Industry Dynamics

- The immediate requirement is to accelerate **deployment of BESS and scale-up of cell and battery manufacturing facilities** in India to meet the growing demand.
- Adequate funding is crucial to support **R&D efforts, technology innovation, and infrastructure development across the value chain.**

Powering BESS Growth: Key Policy Enablers

2021

- **National Programme on Advanced Cell Chemistry (ACC) Battery Storage:** PLI scheme launched worth $2.4 billion to promote domestic cell manufacturing[14].
- **The Electricity (Promotion of Generation of Electricity from Must-Run Power Plant) Rules:** Mandating compensation for must-run RE plants to prevent curtailment, thus incentivizing ESS adoption[15].
- **ESS projects** commissioned before **October 1, 2023,** not required to pay **inter-state transmission charges for 25 years**[16].

2022

- **Electricity (Amendment) Rules, 2022:** Grant legal status to ESS[17].
- **Ancillary Services Regulation:** Term "energy storage" included under secondary and tertiary reserves with performance-based incentives by the Central Electricity Regulatory Commission(CEA)[18].
- **BESS guidelines:** Procurement and utilisation of BESS as part of generation, transmission and distribution assets, and ancillary services[19].
- **The Electricity (Rights of Consumers) Amendment Rules:** Mandates consumers using **diesel gensets** to transition to **cleaner energy within 5 years[20].**
- **Energy Storage Obligation:** RE along with storage to comprise 4% of total consumption of discoms by 2030**[21].**

2023

- **National Framework for Promoting Energy Storage Systems:** Launched for promoting energy storage systems including BESS[22].
- **No Customs Duty:** No duty on import of goods, machinery for making lithium-ion cells up to March 31, 2024[23].
- **Viability Gap Funding (VGF) Approved for BESS projects:**[24] Initial capital outlay of ₹9400 crore (~$ 1.1 billion), with budgetary support of ₹3760 crore (~$455 million) for development of 4,000 MWh of BESS projects by 2030-31. Financial support of up to 40% of the capital cost aimed to reach a levelised cost of storage of ₹5.5 - 6.6 ₹/kWh.
- Guidelines for the third phase under The **FAME** (Faster Adoption and Manufacturing of Electric Vehicles Scheme) drafted specifying an outlay of ₹40,000-₹50,000 Crore (~$5-$7 billion)[25]. This is a follow up to FAME I and FAME II aimed at financially incentivising the EV industry.

The National Framework for Promoting Energy Storage Systems (ESS): A Proposal to Support ESS[26]

The Framework released in August 2023, unveils a comprehensive strategy; a timeline for implementation of the same is yet to be specified

- **Sovereign green bonds** for funding green infrastructure. Financial institutions like Power Finance Corporation (PFC), Rural Electrification Corporation (REC) and Indian Renewable Energy Development Agency (IREDA) may extend **long-term loans to ESS projects.**
- Principles of reduce, reuse, and recycle may be included in the bidding documents of all ESS projects.
- Mandates for **ESS installation in new RE projects** above 5 MW.
- Investing in **R&D** of emerging and existing ESS technologies.
- ESS using RE for charging may be provided with **carbon credits,** improving project economics.
- **Tax incentives and exemption of Electricity Duty (ED) and Cross Subsidy Surcharge (CSS)** on input power. States may also exempt land acquisition for ESS.
- Central Electricity Authority (CEA) **safety and technical standards** may be updated to cover ESS.
- Financial assistance and advisory for PSUs to undertake **pilot/demonstration projects.**
- Standards for repurposing ESS components for reuse in different applications. **Guidelines for developing resource adequacy plans** incorporating ESS to be issued by Central Government in consultation with the CEA. CEA to also release long-term national resource adequacy plan for next 10 years.
- Comprehensive and integrated regulations and policies that govern ESS revenue sources to facilitate ease of doing business.
- ESS developers to offer **various market-based energy and power products,** encouraging financial and commercial viability.

Policy's Catalysing Role

The policies introduced by the Government of India signal a strong commitment **to promoting domestic battery manufacturing and battery energy storage.** As the policy environment strengthens there is an strong case for **continued action and detailed implementation plans** for value chain development, from both public and private players.

Enterprise Focus across Key Segments: A Closer Look

Cell Manufacturers

- Companies establishing large-scale cell manufacturing facilities
- MSMEs developing newer chemistries

Battery Pack Manufacturers & Assemblers

- Players establishing production capacities to ensure scalability
- Battery manufacturers & assemblers backward integrating as they move towards cell manufacturing

Project Developers

- Players developing RE + BESS projects for EVs, charging infrastructure and grid services

Sector Level Challenges towards Deployment & Scaling

Reliance on imports:

In 2020-21, the India LIB import bill stood at ~$1,193 million, with China and Hong Kong combined accounting for 87% of imports, presenting a risk of supply chain disruption and price volatility[27].

The absence of an established domestic supply chain for battery manufacturing is a critical challenge. Coupled with limited understanding with consumers and financers on emerging battery technologies and the high capital expenditure involved, this creates constraints for ecosystem-level investments at scale.

Challenges for Battery Storage Deployment Projects

- **High upfront costs** hinder RE + storage system adoption.
- **Consumers perceive** energy storage as **complex, unwanted, and costly.**
- Technical risk in **integrating cell packs and battery management systems** for safe charge/discharge.
- Lack of **clear policy framework** and **pricing mechanisms** for **ancillary services.**
- **Limited financial support** to early movers and **lack of access to low-cost, long-term financing,** particularly for small players.

Challenges for Cell Manufacturing, Battery Pack Manufacturing & Assembling

- Very **high capital investment** required to set-up manufacturing facilities.
- High technological complexity, **lack of technical skills and manufacturing capabilities.**
- Cost-effective supply of **critical raw materials** needed.
- **Significant R&D investment** and **continuous adaptation** needed to emerging technologies.

Overcoming Challenges to Secure the Supply Chain

- **High dependence on import of critical minerals and LIBs is challenging.** Battery recycling and reuse ecosystem needed to reduce its import dependence and meet increasing demand. **End-of-life batteries** also hold potential for **second life applications.**
- Investments in R&D of **alternative battery chemistries,** an important consideration for India to achieve sustainable supply chain less dependent on critical minerals.

Funding Landscape: Noteworthy Investments in SMEs and Startups

	Grinntech[28]	Cygni Energy[29]	Battery Smart[30]	Log9 Materials[31]	Godi Energy[32]
Priority Areas	To enhance performance of its EV batteries; and introduce high-tech batteries along with its proprietary IoT-enabled BMS.	To build a battery manufacturing gigafactory in Telangana and scale its manufacturing capacity by over 4x.	To expand its battery-swapping business across geographies.	To expand its battery manufacturing capabilities and commission India's first fully integrated lithium-ion cell production line.	To set up supercapacitor and lithium-ion cell manufacturing facilities across India.
Fund Raising	**(2021) $2 million (equity) from existing investors including HNIs**	**(2022) $12.5 million led by Meridian Global Ventures (equity) and Indian Overseas Bank (debt)**	**(2023) $33 million from Tiger Global, Blume Ventures, the Ecosystem Integrity Fund and British International Investment (equity)**	**(2023) $40 million led by Amara Raja Batteries and PETRONAS (equity+debt)**	**(2021) $4.52 million from Blue Ashva Capital (equity)**

Battery Pack Manufacturers & Assemblers

Battery Pack Manufacturers & Assemblers + Deployment

Deployment

Cell + Battery Pack Manufacturers & Assemblers

Industry Gears up: Investment Announcements

	Amara Raja[33]	Exide[34]	Ola Electric[35]	TDSG[36]	TATA Power[37]
Priority Areas	Gigafactory in Telangana to manufacture lithium-ion cells and batteries with an R&D centre.	Lithium-ion cell and battery manufacturing gigafactory in Bengaluru with a capacity of 6 GWh.	Manufacturing of electric cars; Lithium-ion cell gigafactories coming up in Tamil Nadu.	Lithium-ion cell and battery manufacturing plant in Gujarat. To produce 30 million cells/ year by 2025.	Lithium-ion cell and battery manufacturing gigafactory in Gujarat with capacity of 20 GwH.
Projects	**(2021) Planned investment of ~$1 billion over the next 10 years**	**(2022) Planned investment of ~$800 million over the next 8-10 years**	**(2023) Planned investment of ~$920 million**	**(2020) JV between Suzuki Motor Corp., Toshiba Corp. and Denso Corp. To invest ~$689 million over 2 phases**	**(2023) Planned investment of ~$1.58 billion**

Battery Pack Manufacturers & Assemblers

Battery Pack Manufacturers & Assemblers + Deployment

Deployment

Cell + Battery Pack Manufacturers & Assemblers

A Case for Collaborations[38]

India's first grid-scale battery-based energy storage system

Project Developers: TATA Power, AES Corporation, Mitsubishi Corporation
BESS Deployer: Fluence India

The 10 MWh grid connected system, located at Delhi, is being operated by Tata Power Delhi Distribution Limited (Tata Power-DDL) and provides grid stabilisation, better peak load management, added system flexibility, enhanced reliability thereby protecting critical facilities for 2 million consumers served by Tata Power-DDL. **Fluence India** acts as the technology provider for deployment of battery storage.

Such collaborations between project developers and BESS deployers highlight the potential for collaborations resulting in the development of the BESS value chain.

Case Study - Building Global Alliances

Global Energy Storage Program : A Collaborative Effort[39]

The Global Energy Storage Program (GESP) is a funding window under the Clean Technology Fund (CTF) - one of the two multi-donor trust funds of the Climate Investment Funds (CIF)- making CIF the world's largest multilateral fund supporting energy storage. GESP is a global partnership of governments, development finance institutions, and private corporations committed to delivering on a climate-smarter future through energy storage technologies.

Scope of the Programme

Storage systems, including, but not limited to, gravity-based technologies, thermal storage, and electrochemical batteries

Large-scale demonstration projects supporting less mature, but technically viable, long-duration storage technologies

Solar, wind, and hybrid power projects with storage for grid services; Mini-grids and distributed energy applications

Policy and regulatory reforms that promote:

- Battery recycling
- Environmentally friendly storage technologies
- Participation of full range of energy storage services

International cooperation initiatives to address key research, development, and knowledge gaps

Geographies covered:

Sub-Saharan Africa, Middle East & North Africa, Asia, Europe & Central Asia, Latin America & The Caribbean

Funding from CIF is only accessible through DFIs who serve as implementing partners.

Programme focuses on concessional finance, including but not limited to grants, to mobilise DFIs as well as other public and private sector financing.

Emulating a programme of this caliber can help solve the sector's current challenges. Nevertheless, realising this objective hinges on the enthusiastic participation of the private sector and a proactive stance from government policies. This collaborative endeavour involving governmental bodies, public and private stakeholders sets forth a promising blueprint for energising sectoral expansion, capable of fostering sustainable and ingenious solutions. The pivotal role played by DFIs in propelling sectoral growth is further underscored by the subsequent case study:

The Role of Development Finance: ADB-funded Tata Power's BESS Pilot[40]

Project:

Tata Power Delhi Distribution Limited (Tata Power DDL) Battery Energy Storage System (BESS) Pilot Project

Scope:

Set up a 10-MWh BESS to reduce grid instability and integrate renewable energy.

Financing:

$2 million grant from the Climate Innovation and Development Fund and Goldman Sachs, administered by the Asian Development Bank.

Programme description:

South Asia's first grid-scaled BESS at the distribution transformer level enabling electricity storage and on-demand delivery, reducing grid instability and facilitating RE integration.

Expected outcome:

A resilient power distribution system for New Delhi, with improved RE integration and valuable insights for future BESS projects, contributing to India's clean energy goals.

The Faraday Institution : Pioneering Research in Cell Chemistries[41]

A compelling case for research, positioning it as a proactive strategy to maintain a competitive edge in the quest for more efficient battery and cell chemistries has been outlined frequently. An illustrative example is one of the UK's initiative, which amplifies R&D endeavours to uncover chemistries with greater benefits. India, too, could draw inspiration from such initiatives to elevate its own R&D efforts.

Programme:

Faraday Institution - the UK's flagship battery research programme

Objective:

Pioneering research in electrochemical energy storage research while simultaneously working on skill development, market analysis, and early-stage commercialisation.

Programme description:

- **Faraday Institution Research Initiative:** Collaborative research combining scientists and industry partners to reduce battery cost, weight, and volume, enhancing performance and reliability
- **Interreg North-West Europe (NWE) STEPS Programme:** Strengthening competitiveness of innovative energy storage providers through a demand-driven approach to expedite product development.

Expected outcome:

Shorten typical technology demonstration timeline for energy storage SMEs from an average of 5 years to 1-2 years.

Investor Preview: A Snapshot of the Landscape

Country priority	**High**	• Critical pathway towards ensuring uninterrupted supply of energy generated from renewable sources • Regarded as most efficient energy storage systems for India's area of focus - electric vehicles (EVs)
Policy environment	**Supportive**	• National Framework launched to promote and deploy Energy Storage Systems (ESS) in stationary storage and grid management • Viability Gap Funding schemes announced for Battery Energy Storage Systems (BESS) • Production Linked Incentive (PLI) schemes for developing a domestic battery manufacturing chain • Transmission charges waived (up to 2025) for renewable energy (RE) developers, including BESS
Mitigation potential	**High**	• Key technology for scaling up RE generation, reliable and flexible grid infrastructure and EVs • Indirect mitigation in power and transport sectors, which together account for 44% of India's total CO_2 emissions[42]
Technology complexity	**High**	**Technology readiness** **High**
Commercial readiness	**Moderate to High**	• Ability to be deployed swiftly at scale compared to other energy storage technologies • Rapidly declining costs increasing cost competitiveness for deployment in stationary grid applications and EVs • Lithium-ion batteries high on efficiency and salvage value, making them suitable for multiple applications
Enterprise types	• Startups and SMEs innovating with battery pack manufacturing and alternate cell chemistries, developing distributed-scale RE + BESS projects, battery swapping and battery-as-a-service • Large corporations setting up integrated cell manufacturing projects and developing utility-scale RE + BESS projects, charging infrastructure	
Investment or Funding suitability	**Equity & Debt Capital**	• Towards cell and battery pack manufacturers • Towards project developers of stationary storage projects
	Early-stage Equity & Grant Capital	• Towards startups innovating in the development of alternate battery chemistries • Towards startups and SMEs developing distributed-scale RE + BESS projects and providing battery-as-a-service

*Please note that the ratings provided on a "High to Low" scale here are subjective, based on the authors' analysis and stakeholder inputs, and may not precisely mirror the market reality.

What is Needed: Building the Value Chain

Developing Value Chain

Focussing on material sourcing, cell manufacturing, and battery pack manufacturing and assembling

Knowledge Sharing

Enabling investors and lenders to understand the value proposition of BESS

Building Ecosystem for Battery Recycling

Creating Material Circularity to help lower the costs of critical minerals and metals

Fostering Innovation

Introducing novel cell chemistries to enhance efficiency and reduce import reliance

Fostering Collaborations

Creating ecosystem partnerships between different value chain players

What is Needed: Policy

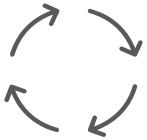
The BESS sector's requirements can be summarised into three key facets - scalability, innovation, and a favourable policy environment. Consequently, to nurture the sector's progress, it becomes imperative for both the private sector and the government to take proactive measures in creating a harmonious ecosystem that fosters its growth. The ensuing section elucidates the interventions, delineating the role that policy can enact to ensure the robust advancement of BESS.

Domestic exploration and international partnerships

Bolster efforts to domestically explore deposits of critical minerals. Trade partnerships with resource-rich countries to secure supply of raw materials to boost domestic manufacturing

Industry Associations, DFIs

Industry associations to spearhead domestic exploration efforts; DFIs to help build international partnerships.



Material circularity to reduce import dependence

Strengthening the ecosystem for battery recycling to improve mineral recovery. International cooperation for development and sharing of technologies required.

DFIs, Academia

Create framework for specialised fund enabling research and deployment of sustainable battery recycling technologies.

What is Needed: Policy

Market expansion for ancillary services, enabling BESS value stacking

Accelerate efforts to expand and streamline the Secondary and Tertiary reserve ancillary services markets at Central and State level. Introduce Primary Reserve Ancillary Services (PRAS) market and ensure ESS is eligible to participate in PRAS.

Industry Associations

Support design, development and scaling up of ancillary services markets.

Skill development and technology transfer programme

Public and private funded programs for improving battery technology know-how by training of workforce and transfer of manufacturing technologies.

DFIs, Industry Associations

Facilitate public-private partnerships to promote workforce training and technology transfer, enhancing industry expertise.

Inclusion of BESS in energy systems planning

Include BESS in National Energy Policy as key technology to enable higher penetration of RE, provide grid management services, and electrify transport. National RE targets could be linked to those for BESS.

DFIs

Share knowledge resources, international best practices, guiding principles for integration of BESS in energy system.

Investing in R&D for creating alternative chemistries

Investments in R&D of alternative cell chemistries, enabling development and commercialisation of high performance BESS suitable for the Indian context.

Enterprises, Academia

Collaborate with government to fund and shape R&D programmes, and facilitate knowledge sharing.

Scaling demand for BESS

Planning and investments in EV charging infrastructure needed to address range anxiety, which will promote faster adoption of battery EVs. Introduce time of day (ToD) pricing, enabling BESS adopters to benefit from price differential between peak and off-peak tariffs.

Corporates, Academia, Think Tanks

Public-private partnerships for charging infrastructure. Advisory support for developing ToD tariff structures.

What is Needed: Capital

While the previous section delved into the government's role in shaping policy interventions, the following section focuses on the critical role the private sector must play in advancing the BESS sector. It outlines key interventions and initiatives that private stakeholders should undertake to foster the robust development of this domain.

Financial and Technical Assistance for Creating a Conducive Investing Environment

Challenges

Limited focussed support for innovation and scaling up of early-stage enterprises

Nature of support required

Support early and growth stage enterprises across the BESS value chain - cell manufacturing, battery assembly, battery deployment and battery recycling

Intervention*

Research, development & demonstration (RD&D) Facilities

- RD&D funding programmes for development and demonstration of alternative/advanced chemistry cells.
- Knowledge-sharing platforms/centres for sharing best practices, international standards and guidelines on technology development and associated policy and regulatory frameworks.

Project preparatory / technical assistance facilities for early-growth stage enterprises

- Provide project preparation support - technical advisory, feasibility studies, market assessments, project development support - for SMEs to address investment barriers, particularly in the cell and battery manufacturing, and distributed-scale stationary storage segments.
- Facilitate networking and partnerships with investors and large corporate players in the EV and RE sectors.

Dedicated funding programme for scaling up BESS enterprises

- Investment funds with flexibility to extend grant/ equity/ debt blended financing and long investment horizons to support scaling up of growth stage enterprises, particularly for capex-heavy manufacturing and businesses.

Actors Involved

Financing actors:

Philanthropic Foundations, Accelerators, Incubators, Governments, DFIs, Impact Investors (VCs)

Implementing actors:

Investors, Consulting Firms, Industry Associations

Financing actors:

Philanthropic Foundations, DFIs, Impact Investors (VCs), PEs, NBFCs

What is Needed: Capital

Financial and Technical Assistance for Creating a Conducive Investing Environment

Challenges

Limited understanding and awareness of BESS

Nature of support required

Address information asymmetry between the real Sector, financial sector and consumers

Intervention*

Technical assistance, capacity building, knowledge sharing and market places on BESS

- Research, advisory and effective communication of the value proposition and the differentiated role of BESS against other energy storage alternatives to all stakeholders, to improve the awareness of the wide-ranging use-cases of BESS.
- Technical assistance and capacity building programmes for FIs for conducting appraisals of BESS projects.
- Knowledge hubs dedicated to the BESS value chain for sharing research, policy and regulatory announcements, updates on latest developments in the sector.
- Online marketplace development for connecting businesses with investors and consumers, and consumers with asset financiers.

Actors Involved

Financing actors:

Philanthropic Foundations, DFIs

Supporting actors:

Consulting Firms, Industry Associations

Challenges

Dependence on international supply chains and imports

Nature of support required

Maximise value of BESS through recycle and reuse

Intervention*

Improve ecosystem for battery recycling and reuse

- Partnerships between EV sector OEMs, battery recyclers and RE project developers for sourcing, re-purposing and reuse of EV batteries in stations storage applications.
- Co-investments by partners in developing the supporting infrastructure required for managing end-of-life batteries.

Actors Involved

Financing and Implementing actors:

Corporates

What is Needed: **Capital**

Financial and Technical Assistance for Creating a Conducive Investing Environment

Challenges

Access to low cost finance for projects and consumers

Nature of support required

Increase finance for stationary storage and e-mobility applications

Intervention*

Low-cost financing for project developers of stationary storage projects

- Increase provision of blended finance instruments, both equity and debt, to mobilise private investments in BESS projects.
- Large companies to increasingly consider tapping into domestic and international markets to raise low-cost capital through available instruments such as green and sustainability-linked bonds and loans.

Credit risk mitigation instruments for lenders

- Extend risk mitigation instruments such as credit guarantees and first loss default guarantee to FIs lending to the BESS sector

Enabling low-cost EV financing

- Improve affordability of EV adoption by providing low-cost, end-user financing to consumers.

Actors Involved

Financing actors:

DFIs, Governments, NBFCs, Commercial Banks, Corporates

Supporting actors:

Consulting Firms, Industry Associations

*Note: Some of the interventions proposed above may have already been put into action, however given the scope of application, the table above suggests actions for implementation at scale.

Food, Agriculture and Livestock

CLIMATE SMART AGRICULTURE

Transforming India's Priority Sector

Agriculture:
A victim of as well as contributor to climate change

Share to GHG emissions: ~14%
Crop losses: ~50%

Climate Smart Agri practices - Pathway to mitigate and adapt to climate change

Impact of Climate Change and Sources of GHG Emissions across Agricultural Value Chain

Pre-production	Production	Processing	Marketing	Consumption
Sources of Emissions • Land use • Application of nitrogen fertilisers	**Sources of Emissions** • Soil and manure management • Methane emissions from crop cultivation • Energy intensive cold storage	**Sources of Emissions** • Energy intensive processing machinery • Crop wastage	**Sources of Emissions** • Transportation emissions • Food wastage	**Sources of Emissions** • Food wastage • Shifts in consumption patterns
Impact of Climate Change • Reduced seed quality (poor germination) • Low availability of resilient varieties	**Impact of Climate Change** • Reduced yield • Crop failure • Poor growth/ stunting/rotting • Additional time and labour required for weeding, harvesting and drying	**Impact of Climate Change** • Reduced quality and quantity of produce for agroprocessing • Higher moisture content • Lower prices for farmers • Increased food losses in processing	**Impact of Climate Change** • Congestion/ damage to transportation routes • Delayed distribution	**Impact of Climate Change** • Inconsistency in availability of agri commodities • Poor quality of produce • Price volatility

Source: *International Institute for Sustainable Development (IISD)*

Given the duality of the agricultural sector with regards to climate, effective mitigation measures and appropriate adaptation technologies must be taken to reduce GHG emissions from the sector and make it resilient to the impacts of climate change.

India's Climate Smart Agriculture Landscape

Climate Smart Agriculture (CSA) is an integrated approach aimed at transforming the agricultural value chain towards green and climate resilient practices, while enhancing productivity and food security.[4]

Given the diversity of agro-ecological regions and land holdings in India, a one-size-fits-all set of practices cannot be adopted by every farmer. These practices need to be localised, based on the extent of vulnerability to climate change, nature and size of farmlands, and types of crops sown.

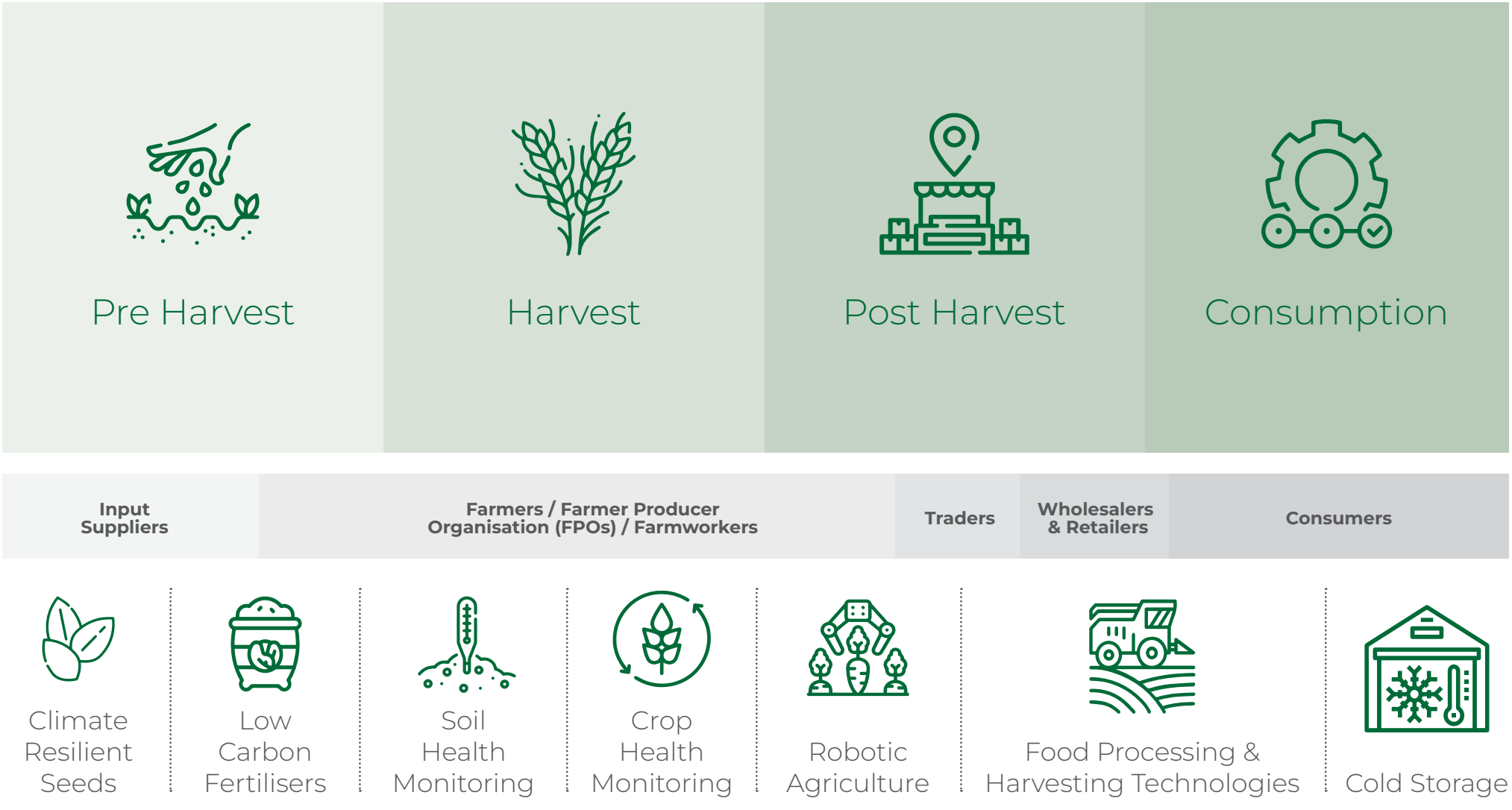
CSA includes an array of climate resilient and green practices driven by a combination of data analytics, innovative technologies and practices, and traditional knowledge. While such approaches help to sustainably increase agricultural productivity and incomes, given the majority are smallholder farmers, there is an equal need to bring behavioural change among farmers. It can be through:

- **Guaranteed income support:** Providing income assurance during the transition to green practices.
- **Reduced upfront costs:** Offering grants and subsidies to lower adoption costs.

Decoding Adoption of CSA

The combination of behavioural change and reduced adoption costs will play a pivotal role in driving the widespread adoption of climate smart practices, benefiting farmers and India's sustainability goals.

The Evolving Industry Landscape



Source: Authors, 2023

Emerging landscape of the Agricultural Sector[6]

Increasing awareness towards new age practices

Example: Using climate resilient seeds, low carbon fertilisers and climate smart farming equipment (drip, sprinklers etc) that improve farm yield

Utilising weather monitoring to plan farm activities

Example: Farmers using rain forecasts during sowing/ harvesting/ spraying chemicals

Minimising intermediaries

Example: Enterprises building market linkages for farmers, assuring sale of farm produce

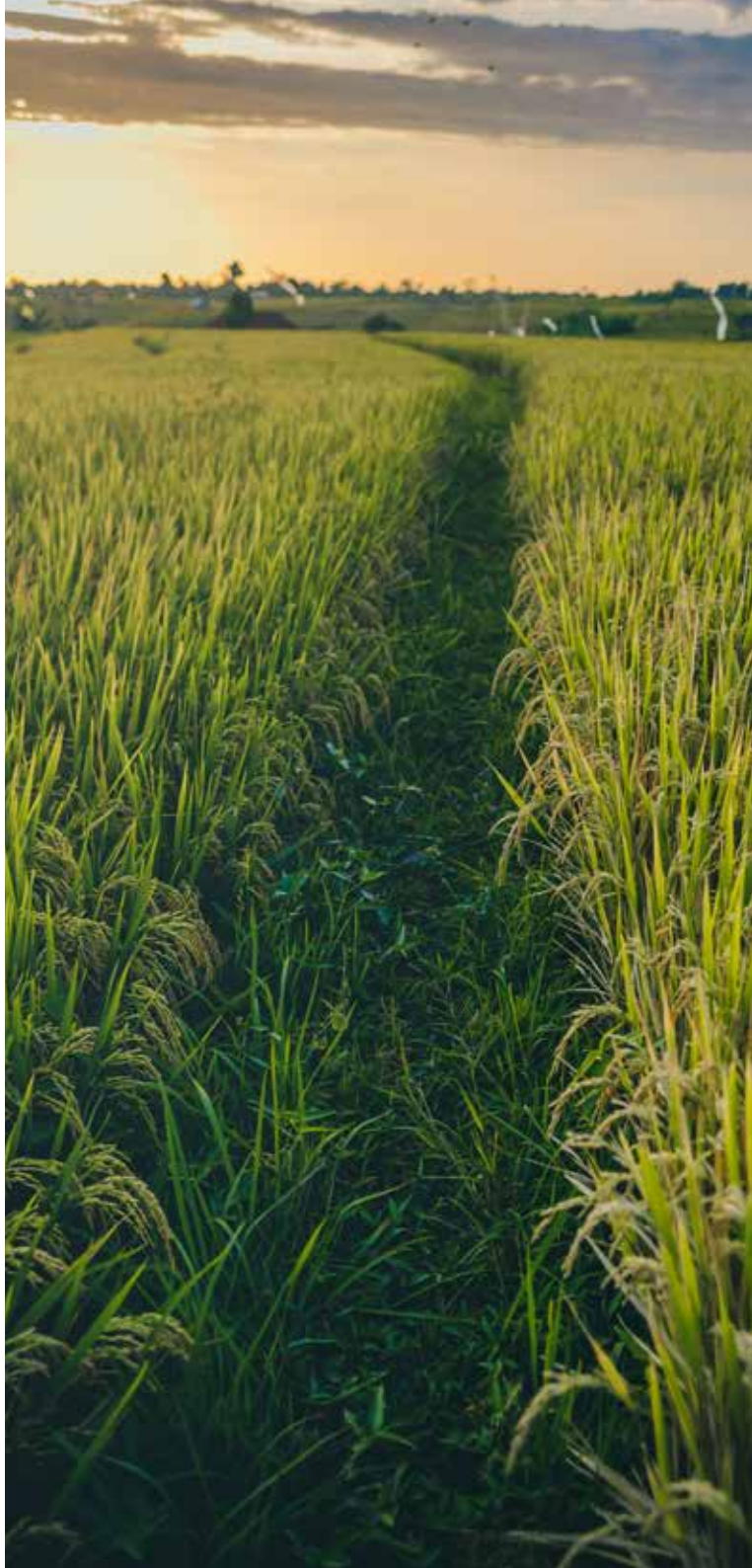
Building Climate resilience as well as livelihoods

Example: Sowing climate resilient crops, optimising usage of farm, and organic farming practices to increase avenues for farm revenue

Creating Ecosystem partnerships

Example: Enterprises building partnerships with FPOs and civil society organisations to improve awareness and technical capacity of farmers

Source: Author's analysis and references from the report by *The Nudge Institute : 'Smallholder Farmers & Climate Change'.*



Climate Smart Agriculture Solutions

Category	Solution	Application	Startups*	Mitigation/ Adaptation
Climate Smart Agri Inputs	Climate Resilient Seeds	To use locally adapted and improved seeds that are heat and drought tolerant.	SAHAJA SEEDS	Adaptation
	Low Carbon Fertilisers	Use of low carbon and organic fertilisers to reduce GHG emissions, reduce soil degradation and improve production quality.	GREENSTAR	Mitigation, Adaptation
Precision Agriculture & Robotics	Soil Health Monitoring	Monitoring to help with informed and sustainable soil management practices to address climate change induced changes in soil nutrient balance, fertility, erosion and degradation.	KRISHITANTRA	Adaptation
	Robotic Agriculture	Robots to automate labour intensive farming tasks such as planting seeds, weed control, spraying fertilisers, harvesting, crop monitoring and soil analysis.	niqo ROBOTICS	Adaptation
	Crop Health Monitoring	To assist farmers identify disease outbreaks and nutrient deficiencies, and make more informed decisions to ensure climate proofing of crops and optimal yield.	pixxel, Fasal	Adaptation
RE Powered Storage & Processing	Cold Storage	RE powered cold storage to reduce energy emissions, food wastage and pest incidences due to climate change induced increase in temperatures and humidity.	ecozen	Mitigation, Adaptation
	Food Processing & Harvesting	To overcome the short shelf life of agriculture produce and reduce post-harvest losses that in turn reduce emissions and enhance food security.	S4S technologies	Mitigation, Adaptation

*Note: The list of startups mentioned above are illustrative and not exhaustive

Mitigation Adaptation

In a Nutshell

- These solutions, encompassing both upstream and midstream solutions, prioritise reducing the impact of climate change, while enhancing income and yields at both individual farm and farmer levels.
- The relevance of technology driven solutions that monitor crop growth and yield holds ground with financing intermediaries as they seek to use farm and farmer level data to improve visibility of the agricultural activity, thereby aiding credit underwriting.

Applications of Climate Smart Agriculture Solutions

Agriculture Intermediaries

- While upstream and midstream solutions lend their direct usage by farmers, some solutions have potential to engage with agri intermediaries, including large corporates, **widening their depth and scope of impact and application.**
- The **increasing impact of CSA solutions can be found in sectors** such as FMCG, food processing as well as among the average consumer.
- The **impact of these solutions can be maximised by localising them** to meet the requirements of different value chain players.

Agriculture Financing

- **Farm and farmer level level data insights** gathered by agri solutions hold the potential to aid traditional credit underwriting, thereby holding potential to fasten lending decisions, bring operational efficiency and enable new-to-credit farmers with access to credit.
- Climate and weather data enable building a **framework for timely assessment of yield losses, giving way to a weather index-based parametric insurance model, leading to timely crop insurance payouts.**

Solutions hold potential for building a pathway to a robust agriculture financing system.

With the applicability of climate smart agriculture solutions across the agri value chain, we witness a few climate smart agricultural enterprises witnessing increasing adoption among the farmers and other stakeholders in the value chain. The following section helps in understanding their business model and their unique features.

Noteworthy Mentions

Name: Fasal
Solution offered: Crop intelligence system
Value chain stage: Pre-Harvest & Harvest
Unique about the business:

1. Localised and tailored crop and farm specific advisory services for farmers to grow better and reduce losses.
2. Incentivising farmers to use their solutions to save water by offering them monetary benefits.

Nature of funding: Grant, Equity
Latest funding stage: Seed

Name: S4S Technologies
Solution offered: Solar powered food dehydrator
Value chain stage: Post-harvest
Unique about the business:

1. Gender lens focus by tying up with women farmers.
2. Enabling market linkages & assurance of produce offtake.
3. Improved quality assurance & input traceability for buyers.
4. Enabling access to affordable financing for the purchase of CSA solutions

Nature of funding: Grant, Equity, Debt
Latest funding stage: Series A

Name: Cropin
Solution offered: Crop intelligence system
Value chain stage: Pre-Harvest & Harvest
Unique about the business:

1. Platform enabling market linkages for farmers
2. Partnerships with agri input companies, agri businesses and lending/insurance companies to offer real-time soil & crop monitoring insights and develop localised farmer-centric solutions.
3. Farm-to-fork traceability to assure quality produce to buyers.

Nature of funding: Equity, Debt
Latest funding stage Series C

Key strategies that helped these enterprises scale up

Enabling access to finance
To purchase climate smart solutions

Enabling access to markets
To assure a price and a buyer for agri produce

Creating awareness programmes
To build technical & technological understanding at last mile

Sharing information & resources
To address agri value chain inefficiencies

Policy as a Strategic Enabler for Progress and Growth

Enterprises along the agri value chain need technical capacity building as well as financial support to achieve impact and commercial viability at scale. Given the priority sector status of the sector and the geographical variations in farm economics and behaviour, different policy interventions –at both the Central and state levels — have come recently, underscoring the criticality and focus towards climate resilient agri practices.

Nationally Determined Contributions under Paris Agreement

Emphasises agriculture as a priority adaptation sector for the country.

National Mission for Sustainable Agriculture

Enables sustainable agricultural practices in India through adaptation measures such as improved crop seeds, water use efficiency, pest management, nutrient management, access to Information, etc.

National Adaptation Fund for Climate Change

Focusses on enabling climate resilient agriculture across climate vulnerable geographies.

Sub-Mission on Agricultural Mechanisation

Facilitates the adoption of drones for assessing crop damage, applying pesticides and fertilisers, and combatting locust invasions.

National Initiative on Climate Resilient Agriculture

Improves resilience and reduces climate vulnerability of the sector through strategic research and technology demonstration.

The Agriculture Accelerator Fund

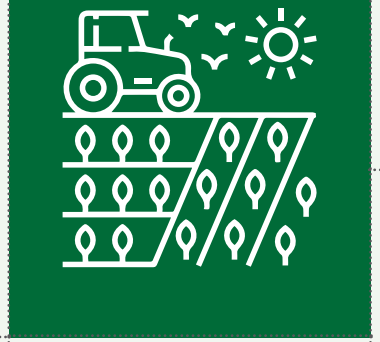
Provides early-stage funding to innovative AgTechs, acting as a catalyst for Indian agtechs to scale.

The SDG Lens: Achieving social impact at scale [7]

15. IMPROVED LAND MANAGEMENT
Life on Land

1. IMPROVING LIVELIHOODS
No Poverty

2. INCREASE YIELD
Zero Hunger



6. TARGETED IRRIGATION
Clean Water & Sanitation

12. MONITOR WASTE PRODUCTION
Responsible consumption and production

8. GIVING THE POWER OF INFORMATION
Decent work & Economic growth

11. IMPROVED INTEGRATION
Sustainable Cities & Communities

9. IMPROVING SUPPLY CHAINS
Industry, Innovation & Infrastructure

17. ALLOW SHARING OF INFORMATION
Partnership for the Goals

Reference : 30MHZ

Policy Driving Innovation and Impact

Policy interventions are paving the way for fostering technological innovation and building investor confidence in climate focussed agri solutions, thereby achieving a double whammy - social impact coupled with climate action.

Exploring the funding landscape

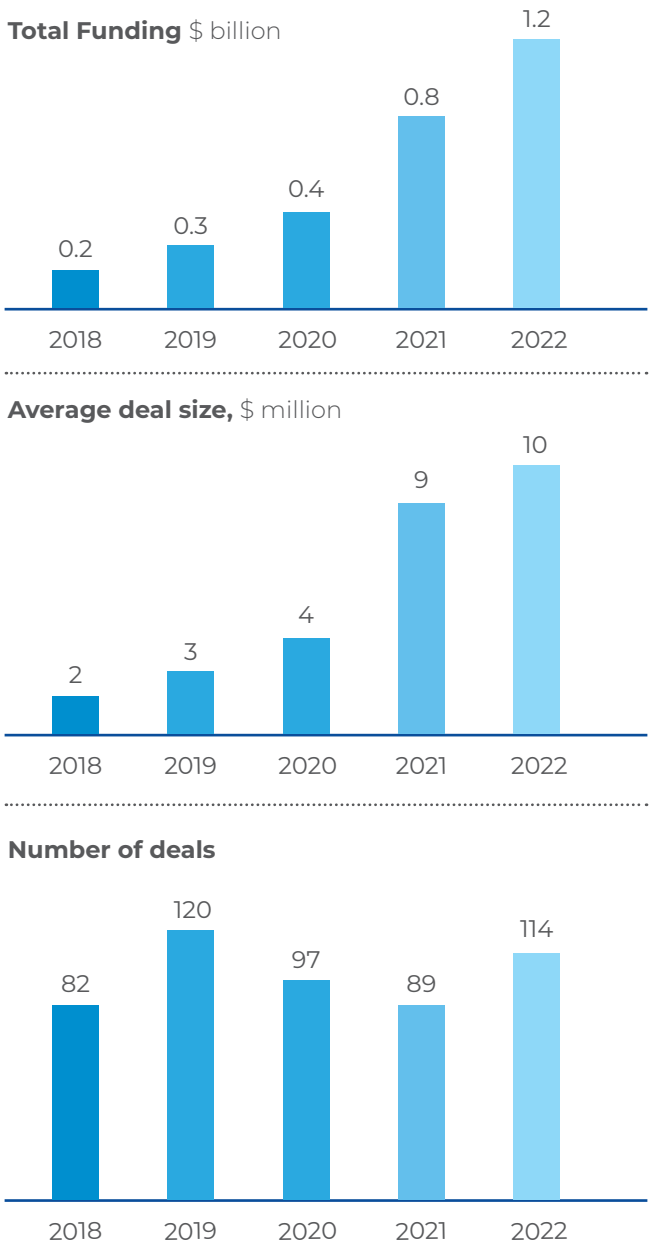
Government support, channeled through accelerator programmes and policies geared towards promoting sustainable agriculture and climate smart practices, has spurred investor interest in agtech enterprises. These are focused on improving smallholder farmers' access to markets, quality inputs, storage, and institutional credit. Beyond government support, various stakeholders, including foundations, non-profit organisations, and patient capital providers, are making multiple efforts to endorse these solutions and make a positive impact on the livelihoods of small-scale farmers.

Equity

In recent years, Indian agtechs have thrived with growing venture equity capital (VC) interest. From **2018 to 2021,** VCs invested around **$1.6 billion** and an additional investment of nearly **$1.2 billion in 2022 alone through 114 deals. Downstream agtechs,** boosting farmers' incomes through assured prices and buyers, saw rising adoption, securing **>60% of VC investments in 2022.**[8]

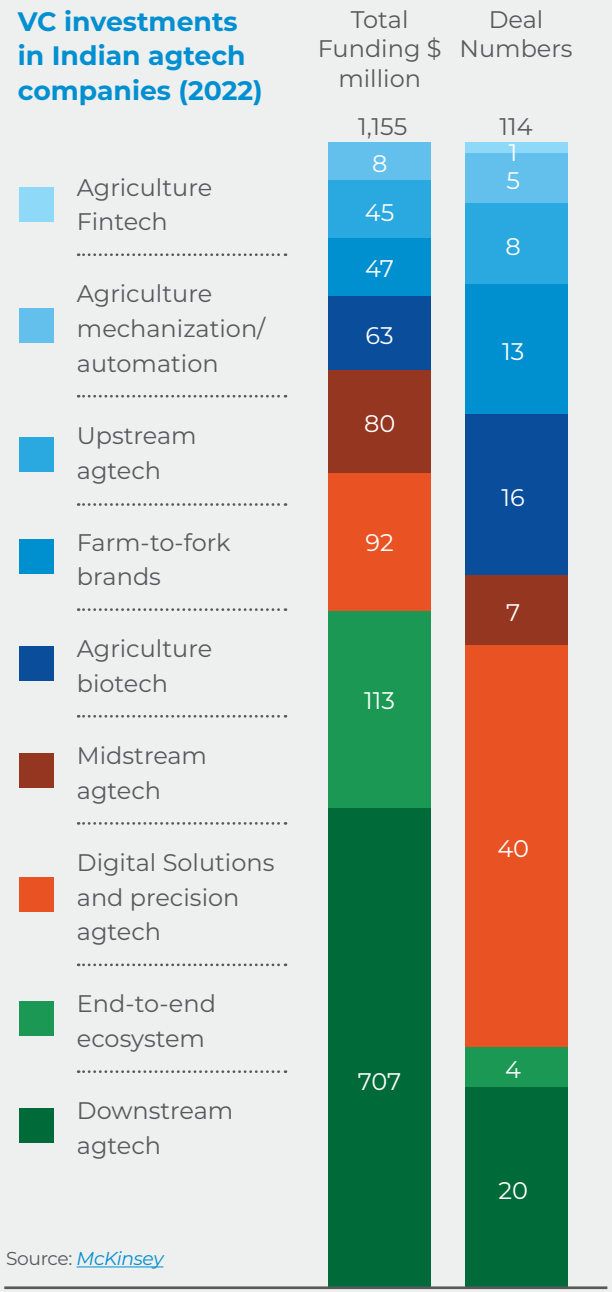
Conversely, **only around 30% of the agtech funding in 2022** was allocated to **upstream and midstream solutions.**[9] As the impact of climate change on agriculture intensifies and gains relevance in today's context, there is a **compelling need for patient capital** to actively facilitate the development and deployment of upstream and on-farm CSA solutions.

Venture Capital investment in Indian agtech companies, 2018-22



Source: McKinsey

VC investments in Indian agtech companies (2022)



Source: McKinsey

Debt

Debt financing in agriculture is directed towards farmers, FPOs, agri-focussed fintechs and NBFCs, and largely downstream agtech companies. However, given the substantial size of the sector, there lies immense potential for debt providers to reorient their lending strategies and financing products to align with the seasonality of the agriculture sector.

De-risking mechanisms through public finance and concessional private capital can open capital flows to this sector by easing credit access towards farmers and enterprises otherwise perceived as low on creditworthiness.

Extending credit across the value chain also enables commercial banks fulfill their Priority Sector Lending (PSL) requirements. With increasing number of enterprises providing asset backed products such as cold storage solutions (e.g. Ecozen) or processing and harvesting solutions (e.g. S4S Technologies) commercial banks extend capital to them with asset as a collateral. However, as more enterprises scale up their operations, the need for more concessional debt finance persists.

Untapped Investment Potential

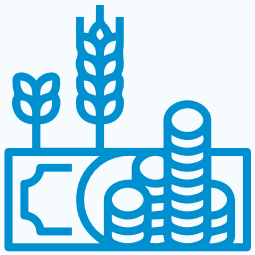
- While agtechs are seeing support from equity investors, majority of the funding is towards downstream agtechs, which are enhancing farmer income through their farm-to-fork models, thereby underscoring the **untapped potential for capital investments towards on-farm and closer-to-farm solutions.**

- Given the varying nature of the land, types of crops grown, and limited knowledge, upstream and on-farm CSA solutions requires localisation, training, and providing financial access to farmers to adopt these solutions. To effectively meet these on-ground necessities and promote the advancement of CSA, **we need patient capital and innovative financing structures to foster the ecosystem.**

- Access to **concessional debt finance** can also play a large role in building scale for innovation to emerge across climate focussed enterprises.

Case Study - Multifaceted Approaches

Blended Finance Intervention to Scale : Acumen Resilient Agriculture Fund (ARAF)[10]



About the Fund

ARAF is the first climate adaptation-focussed agriculture investment fund to support African agribusinesses that help smallholder farmers adapt to climate change.

Impact beneficiaries

Agtech enterprises	Agri focussed financial intermediaries

Funding Structure : ARAF

Technical assistance facility funded by grants	Equity and quasi equity
To provide farmers with hands-on support	To support Agribusinesses

Grant providers: GFC, IKEA Foundation, FCDO and FMO

Funded enterprises: SunCulture, Farmerline, Stable Foods

AGRI 3 Fund : Catalysing private capital for sustainable agriculture [11]

About the Fund

Aims to provide smallholder farmers access to financing and skills to transition to sustainable and climate smart agriculture.

Implementing partners:

UN Environment Programme, Rabobank, IDH The Sustainable Trade Initiative, and FMO

Geography focus:

Brazil, Indonesia and India

Intervention

- Technical assistance for developing agriculture focussed enterprises.
- Capacity building of agriculture focussed enterprises to accelerate development of investable opportunities.
- De-risking mechanisms, subordinated financing structures and innovative financing mechanisms to catalyse additional private, non-concessional funding.

Assam Agribusiness Investment Fund : boosting agricultural productivity [12]

About the Fund

Aims to strengthen rural infrastructure and foster agricultural productivity in the state of Assam by providing patient capital to small and medium agricultural enterprises.

Implementing partners:

Assam Rural Infrastructure and Agricultural Services (ARIAS) Society, State Government of Assam, Caspian Equity, World Bank

Geography focus:

India

Intervention

- A public-private sector specific fund to deploy low cost capital towards agricultural enterprises.
- Collaboration with geography focussed incubators and accelerators to identify and develop local agriculture SMEs.
- A multi-donor innovative funding structure, extending different forms of capital including debt and equity to develop the agriculture ecosystem.

Project Acorn : The Rabobank Programme on Carbon Sequestration[13]

While blended finance interventions are crucial in the development of climate-smart agricultural solutions and livelihood of smallholder farmers, another on-farm practice that can help improve the livelihoods of smallholder farmers and reduce the sector's impact on climate change is of carbon sequestration and trading. This section explores a carbon sequestration program initiated by Rabobank.

About the Programme

- Partnership with Microsoft for building a global, transparent, and technology-enabled marketplace for carbon sequestration.
- Equipping farmers to transition to agroforestry and sell carbon credits to industries.
- Empowering farmers with additional source of income and incentivising them to graduate to climate resilient agri practices.

Implementing partners:

Rabobank, Microsoft

Geography focus:

Africa, Latin America and Asia

Interventions

Awareness programmes among farmers on agroforestry practises

Building awareness among farmers on diversifying the crops sown for carbon sequestration.

Partnerships to build the ecosystem

Collaborations with large corporates to build the carbon trading platform and on-ground civil societies to promote agroforestry.

Leveraging technology for efficient implementation

On-farm monitoring with satellite imaging technology and machine learning models to assess farm development and ensuring traceability between corporates and smallholder farmers with the platform.

Investor Preview: A Snapshot of the Landscape

Country Priority	**High**	• India's priority sector and highly susceptible to climate change • CSA covered as part of India's and the G20 nations' Sustainable Development Goals (SDGs) vision to optimise national agriculture productivity, resilience, and emissions in response to climate change • Potential to address the triple bottom line of climate change, food security and economic growth			
Policy environment	**Supportive**	• Government Initiatives announced to extend financial and incubation support to emerging climate focussed agri solutions • Agriculture Accelerator Fund set up to encourage innovative agri-startups in rural India • National Adaptation Fund for Climate Change set up for promoting climate resilient agriculture across climate-vulnerable geographies			
Mitigation &Adaptation Potential	**Mitigation - Moderate Adaptation - High**	**Technology complexity**	**Low**	**Technology readiness**	**Moderate**
Commercial readiness	**Moderate**	• High scope of application across geographies, although affordability likely to remain a challenge • Certain solutions necessitate localisation to the geographical and demographical context • Enabling environment needed to equip farmers with financial and technical capacity to adopt CSA solutions			
Enterprise types	• SMEs and startup enterprises innovating CSA solutions				
Investment or Funding suitability	**Early-stage Equity & Grant Capital**	• Towards innovation-driven startups and SMEs			
	Debt Capital & De-risking Mechanisms (e.g.: Credit Guarantees)	• Towards agri-focussed NBFCs or commercial banks lending to agtechs, farmers and farmer collectives			

*Please note that the ratings provided on a High to Low scale here are subjective, based on the author's analysis and stakeholder inputs, and may not precisely mirror the market reality.

What is Needed: Building the Agri Ecosystem

Building market linkages

Partnerships with institutional buyers & mandis to ensure guaranteed offtake of grown produce.

Building capacity at farm level

Awareness and on-ground capacity building programmes on new agri practises and solutions.

Enabling access to finance

Institutionalising credit to smallholder farmers to transition to CSA practises.

Building livelihood of smallholder farmers

Improving farmer income by enabling access to market linkages and CSA practises that can uplift their livelihoods.

Offering blended capital to support innovative CSA technologies

Blending capital to support funding towards high perceived risk solutions and leveraging expertise of multiple stakeholders for developing and deploying CSA solutions.

What is Needed : Capital

As the interdependency between agriculture and climate impact deepens, the need for the agricultural sector to build climate resilience along the agri value chain becomes stronger. The promise shown by climate focussed solutions can be amplified through holistic interventions that support on-ground deployment of solutions and make agri finance accessible in an affordable manner. Some of these key interventions are highlighted below:

Credit enhancement support to early and growth-stage enterprises

Challenges

Limited access to affordable finance

Nature of support

Risk mitigation mechanisms to FIs

Intervention*

Financial assistance

Concessional finance and risk mitigation to agri-focussed financing intermediaries. The de-risking mechanisms can include:

- Guarantee backed support
- First Loss Capital
- Co-lending mechanism
- Blended finance

Actors Involved

Financing actors:

DFI, Philanthropic Foundations

Supporting actors:

Commercial Banks and NBFCs

What is Needed : Capital

Building awareness and training smallholder farmers on adoption of new age climate smart agri practices

Challenges

Limited digital literacy and awareness, with small and marginal farmers adopting new age solutions in limited capacity.

Nature of support required

Financial & capacity support to reach smallholder farmers & increase awareness

Intervention*

Technical assistance

- Geography-aligned Technical capacity building programmes & support to local government authorities to develop FPOs and farmer collectives with appropriate technical know-how.

Financial assistance

- Philanthropic capital for piloting and initial deployment of new age solutions near farmlands to increase awareness and adoption.
- Extend technical and financial assistance to SMFs for on-farm deployment of solutions.

Actors Involved

Financing actors:

CSR, Philanthropic Foundations

Supporting actors:

Civil Society Organisations, District Level Government Authorities

Developing impact measurement frameworks for attracting capital

Challenges

Limited visibility of climate impact of innovative solutions; hindering early- stage investment

Nature of support required

Advisory for developing impact frameworks for a CSA investment portfolio

Intervention*

Technical assistance

Facilitation and development of an open access platform showcasing:

- Curated set of vetted climate smart solutions with their climate impact assessment results based on pilots
- Farm-level data capturing climate impact for better visibility of cash flow

Training and capacity building of farmers to access digital platforms hosting localised climate data

Actors Involved

Financing actors:

DFI, Philanthropic Foundations

Supporting actors:

Industry Associations, Consulting Firms, Civil Society Organisations

What is Needed : Capital

Enabling access to affordable financing

Challenges

Limited financial capacity of smallholder farmers to pay for climate smart solutions

Nature of support required

Low-cost financing to ag-fintechs or agri focussed NBFCs

Intervention*

Technical assistance

- Building technical knowledge of financial institutions on climate risks and emerging climate smart agri technologies

Financial assistance & Advisory

Designing financing products and services for extending farmer financing for:

- Purchasing CSA assets such as solar pumps, cold storage units
- Cash flow-based financing for farmers, based on produce purchase guarantee extended by solution provider

Credit enhancement and risk mitigation structures to commercial banks for extending low cost financing to agri-focussed NBFCs

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Supporting actors:

Commercial banks, NBFCs

Enabling easier access to Agricultural Insurance

Challenges

Complexity in designing and implementing weather indices-based crop insurance or parametric crop insurance [14, 15]

Nature of support required

Data driven frameworks and processes to implement weather-linked crop insurance model

Intervention*

Technical assistance

- To develop tailored, localised, need based and simplified insurance products based on area specific climate change, weather variability and farmers' vulnerability
- Collaboration with agtech and climate tech enterprises to improve access to farm and farmer linked data, climate and weather information
- Awareness and capacity building of farmers on understanding and accessing available weather-based insurance products

Financial assistance

Public-private partnerships (PPP) between government and commercial banks to deploy weather-based/ parametric crop insurance schemes through innovative financing structures

Actors Involved

Financing actors:

DFIs, Commercial Banks

Supporting actors:

Agri Cooperatives, Government, Agri enterprises, Civil Society Organisations

What is Needed : Capital

Economic incentives to farmers

Challenges

Limited economic incentive to farmers to transition to CSA solutions

Nature of support required

Income incentive programmes for farmers

Intervention*

Technical assistance

Developing a carbon credit programme for small and marginal farmers and FPOs, for integrating farmers into the carbon credit market

Allocation of funds and technical assistance for carrying out the following:

- Creating awareness at farmer and FPO level for participation in voluntary carbon credit markets
- Collaborating with third-party verification parties for verifying and approving farming projects enlisted for availing carbon credits

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Supporting actors:

Civil Society Organisations, Industry Associations, Think Tanks, Consulting Firms, District Level Government Authorities

Building bankability of climate smart solutions in agriculture

Challenges

Innovative technologies yet to reach commercial scale

Nature of support required

Financial support for nascent technologies

Intervention*

Technical assistance

- Mentorship to early-stage enterprises
- Facilitate collaboration with agri intermediaries to data gathering and feasibility analysis of solutions
- Knowledge transfer of successful international pilots and technological trends

Financial assistance

Grant and equity support to early-stage enterprises for:

- On-ground deployment of solutions
- Ongoing R&D efforts to build effectiveness of solutions

Actors Involved

Financing actors:

Incubators, Impact Investors (VCs)

Supporting actors:

Think Tanks, Industry Associations

*Note: Some of the interventions proposed above may have already been put into action, however, given the scope of application, the table above suggests actions for implementation at scale.

Waste and Circular Economy:

WASTE MANAGEMENT & MATERIAL CIRCULARITY

Tackling India's Growing Waste Problem

Increasing quantum and diversity of waste

4% of GHG emissions: Attributed to waste alone[1]

Waste collection to management: A complex chain

India's waste management value chain

Waste Generation	Collection	Segregation & Processing	Recycling	Upcycling	Consumption
Key Players	• Municipal Authorities, Urban Local Bodies (ULBs) • Civil Society Organisations (CSOs) • Startups / SMEs setting up collection & segregation facilities		Small, mid and large-scale enterprises		Startup Enterprises
Key Value Add	• Potential to organise the unorganised waste picker workforce • Better segregation of different forms of waste • Geography-specific waste management programmes		• Innovative technologies for recycling • Better efficiency in waste management systems • Building scale with recycling solutions		• Innovative upcycled products • Market demand creation for upcycled products • Consumer awareness creation

End to End Waste Management Services

ANTONY WASTE · NEPRA · Blue Planet Environmental Solutions · ATTERO

Recycling & Upcycling solutions

Lucro PLAST-E-CYCLE PRIVATE LIMITED · PHOOL

Source: Authors, 2023

The waste generated in the country is diverse in type and scale. While the below table is not exhaustive, it enlists the key forms of waste that are pose a waste management challenge - plastic waste, battery and high value metal waste, construction material waste, and agricultural and food waste. Given the volume of waste generated, it is imperative to develop holistic solutions (e.g. Blue Planet Environmental Solutions, NEPRA) to sustainably manage and dispose off different forms of waste.

Waste Management: A Growing Market Opportunity

Types of waste	Current landscape in india	Key application	Demand potential
Battery (lithium) and high-value metal waste	50,000 tonnes of lithium-ion battery waste generated every year[2], with only 10% of waste is being recycled[3]	Electronics, electric vehicles, stationery energy storage	Lithium-ion battery recycling is expected to grow at 37.5% y-o-y, creating a $ 1 billion opportunity for battery recycling by 2030[4]
Plastic waste	3.4 million tonnes of plastic waste produced every year, only 30% of it being recycled[5]	Packaging	Indian plastic recycling market is valued at $520 million and expected to grow at a CAGR of 7.58%[6]
Construction and Demolition (C&D) waste	150 million tonnes of C&D waste generated every year, only 1% being recycled[7]	Construction industry	A circular economy approach in infrastructure is expected to derive benefits of $76 billion by 2050[8]
Agricultural and food waste	350 million tonnes of agricultural waste every year[9]	Agriculture	A circular economy approach in the food systems is expected to create annual benefits of $61 billion by 2050[10]

Outlook of India's Waste Management Scenario

The global circular economy is anticipated to reach **$4.5 trillion by 2030;** and India, which currently holds only a 1% share in this market, has the potential to grow to a **$45 billion market[11]. Surmounting waste, necessitates solutions that build efficient waste management processes in a scalable and sustainable manner. Policy interventions have been setting the base for such innovations.**

Catalysing Transformation: The Vital Function of Policy as an Enabler

2021

EPR Guidelines on Plastic Packaging, 2021

Producers to recycle up to 50% of plastic they use or produce until 2025

2022

Battery Management Rules, 2022

Producer & importer is responsible for collection & recycling of battery waste

E-waste Management Rules, 2022

ULBs to facilitate establishment of waste collection, segregation & disposal systems

Swachh Bharat Mission 2.0

Source segregation of trash & safe sanitation in urban areas

2023

GOBAR-Dhan Scheme, 2023-24

Allocation of Rs. 10,000 crore to set up waste-to-wealth plants

Funding Landscape

While we witness **both equity investors and debt providers** supporting the development and growth of this sector, investments in waste management solutions are **yet to see high traction.** The funding landscape in this section pertains to the **entirety of the waste management sector,** with **focus** on the **emerging area of battery recycling,** which is attracting increasing attention from equity investors.

Debt

Debt support can be witnessed towards relatively **mature** enterprises such as **Anthony Waste Limited** and **Attero** that have achieved scale and have integrated solutions. The well-established value chain of such enterprises not only offers recycling facilities but also provides efficient on-ground waste collection, segregation and transportation.

Such scalable models are fewer in number and capital is needed to develop more such enterprises. With adequate capital support these solutions have the potential to recycle and manage India's growing waste problem.

Equity

Increasing number of startups with innovative technology to recycle waste are attracting equity investments.

During 2020-2022, as per IIC's analysis of startup enterprises attracting equity capital, investors have invested close to **$161 million - across 41 deals -** into enterprises that process, recycle and upcycle different forms of waste.

Enterprises such as **Phool.co, Ricron Panels and Green Joules,** engaged in recycling and upcycling agricultural waste, plastic waste, and industrial waste into various value-added products and raw materials, demonstrate investor interest with innovative solutions.

Notably, solutions engaged in lithium-ion waste recycling stand out with **~$19 million invested across 7 equity deals. Battery recycling startups such as Ace Green Recycling, Lohum Cleantech, Batx Energies and Metastable Materials are seen developing innovative solutions to recycle lithium-ion batteries; a strong indication of the increasing potential this space holds.**

Avenue for Investments

The waste management & material circularity sector is evolving and **holds scope for different sources of capital to support two broad segments:**

- Enterprises **building efficiency and scale** across the value chain
- New age startups with **innovative technologies** processing **different types of waste**

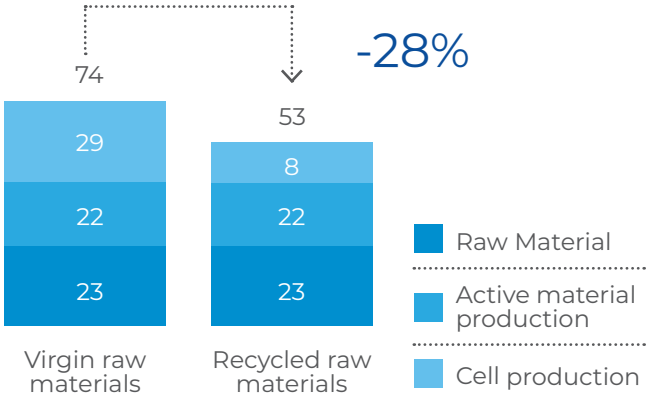
An advancing economy and government impetus have, especially, resulted in battery recycling garnering early stage equity support. Its wide **scope of application** makes it a **space to watch out for.**

An Emerging Space : Battery Recycling

As the discussion around waste management and recycling solutions gains traction, presenting investable opportunities to multiple stakeholders, one space that increasingly stands out is that of battery recycling.

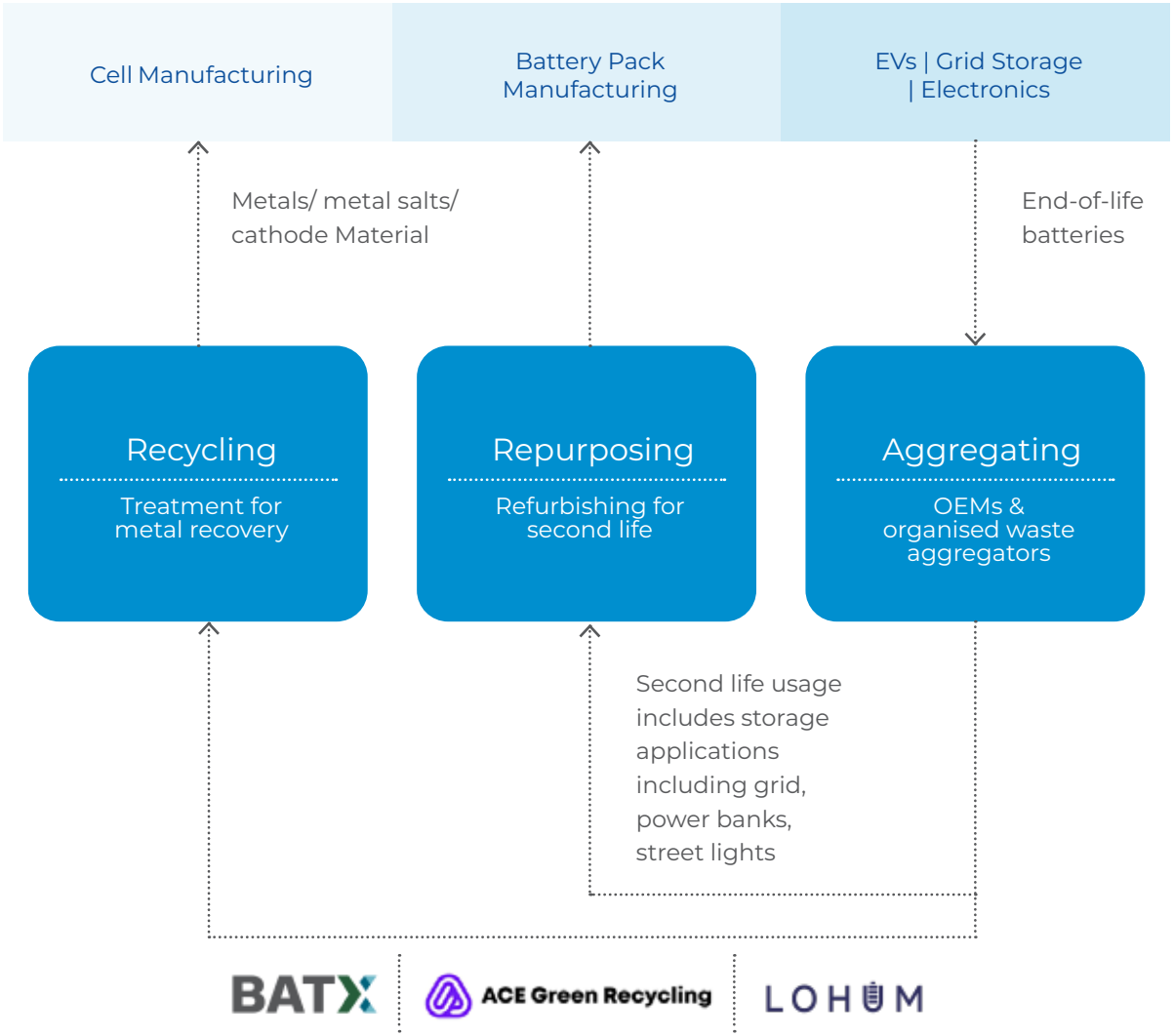
Lithium (Li) batteries play a pivotal role in **EVs, grid storage applications, and electronic devices.** As the demand for batteries in these three sectors continues to surge, effectively handling battery waste becomes vital to reduce environmental repercussions and enhance efficient use of resources. **With Li-ion battery demand expected to cross 235 GWh by 2030 in India,**[12] leveraging battery recycling and repurposing them is crucial, presenting a lucrative opportunity for recycling and repurposing companies.

Total CO_2 emissions from battery cell production from a nickel-based Li-ion battery with virgin vs recycled materials



Source: *Battery recycling takes the driver's seat - Mckinsey*

Unpacking the Value Chain



Source: Authors, 2023

Factors Propelling Demand for Battery Recycling

- **Resource scarcity:** Limited reserves of key input materials such as lithium make recycling crucial to reduce imports
- **Policy focus:** Impetus towards responsible battery lifecycle management by manufacturers
- **Li-waste generating industries on high growth path:** Strong demand for Li battery storage from EVs, consumer electronics and stationary energy storage
- **Burgeoning Supply Chain:** Increasing capacities towards domestic cell and battery manufacturing
- **Access to battery recycling technology:** Developed by Ministry of Electronics and Information Technology (MeitY) for recycling enterprises, fostering growth of battery recycling[13]

Battery Recycling: Looking Ahead

- With the increasing application of Li-ion batteries across industries, the demand for lithium raw materials and **battery recycling** is projected to grow significantly. This trend presents a highly **promising and lucrative opportunity for stakeholders including battery recycling enterprises and investors.**

Case Studies - Exploring Synergistic Approaches

Given the high volume and multiple forms of waste generated within the country, it is essential to understand and learn from successful pilots on how they tackled the challenge of waste management and achieved the intended impact.

Circulate Capital Ocean Fund [14]

Objective:

Financing enterprises across the plastic recycling and waste management value chains, including early-stage startups focused on innovative technology

Key players (Investors):

PepsiCo, Coca-Cola, Unilever, Mondelēz International, USAID

Intervention:

- Leveraging capital from diverse stakeholders including DFIs, philanthropic foundations, venture capitalists, and family offices to support early-stage waste management enterprises
- The fund can assume junior or subordinate positions, enabling higher potential returns for co-investors
- Guarantees up to 50% of the loan value to de-risk private co-investors investments

India Funded enterprises (Equity):

Srichakra Polyplast, Recykal, Ricron panels and Dalmia Polypro Industries

India – Waste Solutions for a Circular Economy[15] (A NAMA Facility Project)

Objective:

To promote source segregation, home composting, Material Recovery Facilities and recycling by formalising the waste picker workforce, providing technical advisory and financial assistance through innovative financing mechanisms.

Key Ecosystem Players:

MoEFCC, MoHUA, NAMA Facility, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, SIDBI

Intervention:

Support for ULBs

- Grant support & technical assistance in setting up waste management facilities
- Capacity building of ULB's workforce & other stakeholders
- Integration of the waste pickers workforce
- Awareness programmes to promote source segregation & home composting

State & National Level Support

- Technical support Unit at MoHUA
- Sub-national EPR policy development & implementation
- Developing SOPs and national standards for waste management facilities
- Onboarding Swachhata knowledge partners

Financing Support

- Grant Funding Mechanism for waste management projects
- Risk Sharing Facility - Credit Guarantees of up to 50% to commercial lenders

Sustainable Waste Management in Indore[16,17]

Objective:

Effective management of waste generated in Indore city by building and developing waste management value chain of waste collection, disposal and recycling.

Key Ecosystem Players:

Indore Municipal Corporation(IMC), Sarthak (NGO), Basix (NGO) and private recycling units like GPS Renewables and NEPRA

Intervention:

Segregating waste at source

Mandated waste segregation at households through policy, improving waste collection and processing

Formalising unorganised waste pickers

Collaborations with NGOs to integrate the informal workforce, improving waste segregation and their livelihoods

Building traceability across value chain

Leveraging technology to digitise the value chain, with GPS enabled vehicles to efficiently monitor waste collection and disposal

PPP for Infrastructure development

PPP to develop Material Recovery and Recycling Facilities, reducing the financial burden on municipal corporations

Creating awareness campaigns

Increased community involvement and support for the waste management programme through awareness campaigns

Role of emerging innovative startups

GPS Renewables

Commissioned Asia's largest BioCNG plant in Indore

Nepra Resource Management

Setup state-of-the-art Material Recovery facility

Investor Preview: A Snapshot of the Landscape

Country priority	**High**	• Increasing population and rapid urbanisation with high GHG emissions attributed to landfills • High potential to develop a scalable, domestic, circular economy leading to increased employment opportunities, improved livelihoods and high climate impact			
Policy environment	**Supportive**	• Swachh Bharat Mission 2.0 emphasising waste segregation at source • Extended Producer Responsibility (EPR) rules outlined to encourage waste management practices • Battery Management Rules 2022 focussing on efficient battery recycling practices • Battery Recycling Technologies extended by the Ministry of Electronics and Information Technology (MeitY) to recycling enterprises			
Mitigation potential	**Moderate**	**Technology complexity**	**Moderate**	**Technology readiness**	**Moderate to High**
Commercial readiness	**Moderate**	• EPR rules mandate waste management for waste producers, thus inducing demand for waste management solutions. • Increasing demand for recycled materials such as LiB owing to inconsistent supply of critical inputs materials • Increasing efforts to organise waste collection and segregation by formalising waste picker workforce			
Enterprise types	• Startups and SMEs engaged in waste recycling and/or extending waste management solutions • Municipal corporations & Urban Local Bodies (ULBs) implementing waste management projects				
Investment or Funding suitability	**Debt Capital**	• Towards waste management projects set up by local municipal authorities/Urban Local Bodies (ULBs)			
	Early-Stage Equity & Grant Capital	• Towards innovation-driven waste management startups and SMEs			

*Please note that the ratings provided on a 'High to Low' scale here are subjective, based on the authors' analysis and stakeholder inputs, and may not precisely mirror the market reality.

What is Needed: Building a Sustainable Value Chain

Mandating waste Segregation at source

Availability of clean segregated waste improves recoverability from waste and attracts higher number of recyclers

Organising the unorganised waste pickers

Integration of rag pickers and kabadiwalas to ensure efficient collection and segregation while improving livelihoods

Digitising the waste management value chain

Tracking waste generated from source to waste collector and to material recovery centres, ensuring easy governance

Derisking mechanisms to attract private capital

Reducing risks associated with lending to waste management enterprises through guarantee support

Supporting innovative waste management technologies with patient capital

Longer than market sector focussed funds to develop innovative forms of recycling technologies

What is Needed : Capital

Waste management and recycling is a highly fragmented sector with multiple intermediaries across the value chain. The high dependency on every intermediary in the value chain makes a case for a holistic approach to not only deploy different forms of capital across the value chain but also establish partnerships and collaborations to build capacity and scale. We propose the following structural interventions that can support the overall ecosystem building as well as create technological advancements for an efficient and self sustainable value chain.

What is Needed : Capital

Credit enhancement support to early and growth-stage enterprises

Challenges

High perceived credit risk for early & growth-stage waste management & recycling enterprises

Nature of support required

Reduce counterparty risk through Credit enhancement and Risk Mitigation mechanisms

Intervention*

Partnerships to create derisking mechanisms and mobilize funding through

- Risk-sharing facility
- First Loss Capital

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Supporting actors:

Commercial Banks and NBFCs

Building traceability and organising the waste collection and segregation workforce

Challenges

- Fragmented unorganised workforce for waste collection
- Geographical variations in waste management models implemented by municipal authorities/ ULBs

Nature of support required

- Organisation of the waste picker workforce
- Supporting on-ground social enterprises & civil society organisations working to organise waste collection
- Geography-specific projects/models & solutions for waste collection & segregation

Intervention*

Technical assistance

Geography aligned capacity-building programmes to organise & train the workforce for providing:

- Mentorship for enterprises involved in collection & segregation
- Technical training to train the unorganized workforce
- Sharing of best practices from successful pilots
- On-ground partnership and mentorship support to civil society organisations and Self Help groups

Financial assistance

Financial support for aggregation of unorganized workers, enabled through a Results-based or outcome-based financing structure

Actors Involved

Financing actors:

CSR, Philanthropic Foundations

Supporting actors:

Civil Society Organisations and Self-Help Groups

What is Needed : Capital

Support to municipal corporations for effective design and delivery of waste management projects

Challenges

Challenges for ULBs and municipal corporations in building self-sustainable, scalable, and viable waste management models

Nature of support required

Support in project design and planning, implementing, and establishing linkages for waste management solution providers

Intervention*

Technical assistance

- Designing, planning and implementation of waste management projects and extending specialized strategic, financial and technical advisory services to ULBs and municipal corporations
- Building awareness among debt providers and waste management enterprises on innovative financing mechanisms involving guarantee support

Facilitation

Facilitating creation of digitised platform enabling better linkages between solution providers and local municipal authorities, thus aiding:

- Ease of discovery of waste management projects underway
- Aggregation of solution providers
- Transparency in price discovery of solution providers
- Showcase of validated, credible, high-impact waste management and recycling solutions

Financial assistance

- Improve and build waste management facilities at local municipal level
- Development capital invested in waste management projects implemented by municipal authorities
- Subscription to sovereign green bonds
- Provide credit guarantee support for waste management solution providers, seeking debt capital

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Supporting actors:

ULBs, Municipal Corporations, Social Enterprises, Commercial Banks, Industry Associations, Consulting Firms, Civil Society Organisations

What is Needed : Capital

Technical and financial assistance to emerging technologies for enabling commercial deployment at scale

Challenges

Early-stage innovative recycling enterprises constrained by limited capital and technical guidance

Nature of support required

Early-stage capital for innovating, and building investment pipeline

Intervention*

Technical assistance

Setting up financing platform connecting curated and high-impact early stage solutions with prospective funders & incubators

Financial assistance

- Grant capital directed towards R&D investments
- Deployment grants that fund the cost of deploying early-stage technologies
- Dedicated sector-focused funds for extending low-cost venture capital to early-stage startups in order to:
  - Support research and advancement of innovative & sustainable recycling technologies
  - Support the deployment of technologies at scale

Actors Involved

Financing actors:

DFIs, Philanthropic Foundations

Supporting actors:

Social Enterprises, Impact Investors (VCs), Incubators, NBFCs, Industry Associations

Financing actors:

Incubators,
Impact Investor (VCs),
Philanthropic Foundations

Supporting actors:

Think Tanks, Civil Society Organisations

Economical demand-side incentives and improved consumer awareness to scale

Challenges

Limited economic Incentives to transition to recycled materials as input

Nature of support required

Enable economical demand-side incentives by facilitating setting up voluntary carbon credit trading platform

Intervention*

- Facilitate collaboration between industry and policy & regulation to leverage expertise of both to build carbon trading platform
- Facilitate bilateral partnerships for carbon trading

Actors Involved

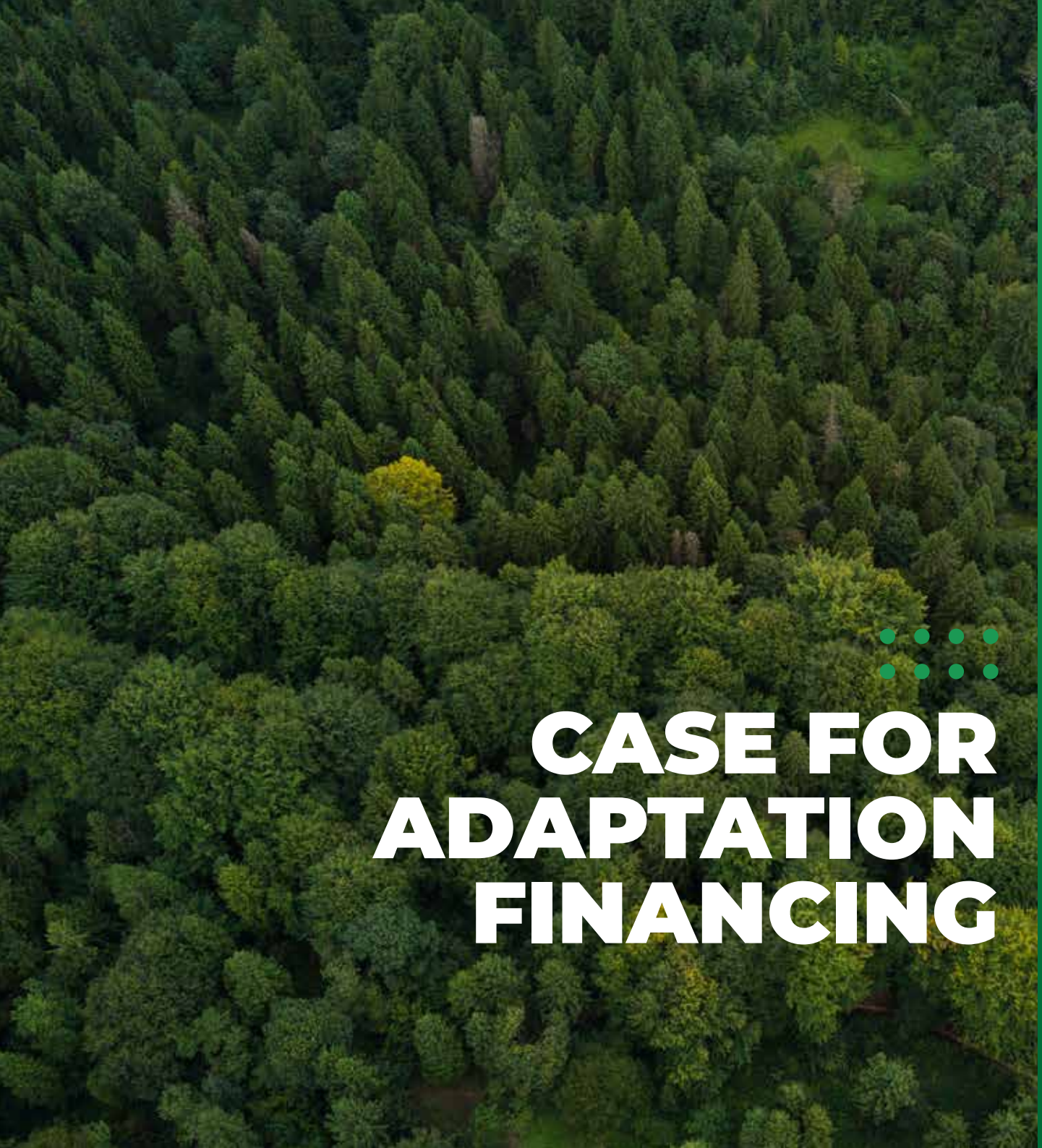
Financing actors:

DFIs

Supporting actors:

Philanthropic Foundations, Civil Society Organisations, Industry Associations, Think Tanks

*Note: Some of the interventions proposed above may have already been put into action, however given the scope of application, the table above suggests actions for implementation at scale.



CASE FOR ADAPTATION FINANCING

Translating needs into opportunities

Impacts of climate change threaten to cause widespread damage to India's economy, people and ecosystems, making adaptation the need of the hour

Barriers to scaling private sector investments and engagement in adaptation are manifold

The public sector plays a crucial role in de-risking and building an enabling environment for scaling private capital flows in adaptation

With the growing need for adaptation, multiple sectors will hold immense opportunities for India's private sector in the medium-to-long term

Why Adaptation?

Enabling adaptation to climate change is **imperative for India's economic, social and environmental transformation**. The country's economy, people and ecosystems are highly vulnerable to the impacts of climate change, with 12% of the total land area exposed to floods, 68% land area to droughts, landslides, and avalanches, and 75% of the coastline extremely vulnerable to cyclones and tsunamis[1].

In 2021, India suffered a total loss of $3.2 billion from heavy rains and flooding alone[2]. In the absence of timely action, India may lose anywhere between **3–10% of its GDP annually by 2100** due to the impacts of climate[3].

The poor and marginalised sections of the population who are dependent on climate sensitive sectors such as agriculture and highly exposed to heatwaves and extreme events, lack adequate access to welfare resources and are often located in climate vulnerable locations are at climate risk twice over[4].

State of Financing Adaptation in India

Total finance for adaptation in India in 2019-20 was about **₹74 thousand crore ($10 billion), vis-à-vis the estimated requirement of ₹28.9 lakh crore ($4 trillion)** by 2020[5]. Currently, most investment in adaptation is **driven by public capital. The private sector's contribution** to adaptation financing remains limited and **will need to increase considerably** to meet India's targets.

According to an estimate, 80% of the markets in key adaptation solutions in India are currently **at a nascent or mid-level stage** with the potential for high growth, but private investment in these solutions is mostly low to medium[6].

Globally, **the economic case for adaptation is established,** with research indicating that around $1.8 trillion worth of investments globally can **generate close to $7.1 trillion in total net benefits** during 2020- 2030 in five areas: i) early warning systems, ii) building resilience of new infrastructure, iii) enhancing dryland agriculture production, iv) mangrove protection, and v) building resilience of water resources management[7].

Priority Adaptation Sectors for India

Built environment & infrastructure

- Coastal protection
- Embankments
- All weather road technology
- Cool roofs

Agriculture

- Precision agriculture
- Climate resilient varieties
- Soil health monitoring
- Cold storage

Water

- Rainwater harvesting and storage
- Sustainable water supply
- Desalination
- Wastewater treatment and recycling

Ecosystem based adaptation

- Mangrove restoration
- Wetland conservation
- Urban forests
- Slow-forming terrace farming systems

Climate change forecasting & monitoring

- Early warning systems
- Weather forecasting
- Meteorological equipment
- Aerial LIDAR remote sensing

Climate Adaptation: **The Imminent Need for Financing**

- Assets, businesses and people across the country are already facing the impacts of climate change.
- India's transition to resilient growth will require significant investment, which can be delivered through strong and sustained private sector engagement.
- While climate change poses huge risks, it also presents opportunities in various forms, such as development of new products and services in response to climate change, increasing efficiency and reducing operational costs, business continuity and improved risk management, supply chain resilience and leadership in the emerging adaptation market, among others.
- However, due to the public good nature of key adaptation sectors such as water, critical infrastructure and ecosystems, and lack of viable business cases and pipelines in India, adaptation investments are mostly driven by public capital from domestic (national and state budgets) and international sources (multilateral institutions).

Current Policy Environment & Government Initiatives

- **India's NDCs** emphasise the need to enhance investments in climate vulnerable sectors including agriculture, water resources, coastal regions and disaster management[8].

- **National Action Plan on Climate Change (NAPCC) and State Action Plans on Climate Change (SAPCCs)** at the national and sub-national levels outline national missions, priority sectors for adaptation and adaptation activities[9].

- **National Adaptation Fund for Climate Change** was established in 2015 with a budget provision of ₹350 crore for 2015-16 and 2016-17 to support adaptation missions and measures as identified in NAPCC and SAPCCs[10].

- The Government of India has launched two schemes, **Amrit Dharohar Yojana and MISHTI** (Mangrove Initiative for Shoreline Habitats and Tangible Incomes) **Yojana** to revive wetlands and mangroves under the Ministry of Environment, Forests and Climate Change (MoEFCC)[11].

Why are Private Investments in Adaptation Not Scaling up?

Sources:
Climate Policy Initiative,
The World Bank,
Observer Research Foundation

Role of Private Sector In Enabling Adaptation

Safeguarding internal operations

Building measures to adapt to climate change in internal operations and supply chains

Financing adaptation

Providing concessional finance to enterprises and projects engaged in providing or adopting climate adaptation solutions

Developing climate resilient solutions

Engaging in research, development and deployment of innovations that help build resilience of sectors towards climate change, e.g., early warning systems and climate analytics data

Source: *Climate Policy Initiative, 2022*

From challenge to opportunity

- India has clear policy directives for adaptation at the national and sub-national levels. However, India's adaptation financing needs and actions, including levels of private sector engagement, remain difficult to quantify due to lack of standardised taxonomies, methodologies and financing approaches.

- Scaling private investments in adaptation continues to be a challenge due to the lack of an enabling environment as well as business and funding barriers, which in turn make it difficult to develop a pipeline of bankable adaptation projects.

- As it stands, currently, public finance plays a crucial catalytic role in translating adaptation needs to business opportunities through de-risking investments and creating an enabling environment for scaling investments and mobilising commercial finance.

Case Study - Green affordable housing for women

ADB's Urban Climate Change Resilience Trust Fund (UCCRTF)[12]

About the Technical Assistance (TA)

- **Fund structure:** TA grant of **$1 million** from **UCCRTF** under the **Urban Financing Partnership Facility** to help identify and overcome obstacles to enabling an ecosystem for green certified, resilient and affordable housing in India. This TA will inform the ADB project on **'Supporting Access to Affordable Green Housing for Women', for which debt financing of $58 million and a loan of $10 million have been administered to IIFL Home Finance Limited.**
- **Objective:** Accelerate the adoption of green and climate resilient building technologies by developers and align them to home buyer needs in the affordable segment. This fits into UCCRTF's overarching goal of rolling out **25 infrastructure projects** and other resilience measures to protect around **2 million poor and vulnerable people** in select Asian cities and leverage about **$1 billion** in investments from public, private and municipal sources.

Focus areas of the TA:

- Conducting market research of the green housing market
- Creating awareness on green-certified housing standards
- Developing climate adaptive strategies in housing
- Identifying cost effective & innovative green technologies

Project and TA investors:

Asian Development Bank (ADB), The Rockefeller Foundation, Governments of Switzerland and the UK, Canadian Climate Fund for the Private Sector in Asia

Private sector partners:

IIFL Finance, Housing Finance Institutions, Housing Developers

Case Study - Climate Resilience for India's Coastal Communities

Green Climate Fund (GCF)[13]

About the Project

- **Fund structure: $130.3 million** including **$43.4 million grant funding from GCF,** the largest multilateral climate fund, and **co-financing of $86.9 million** from the Government of India and State Governments of Andhra Pradesh, Maharashtra and Odisha.
- **Objective:** Enhancing climate resilience of India's coastal communities in Andhra Pradesh, Maharashtra and Odisha. The project specifically aims to strengthen the lives and resilience of the most vulnerable communities, especially women, to climate change and extreme events in coastal areas through an ecosystem-centered and community-based approach. This falls within the purview of the objectives of GCF.

Focus areas:

Enhancing resilience of coastal and marine ecosystems and their services

Promoting climate adaptive livelihoods and developing associated value chains

Strengthening governance and institutional frameworks for climate-resilient management of coastal areas including integration of ecosystem-based adaptation principles into planning for resilient infrastructure development

Investors:

Green Climate Fund, State Governments of Andhra Pradesh, Maharashtra & Odisha, MoEFCC

Financial support:

Senior & Subordinated Loans, Equity, Guarantees, Grants, Returnable Grants, In-kind Support

With increasing awareness about the impacts of climate change and recognition of the opportunities arising from it, investments in adaptation require the strategic use of both private and public capital and use of blended finance solutions to address existing barriers to scaling private sector investments. The two case studies presented above showcase climate resilience measures that use blended finance structures and lay the potential foundation for private investments at scale.

While the report highlights these case studies for their potential for scaling private investments, it also recognises ongoing efforts by various private sector organisations in climate proofing their businesses, and value chains and introducing pilot projects on enabling climate change adaptation.

CONCLUSION

In Conclusion: The Road Ahead...

India's pathways to a net-zero economy merit investments in sectors that hold significant potential to mitigate climate change as well as help build a domestic economy that is adaptive to the changing climatic conditions. While this includes investment opportunities in several sectors, each holding a potential to accelerate India's decarbonisation ambitions, it is also apparent that most of them are emerging spaces.

Critical emerging sectors and decarbonisation solutions can be scaled up further, provided they are supported by public and private sector led interventions. Our research highlights four key investment opportunities for different forms of capital to step in. While these emerging areas vary in their relative stages of growth and maturity, they are united by their climate impact and by the important role they play in India's net-zero transition.

Green Hydrogen

- ★ Electrolyser manufacturing
- ★ Green hydrogen production

Battery Energy Storage Systems

- ★ Lithium-ion battery (LIB) manufacturing
- ★ LIB application in power and transportation sectors

Climate Smart Agriculture

- ★ Innovative on-farm and closer-to-farm solutions for building farmer livelihoods & resilience to climate change

Waste Management & Material Circularity

- ★ Strengthening the waste management value chain
- ★ More focus on LIB recycling

India's Clean Energy and Industrial Transition

Interlinkages between Climate and Social Impact

Each of these sectors present a unique investment opportunity.

Apart from a positive climate impact, some of these emerging areas also hold the potential to drive social change and improve livelihoods. These sectors, therefore merit greater attention from investors and development of investment strategies that are devised in-keeping with the nuances of these sectors.

As the narrative around green financing for India sharpens, there is a key role for every stakeholder to play.

Time is ripe for the financing actors to foster collaborations and partnerships and nurture the financing and impact ecosystem. With policy and regulatory actions clearly outlining India's commitment to a green transformation, it is only through a combined play of both commercial and concessional capital, that the next rung of emerging 'green' sectors could receive the support they merit.

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Green Hydrogen: Gamechanger for Energy Transition

NEEV FUND

Anjana Seshadri
Vice President, Neev Fund, SBICAP Ventures

Green hydrogen could be a crucial piece in helping India reduce greenhouse gas emissions and achieve its ambitious targets of net-zero emissions by 2070. Over the last couple of years, several factors have improved the investment climate in India for green hydrogen including government support schemes such as National Green Hydrogen Mission, abundant renewable energy resources, decrease in cost of electrolysers, and growing need to decarbonize the industrial and transportation sectors which currently rely heavily on grey hydrogen.

The growing global momentum towards hydrogen could mean that the demand in India for hydrogen is set to quadruple by 2050, accounting for nearly 10% of global hydrogen demand; on a price parity basis alone, green hydrogen's share of this demand could increase from 16% in 2030 to nearly 94% by 2050.

With India's economic growth heavily dependent on abundant and cheap energy availability, we could see an increased reliance on green hydrogen manufacturing, which is at an inflexion point in India and has also attracted investments in firms across the value chain. There are also few sub sectors, where we are seeing increased traction from both government and private players:

a) Offtake from Private Sector: Several private sector players across Industries such as steel and fertilizers are investing in green hydrogen and ammonia production to decarbonize their operations.

b) Electrolysers: The cost of electrolysers has fallen significantly in recent years, making them more commercially viable. In 2021, the Government of India launched the Production Linked Incentive (PLI) Scheme for electrolysers to promote the manufacturing of electrolysers in India and provide financial incentives to manufacturers based on their incremental sales. The PLI Scheme is expected to attract significant investment in the electrolyzer manufacturing sector in India and is expected to help India become a global leader in electrolyzer manufacturing.

c) Storage and transportation: Green hydrogen needs to be stored and transported before it can be used. There are several emerging technologies for storing and transporting green hydrogen, such as liquid organic hydrogen carriers and metal hydrides. Several Indian companies are developing and commercializing these technologies.

The sector is still in its early stages of development, and the technologies involved are constantly evolving. More capital inflows are needed to support early-stage R&D projects in the sector to accelerate the development of new technologies and drive down the costs across the value chain. Also, with new projects coming up, there is a growing need for innovative financing instruments to make the projects more financially viable.

We at Neev Fund, believe green hydrogen and associated compounds such as green ammonia & green methanol would find applications in many industries, with Commercial and Industrial sectors (chemical, steel, glass and oleochemical industries) and hydrocarbon players being the early adopters given the cost parity between green and grey hydrogen has already been established in these sectors. We've seen the emergence of different viable business models such as Build-Own-Operate and Build-Own-Operate-Transfer basis and commodity offtake and Global C&I players enter into long-term offtake contracts for green hydrogen In India, reinforcing our commitment to the sector.

With the increasing demand of the sector, investments and policy support from both the public and private organizations are essential for the development of green hydrogen sector in India. We've already witnessed the rollout of the National Green Hydrogen Mission which aims to develop green hydrogen production capacity of at least 5 MMT/annum, alongside adding renewable energy capacity of about 125 GW in India by 2030. The policy has an initial outlay of INR 19,744 crore, which includes incentives for production of green hydrogen and manufacturing electrolysers.

The Policy initiatives reflect the government's commitment to make India a global hub for producing, using and exporting green hydrogen. With the current policy and regulatory framework, focused more on supply side incentives, we also need to focus on demand interventions such as green hydrogen purchase obligations and price subsidies.

Overall, the green hydrogen sector in India is at a critical stage of development and is poised to attract significant investment in the coming years. The improved investment climate in India for Green hydrogen is good news for the investors as they now have several opportunities to invest in various parts of the value chain, depending on their risk appetite and investment horizon.

About Neev Fund:

Founded in 2015, the Neev Fund, managed by SBICAP Ventures Limited, invests in SMEs that have a transformative impact and seek growth and catalytic capital. In a market first initiative, the fund's performance is measured by its financial as well as developmental returns. The Fund aims to provide growth and expansion capital to SME companies working towards climate, environment and social infrastructure sectors. More about the Neev Fund: *https://neevfund.com/*

Battery Energy Storage Systems (BESS): The Key to the Energy Transition

Vasudha Madhavan
Founder & CEO,
Ostara Advisors

Setting the Context: Global trends in Green Energy

Global investments in Energy Transition technologies reached a record high of $1.3 trillion in 2022, a 19% increase from 2021, according to the International Renewable Energy Agency (IRENA), with major share of the investments flowing into solar and wind technologies.

In the first six months of 2023, new investments in Renewable Energy which is a sub-set of the Energy Transition, reached $358 billion, a 22% increase compared to the start of last year and an all-time high for any six-month period. This amply illustrates the growing importance of Renewable Energy globally as countries chart their paths to Net Zero.

At the heart of these transformative shifts lies the battery - an unassuming yet indispensable component that is reshaping industries, powering our lives, and enabling a sustainable future.

Renewable energy, while environmentally friendly, has faced challenges with intermittency, a problem that hinders its ability to provide a constant energy supply. This issue is linked to the concept of "base load" energy, which refers to a power source's ability to provide a minimum, uninterrupted amount of energy to a grid. Batteries play a crucial role in addressing intermittency through energy storage and reducing dependence on continuous baseload power from a single source.

The India BESS Opportunity

As India moves towards greater use of renewable energy, having set a goal of meeting 50% of its energy requirement from renewable or non-fossil energy sources by 2030, it will need to invest in Battery Energy Storage Systems (BESS). As of FY23, India had around 37MWh of BESS capacity, and according to the Central Electricity Authority, the requirement for battery storage will reach 236.22 gigawatt-hours by 2031-32.

India's BESS market is estimated to grow from US$3.10b in 2022 to US$5.27b by 2028, registering a CAGR of over 11.20% during the forecast period, as per Mordor Intelligence. RMI and NITI Aayog estimate a conservative scenario of 106GWh of BESS installed capacity coming on stream by 2030, representing an annual market of over US$6 billion a year and say that localising parts of the BESS supply chain could enable the country to capture "significant value".

Lithium-ion batteries and pumped Hydrogen are emerging as the two most likely technologies for large-scale BESS deployments while other battery technologies are in early stages of testing and validation.

Key Stakeholders in Financing India's BESS deployments

This is a huge investment opportunity and will require proactive financial support and collaboration between the Public Sector and Private Industry. Let's take a look at key players who might be instrumental in Financing and/or Operating BESS frameworks.

As in any new industry, the Government will play the most important role in terms of both regulatory and financial support for BESS. Following through on the Finance Minister's announcement in the 2023 Union Budget of a Viability Gap Funding facility for 4000 MWh of Battery Energy Storage capacity, the Union Cabinet approved a $455m viability gap fund (VGF) in Sep 2023. Under the scheme, the government will provide financial support, in the form of grants, of up to 40% of the capital cost of BESS projects totalling 4,000 MWh till FY31. An official statement in Sep 2023 said the scheme aims to reduce the levelized cost of storage (LCoS) to ₹5.50-6.60 per kilowatt-hour (kWh), making storage a viable option to manage peak power demand. According to industry estimates, the LCoS currently stands at around ₹10-11 per kWh.

The Ministry of Power is also working on a production-linked incentive (PLI) scheme which will enable local production of large battery energy storage systems. There is also a move to reduce the goods and services tax (GST) on grid-scale battery storage to 5%, from the current 18% applicable on lithium-ion BESS.

On the back of this significant policy push, we expect private players including Renewable Energy Asset Developers, large Global and Indian Energy companies to make BESS a central element in their New Energy business strategies.

This will also accelerate private capital flows from global and Indian strategic and financial investors into Indian startups that are working in areas incl advanced battery storage packs and related

electronics, software and data analytics solutions for monitoring BESS assets, Vehicle-to-grid solutions as well as Circular economy solutions that focus on repurposing EV batteries for energy storage applications.

At Ostara Advisors, we are bullish on the investment opportunity that this energy transition entails and continue to engage closely with startups and investors in this domain.

Sources: *World Bank, Know How, Livemint,* Mordor Intelligence

About Ostara Advisors:
Founded in 2015, Ostara Advisors is India's first specialist investment banking firm focused on Electric Mobility and Sustainability, providing growth capital raising and M&A solutions to climate-positive businesses. Taking a thought-leadership based approach in these sectors, the firm is an early mover in institutionalizing fund-raising for the Indian Mobility & Sustainability ecosystem, having successfully closed marquee M&A and fund-raise deals including India's first Electric Vehicle two-wheeler M&A transaction, Greaves Cotton Limited's acquisition of pioneering EV two-wheeler company, Ampere Vehicles, as well as one of the largest growth capital rounds in the EV three-wheeler space, to name a few. The firm was founded by Ms. Vasudha Madhavan, who is one of the first investment bankers in India to specialize in Electric Mobility. She has over 20 years of experience in Corporate and Investment Banking and was featured in the Top 20 on the All-India M&A League Tables by Venture Intelligence in late-2018. More about us on our website *www.ostara.co.in.*

Empowering Change: The Positive Impact of Gender Lens Investing in Combating Climate Change

Bram Spann
Lead Program Manager, Asia,
Rabo Foundation

The climate crisis is one of the most pressing challenges of our time, threatening our planet's ecosystems, economies, and the well-being of billions of people. As we grapple with the urgent need to reduce greenhouse gas emissions and adapt to a changing climate, it has become increasingly clear that addressing gender equality and climate change must go hand in hand. Gender lens investing, an approach that considers the gender-related impacts of investments, is emerging as a powerful tool for driving positive change in both areas.

Investing for women empowerment involves evaluating the social and economic implications of investments through a gender-sensitive lens. It seeks to promote gender equality and empower women and girls while generating financial returns. The core idea behind this is that by considering the specific needs, opportunities, and contributions of women, investments can yield both social and financial benefits.

Women as Climate Leaders

One of the key positive impacts of gender lens investing in relation to climate change is the recognition and support of women as climate leaders. Women around the world have played pivotal roles in advocating for environmental sustainability, resilience, and adaptation strategies. By investing in women-led initiatives and organizations, gender lens investors are helping to amplify the voices and contributions of women in the climate movement.

It is well known that companies with greater gender diversity at the executive and board levels tend to perform better in terms of environmental, social, and governance (ESG) criteria. These companies are more likely to adopt environmentally sustainable practices, prioritize renewable energy, and make responsible choices regarding resource consumption.

Fostering Inclusive Innovation

Gender lens investing also fosters inclusive innovation within the climate sector. Women entrepreneurs and scientists bring unique perspectives and innovative solutions to address climate challenges. By providing financial support and mentorship to women-led startups and initiatives, gender lens investors help unleash the untapped potential of female innovators in climate-related fields. Their innovations not only contribute to reducing carbon emissions but also create economic opportunities and improve the livelihoods of marginalized communities.

Advancing Climate Resilience

Climate change disproportionately affects women, particularly in vulnerable and marginalized communities. Gender lens investing recognizes this reality and seeks to advance climate resilience by supporting projects and initiatives that empower women and enhance their capacity to adapt to a changing climate.

Investments in women's agricultural cooperatives, for instance, can help build resilient food systems by promoting sustainable farming practices and diversifying income sources. Similarly, access to clean energy technologies, often led by women-focused initiatives, improves the resilience of households and communities to climate-related disasters.

Bridging the Gender Gap in Access to Finance

One of the critical barriers that gender lens investing addresses is the gender gap in access to finance. Women entrepreneurs and climate leaders often face greater challenges in securing funding for their ventures compared to their male counterparts. By investing in women-led businesses and projects, gender lens investors are helping to bridge this financial gap, enabling more women to participate in climate action.

Driving Sustainable Supply Chains

Gender lens investing can also drive sustainable supply chains by encouraging businesses to adopt ethical and environmentally responsible practices. Companies that prioritize gender equality in their supply chains are more likely to engage in sustainable sourcing, reduce waste, and promote fair labor practices. When investments are directed towards businesses that support women-owned suppliers and female workers, it creates a ripple effect that positively impacts the entire supply chain.

Conclusion

Gender lens investing is a potent force for positive change in the context of climate change. By recognizing and empowering women as climate

leaders, fostering inclusive innovation, advancing climate resilience, bridging the gender gap in access to finance, and driving sustainable supply chains, gender lens investing addresses critical aspects of the climate crisis while promoting gender equality.

At Rabo Foundation we acknowledge the important position of women to combat climate change, while at the same time they are amongst the most vulnerable ones, especially in marginalized communities. Therefore, in 2022 we launched a program in India specifically addressing the financial needs of women-led agri enterprises and companies working with female farmers in combination with climate-smart solutions. The 5-year program should empower women in the agri value chains to strenghten their position as essential stakeholders in the battle against climate change. By increasingly focusing on women as an investment for a sustainable future, we hope to inspire others in doing the same.

The time to act is now, and gender lens investing is a powerful tool in our arsenal for a more resilient and equitable world.

About Rabo Foundation:
As a provider of impact funding, Rabo Foundation operates worldwide to achieve continuous positive change to vulnerable groups: economic, social and ecological. The foundation focuses internationally on access to finance and related support for producer-based agricultural cooperatives, agri-enterprises and agtech start-ups. Also, Rabo Foundation works closely together with local financial intermediaries to unlock capital for the described target group. More about Rabo Foundation: *https://www.rabobank.com/about-us/rabo-foundation*

Investing in Climate Smart Agriculture: The Vital Role of Financial Institutions in India's Sustainable Future

Luca Torre
Founder & Co-CEO,
GAWA Capital

Indian agriculture faces unprecedented challenges due to climate change. Erratic weather patterns, water scarcity, and extreme events threaten crop yields and food security. Climate Smart Agriculture (CSA) emerges as a beacon of hope, offering a sustainable path forward for farmers to adapt to these new climate conditions. However, the successful implementation of CSA hinges on the active adoption of these new techniques by farmers as well as on the active participation of financial institutions.

Climate change's impact on Indian agriculture is undeniable. Farmers grapple with unpredictable monsoons, prolonged droughts, and more frequent pest outbreaks. The need for climate-resilient practices is urgent, not only for safeguarding livelihoods but also for ensuring food security for a growing population.

CSA offers a promising solution. By integrating climate-resilient techniques, CSA enhances yields, fortifies farmers against climate-related risks and indirectly reduces greenhouse gas emissions. Moreover, it can lead to cost savings, ultimately improving farmers' incomes.

The potential for CSA in India is immense. Investments are required in various aspects, including adopting drought-resistant crop varieties, implementing efficient irrigation systems, promoting sustainable land management practices, and developing climate-smart livestock management. Additionally, technology-driven solutions, such as data-driven decision-making tools for farmers, hold substantial promise.

India has developed some of the best climate solutions in the agricultural technology and precision agriculture space. It is now time to work on adoption. At GAWA Capital, amid this transformative journey, financial institutions occupy a pivotal role. They possess the resources, expertise, and capacity to drive CSA investments to scale. Here's how:

Providing Capital: Financial institutions can offer loans and credit lines to farmers for CSA adoption. These funds enable farmers to invest in resilient practices, such as drip irrigation and climate-resilient crop varieties.

Investing in CSA Initiatives: Financial institutions can channel their investments into CSA-focused initiatives. By supporting these projects, they not only diversify their portfolios but also contribute to sustainable development.

Technical Expertise: Financial institutions can bring technical expertise to the table. They are well-versed in risk assessment and project management, crucial for evaluating the viability of CSA projects.

Partnerships and Collaborations: Collaboration is key. Financial institutions can partner with agritechs and climate tech to build embedded finance solutions. They must also continue collaboration with government agencies, non-governmental organizations, and other stakeholders to create synergistic approaches to CSA financing. Government policies can further incentivize financial institutions to invest in CSA. Subsidies and risksharing mechanisms can promote CSA adoption and financial institutions can be great channels to deliver them to vulnerable communities.

Around India, there are notable examples of financial institutions that have already embraced supporting CSA practices. These institutions have invested in projects aimed at enhancing climate resilience, improving farmer incomes, and reducing emissions.

But more is needed: at GAWA Capital we are launching a new fund called Kuali which aims at promoting climate adaptation among farming communities by investing and providing technical assistance to financial institutions that finance climate smart agriculture. The fund will also invest in climate solutions providers to ensure that farmers have access to technologies and practices that lead to real changes in the way farmers work their fields. The fund aims at building synergies between financial institutions and climate tech through embedded finance schemes. The fund is expected to invest 100 million EUR in India.

In conclusion, investing in Climate Smart Agriculture is not just a choice; it's a necessity. India's agricultural sector must adapt to the changing climate to ensure food security and prosperity for its people. Financial institutions are not mere observers in this transformation; they can be the driving force. By providing capital, expertise, and collaboration, they can catalyze the transition towards resilient and sustainable agriculture. The time to invest in Climate Smart Agriculture in India is now, for a more secure and sustainable future.

About GAWA Capital:
With over 14 years of experience, Gawa Capital is a European impact investment management firm committed to supporting positive social and environmental impact while generating financial returns for investors. Since its inception, GAWA has pioneered the introduction of the impact investing asset class in Spain, having launched three funds, in addition to advising a third-party fund. Each of these funds invests equity and debt in developing countries, in companies focused on providing market-based solutions to key societal issues such as poverty. More about Gawa Capital: *https://www.gawacapital.com/about-us*

Conscious Consumerism: Opportunities emerging from reimaging brands and supply chain

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In recent years, India has witnessed a significant transformation in consumer behavior, largely driven by millennials and further accelerated by the COVID-19 pandemic. Increasingly, the Indian consumer is opting for sustainable choices when making purchases, signaling a burgeoning trend that has caught the attention of brands as well. According to a recent survey conducted by Bain & Company, a notable 52% of consumers in urban India anticipate increasing their spending on sustainable brands in the next two to three years. This shift, though gradual and in its early stages, is sizable enough to be noticed by the brands who are increasingly introducing products made with greener alternatives and clean ingredients to cater to this evolving market segment.

The Emergence of D2C Sustainable Brands:
The most promising development in the sustainable brand space is being seen in the food and lifestyle industries which have seen emergence of multiple startups like Foret - a vegan and sustainable fashion brand that creates bags and products using cork and banana bark, offering an ethical alternative to traditional leather goods, Superbottoms which specializes in sustainable baby and mom care products, Shumee which offers eco-friendly and child-safe toys, catering to parents who prioritize both safety and sustainability and GoodDot, a plant-based meat and vegan food brand tapping into the increasing interest in plant-based diets and sustainable protein sources. These startups exemplify how Indian entrepreneurs are recognizing the shift in consumer preferences and seizing the opportunity to provide sustainable alternatives across various product categories.

The Rise of Traceability:
Conscious consumerism is not limited to the desire for eco-friendly products; it also extends to the desire for transparency in the supply chain. Consumers are increasingly seeking information about the sourcing, production methods, and ingredients used in products. This trend is compelling companies to share more data about their processes and materials, aiming to distinguish themselves in the market as transparent and ethical brands. Technologies like IoT and blockchain will play a pivotal role in enabling this end-to-end visibility. Companies like TraceX are leveraging blockchain to enable digital traceability for food and agriculture supply chains, thus paving the way for the adoption of sustainable and climate resilient food production practices.

Government Initiatives Towards Sustainability

In parallel, Indian policymakers and regulators are actively working to build an ecosystem with a low-carbon future at its core. Several notable initiatives underscore the government's commitment to fostering sustainability:

Extended Producer Responsibility (EPR): This government mandate holds producers of plastic or electronic waste responsible for the proper end-of-life handling of their products, thus compelling companies like ITC, HUL and many others to take responsibility for the waste they generate.

Ban on Single-Use Plastics: In July 2022, India introduced a ban on single-use plastics, a significant step in reducing plastic pollution and promoting eco-friendly alternatives. These measures not only make companies accountable for their environmental impact but also incentivize the development of sustainable alternatives to environmentally harmful materials and packaging.

Innovations in Alternative Materials: Indian companies are rising to the challenge by exploring innovative materials that can replace traditional, less sustainable options. A few noteworthy examples include companies like Zero Circle which utilizes seaweed as a raw material to produce plastic alternatives, reducing the reliance on petroleum-based plastics, Fibmold which specializes in molded fiber packaging solutions for the food and beverage industries.

The Circular Economy Imperative

India stands at a critical juncture in its economic growth, and the adoption of a circular economy is of paramount significance to future-proof this growth. It addresses pressing challenges such as waste management, resource constraints, and import dependence.

A notable example of India's commitment to sustainability is the government's goal to increase the share of electric vehicles (EVs) in the overall

automobile market from 2% to 30% by 2030. However, achieving this goal poses challenges, particularly regarding the supply of essential metals like lithium and cobalt needed for manufacturing Li-ion batteries which are used in these vehicles. Thus, domestic recycling of Li-ion batteries is essential for self-sufficiency. Indian startups like Lohum, MiniMines, and Metastable are already pioneering technologies for efficient battery recycling, providing essential metals like lithium, cobalt, and nickel to Indian original equipment manufacturers (OEMs).

Another innovative segment is food upcycling. Companies like Wastelink and Loopworm are converting food waste— which constitutes a staggering 40% of food produced in India—into ingredients for animal feed. This not only addresses the issue of food waste but also creates a sustainable supply chain for animal nutrition.

A Sustainable and Ethical Future

In conclusion, the rise of conscious consumerism in India coupled with the increasing regulatory push is reshaping the market and compelling businesses to embrace sustainability and transparency in their operations. By seizing these opportunities, Indian companies can meet the evolving demands of conscious consumers, contribute to a more sustainable and ethical future, foster uniqueness in a competitive market, and align with India's AtmaNirbhar Bharat goals.

To transition to a more sustainable supply chain and circular economy, concerted efforts from businesses, government bodies, investors and consumers are essential. In our capacity as impact investors, it is incumbent on us to catalyze this transition which is still at nascent stages even as we await a critical mass of consumers to willingly and readily pay premium for sustainable products and services. This collaborative approach will prove to be a strategic imperative for India's sustainable growth and future prosperity.

About Asha Ventures:
Asha Ventures is an Inclusion & Sustainability focused fund investing at an early growth stage in India. In order to drive Inclusion & Sustainability, the firm specifically focuses on areas of Financial Empowerment, Job Creation & Education, Healthcare for all, AgriTech and ClimateTech. Across these sectors, Asha Ventures partners with ambitious entrepreneurs who leverage technology to build Innovative businesses for India's Emerging Middle Class. More about Asha Ventures: *https://ashaventures.in/*

From Crisis to Innovation: Housing Solutions in the face of Climate Change

Habitat for Humanity

Terwilliger Center for Innovation in Shelter

Anoop Nambiar

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The challenge of climate change does not exist in a vacuum. Rather, it intersects with multiple global trends, including growing urbanization, migration, rising systemic inequity and loss and damage from extreme events. The dual crises of climate change and the global affordable housing shortage are intertwined: in low-income countries, where the effects of the climate crisis on communities are felt the most, climate change is profoundly related to housing, which is where the bulk of unmet housing need is located.

At the same time, the built environment produces a third of the world's waste. Every year about 100 billion tons of raw materials are extracted for use across the buildings and construction sector and annually, buildings are responsible for about 39% of energy-related global carbon emissions[1]. The use of these materials is also set to increase, especially in low-income countries where new infrastructure and housing growth is anticipated to accelerate most, due largely to rapid urbanization and the quality limitations of existing housing stock. Housing has a huge role to play in adapting against a changing climate while also mitigating emission impacts by embracing more circular, sustainable practices.

The global housing shortage is growing: Worldwide, 1.6 billion people lack adequate housing, including 1 billion living in slums and informal settlements, a situation that severely undermines efforts to address and eradicate all facets of poverty[2]. The United Nations estimates that 3 billion[3] people — 40% of the world's population — will need access to adequate housing by 2030, equivalent to 96,000 new affordable and accessible housing units every day. Affordable housing has a direct impact on numerous global calls to climate action, including Sustainable Development Goals (SDGs), notably SDG11: Sustainable Cities and Communities among other SDGs.

Low-income families experience unequal impact: The impacts of climate change are vastly unequal and felt the most by the world's poorest communities. The 46 least-developed countries only account for 1.1% of total world carbon dioxide CO_2) emissions from fossil-fuel combustion and industrial processes, despite being home to 1.1 billion people, approximately 14% of the world's population[4]. These countries were affected by less than a fifth of climate-related disasters yet have suffered 69% of deaths worldwide attributable to the same occurrences. For those who live in coastal areas, climate change poses an existential threat due to rising sea levels. Housing can be the best defense against a changing climate, including protection from increasingly erratic weather events, disasters as well as rising temperatures.

Tamilarasi Kamaraj, a beneficiary, of LaRaksha Social Impact Trust's Roofing Loan stands in front of her house in Nagapattinam.

Source of image: Terwilliger Center for Innovation in Shelter

Adaptation efforts must include quality housing: Habitat's Terwilliger Center, works to expand low-income families' access to innovative housing products, services, and financing. The Center's MicroBuild Fund supports microfinance institutions to develop affordable, housing-specific loan products tailored to the needs of low-income families. When it launched in 2012, MicroBuild was the first housing-specific microfinance investment vehicle in the world. The fund invests in financial institutions, which on-lend this capital as housing microfinance loans directly to low-income borrowers. The fund has distributed over USD 160 million, across 33 countries impacting 1.08 million individuals so far, with 69% of the borrowers being women[5]. The total investee housing microfinance portfolio stands at over USD 1.55 billion.

The fund has allowed families to build and improve their homes, and in places like coastal areas of India and the Philippines that means disaster resilience.

Additionally, in Bosnia and Herzegovina the fund has helped link families with energy efficiency improvement loans. In addition, the Center has been advancing innovative housing solutions for climate mitigation and adaptation, supporting startups worldwide through its global platform, ShelterTech, as well as with patient capital via the Shelter Venture Fund. So far, the Center has supported over 110 startups focused on affordable and sustainable housing worldwide, including 17 in India, and have made 11 investments through the fund. A good example is Indian startup ReMaterials that makes ModRoof, a modular system of lightweight roofing panels from cardboard waste combined with natural binders, that significantly reduces the indoor temperature inside homes, improving habitability and health of families.

Given that those who are most impacted by climate change are also those most affected by the global housing shortage, any measures to support climate change mitigation and adaptation must incorporate housing needs to succeed. Quality, affordable, and sustainable housing can help low-income families build resilience against the perils of climate change.

References:

Net-Zero Homes *https://www.habitat.org/sites/default/files/documents/Net-Zero_Homes_report_2022.pdf*
MicroBuild Fund Annual Report FY2022 *https://www.habitat.org/sites/default/files/documents/FY22_MBF-annual-report.pdf*

About the Terwilliger Center for Innovation in Shelter:
Habitat for Humanity's Terwilliger Center for Innovation in Shelter focuses on the most pivotal yet uncharted intervention points in global housing markets. We conceptualize, pilot, and accelerate scalable solutions that have the greatest potential to close the global affordable housing deficit for low-income communities. The Terwilliger Center has helped over 36.5 million people access improved housing through market-based approaches. Anoop Nambiar serves as the Country Director for India. More about Terwilliger Center for Innovation in Shelter: *https://www.habitat.org/our-work/terwilliger-center-innovation-in-shelter*

Regulatory Reforms Encouraging Green Investments in India

TRILEGAL

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As India prioritizes its ambitious goals of decarbonizing energy to 50% and achieving 500 GW ofgreen energy capacity by 2030, and a long-term net zero strategy, the role of regulations in fostering and accelerating green investments is crucial. Few of such key recent regulatory reforms in the green sectors are discussed below.

Renewable Energy

India's installed renewable energy capacity stands at 179.322 gigawatts (GW) as of July 2023, which is globally the fourth largest installed capacity of renewable energy, as per the International Renewable Energy Agency's Renewable Energy Statistics, 2023. The renewable energy sector in India has witnessed exponential growth over the last decade, and supporting regulatory reforms are a key reason. Recent regulatory developments that continue to provide impetus for green investment:

(a) Electricity sector reforms

- The introduction of the Central Electricity Regulatory Commission **(CERC)** (Connectivity and General Network Access to the Inter-State Transmission System) Regulations, 2022 **(GNA Regulations)** marked a new paradigm in transmission system planning by enabling flexible and non-discriminatory open access. Generating stations now have open access without need to identify the consumer, unlike the erstwhile regulations. This enables the flexibility to schedule and dispatch surplus power to demand centers across the country. Honoring the "must-run" status of generating stations based on renewable energy sources **(REGS)**, the regulations clarify that bilateral transactions and collective transactions of power, based on conventional sources will be curtailed before the transactions involving REGS.
- The recent CERC (Sharing of Inter-State Transmission Charges and Losses) Regulations, 2020 provide a 25 years' waiver of the transmission charges payable for scheduling power sourced from REGS commissioned up to 30 June 2025. Further, the transmission charges for battery energy storage system **(BESS)** charged with REGS, commissioned up to 30 June 2025, is also waived for 12 years.
- The Ministry of Power **(MoP)** notified the Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022 **(GEOA Rules)**[1] which aim to encourage the use of clean energy including from waste-to-energy plants, by eliminating capacity limits for captive consumers, allowing for renewable energy banking and providing for appointment of nodal agencies for streamlining the open-access approval process. The GEOA Rules allow consumers with a sanctioned load of 100 kW or above to purchase electricity directly from the renewable power producers through open access (DISCOMs)[2]. These rules benefit Commercial and Industrial (C&I) sector and MSME consumers who can purchase green power and allows captive consumers to take power with no minimum limitation. The GEOA Rules provide a significant boost for private renewable energy procurement in India and support individual consumers in their choices to decarbonise through open access.
- The GEOA Rules also grant incentives such as fixing standards for levy of the cross-subsidy surcharge (for C&I consumers) and standby charges, exempting the open access consumers from levy of additional surcharge if the power is produced from offshore wind projects commissioned up to 2032, and exempting levy of cross subsidy surcharge and additional surcharge if the power is produced from non-fossil fuel based waste-to-energy plants or is utilised for production of green hydrogen or green ammonia.

(b) Green Hydrogen

- The Green Hydrogen Policy was introduced by the Government in 2022 to promote the generation and procurement of green hydrogen and green ammonia. The policy incentivizes production of green hydrogen and green ammonia by waiving inter-state transmission charges for green hydrogen projects commissioned before 30 June 2025 and capping banking charges. The policy also eases the allotment of land for green hydrogen projects by providing allotting land in renewable energy parks and creating manufacturing zones for such projects.
- The Government has also launched the National Green Hydrogen Mission with the aim to create green hydrogen production capacity of 5 million metric tons per annum and add 125 GW of renewable energy capacity by 2030. The mission seeks to attract over INR 8,00,000 crores in investments, reduce fossil fuel imports, and decrease annual greenhouse gas emissions by nearly 50 million metric tons.
- The Ministry of New and Renewable Energy recently unveiled an INR 4 billion research

and development **(R&D)** road map for the National Green Hydrogen Mission. The roadmap recommends R&D actions for each aspect of the green hydrogen value chain and prioritizes technologies, infrastructure and safety to improve the efficiency and reliability of green hydrogen production, storage and transportation. The roadmap categorises projects basis their impact horizon and gives first priority to initiation of projects with up to 5 years of impact horizon. The mission will also facilitate a public-private partnership framework for R&D.

(c) Energy Storage

In its effort to transition from simple vanilla grid connected REGS to REGS with energy storage solutions to manage peak power demand nationwide, the government has approved the Viability Gap Funding **(VGF)** scheme for the development of 4,000 MWh of battery energy storage systems **(BESS)** projects by 2030-31. This is to ensure to round-the-clock supply of power and access to such green power. Under the VGF scheme, the government will provide financial support up to 40% of the capital cost as VGF.

Pumped Storage Projects **(PSPs)** form a crucial component of the Government's renewable energy integration strategy as they form clean, green, safe sources of energy without any poisonous/ harmful output. The Government has notified guidelines to promote PSPs by granting incentives such as exemptions from stamp duty and registration fees, grant of government land at concessional rates and waiver of electricity duty and cross subsidy surcharge.

Transport and Mobility

- The Government had introduced the National Electric Mobility Mission Plan **(NEMMP)**, 2020 to boost the manufacturing and adoption of electric vehicles in India. As a part of NEMMP, 2020, the Ministry of Heavy Industries **(MoHI)** is currently implementing the second phase of 'Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India' scheme **(FAME)**, to facilitate the deployment of e-vehicles in public transportation by providing charging infrastructure and demand incentive for consumers (in the form of an upfront reduced purchase price of certain categories of hybrid and electric vehicles to enable wider adoption, which will be reimbursed to the OEM by Government). The cabinet has also recently approved the 'PM e-Bus Sewa' scheme under which the Government aims to augment city bus operations with 10,000 e-buses along with associated infrastructure, on public private partnership model.

Circular Economy

- With the emergence of more sustainable production and consumption practices across the globe, the Indian Government in 2021, recognised 11 focus areas to expedite the transition of the country from linear to circular economy, i.e. an economy that incorporates the principles of reusing, re-manufacturing, and recycling. These focus areas include municipal solid waste and liquid waste, ferrous and non-ferrous scrap metal, electronic e-waste, solar panels, toxic and hazardous industrial waste, agriculture waste and end-of-life vehicles.
- To promote circular economy, Ministry of Environment, Forest and Climate Change of India **(MoEFCC)** notified the Plastic Waste Management Rules, 2016 (as amended in 2022), E-Waste (Management) Rules, 2016 (as amended in 2022) **(E-Waste Rules)** and Construction and Demolition Waste Management Rules, 2016. Pursuant to these rules, the Central Pollution Control Board **(CPCB)** issued guidelines on environmental management of construction and demolition wastes, 2017 and the framework for issuance and recently amended the 'extended producer responsibility' **(EPR)** which require producers and industrial users of plastic packaging to meet a minimum level of recycling of plastic packaging waste on a category wise basis.
- The Ministry of Road Transport and Highways also notified the Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021, and introduced registered facilities which are authorised for scrapping of un-fit vehicles. Similarly, the Ministry of Steel issued a recycling policy for steel scraps to promote circular economy and the 6Rs principles in the steel sector, i.e. 'Reduce, Reuse, Recycle, Recover, Redesign and Remanufacture' through scientific handling, processing and disposal of all types of recyclable scraps, including non-ferrous scraps.

Carbon Markets

- The Energy Conservation Act, 2001 was recently amended to pave the way for an Indian carbon market. The amendment empowers the Government to specify a carbon credit trading scheme **(CCTS)** under which an authorized agency will certify carbon credit for trading in India. It also allows any person to purchase an energy saving certificate on a voluntary basis. Thereafter, the power ministry notified the Carbon Credit Trading Scheme, 2023 **(Scheme)** on June 30, 2023. The Scheme identifies a National Steering Committee and the Bureau of Energy Efficiency **(BEE)** to institutionalize and oversee the operations of the carbon market, formulate procedures and set emission targets for obligated entities.

- The Green Credit Programme Implementation Rules, 2023 **(GCP)** was notified on 13 October 2023 as an innovative market-based mechanism designed to incentivize voluntary environmental actions across diverse sectors. The GCP contemplates a domestic voluntary mechanism for individuals, industries, private sectors to earn green credits which will be tradable on a domestic market platform. The Ecomark Scheme was also notified on 13 October 2023 which provides accreditation and labelling for consumer products that meet quality standards ensuring minimal environmental impact. These initiatives are intended to build consumer awareness of environmental issues, encourage eco-conscious choices and motivate manufacturers to shift towards environment friendly sustainable production.

Notes:

1. While the GEOA Rules have been notified by the Central government, the implementation of these rules remain under the purview of the State governments. The GEOA Rules have already been adopted by Karnataka, Madhya Pradesh, Haryana, Punjab and West Bengal, and various other states have introduced drafts for implementation of the GEOA Rules.

2. Earlier limit was 1 MW.

About Trilegal:

Trilegal is one of India's leading law firms, with expertise across the full spectrum of corporate legal services. Trilegal has offices in four key cities of India.

Trilegal has been recognised as the India Deal Firm of the Year by Asian Legal Business **(ALB) India Law Awards 2023;** one of the 'Best Overall Law Firms' at the **India Business Law Journal Indian Law Firm Awards 2022;**'Firm of the year' for Client Service Excellence by **Asia Law Awards 2021;** "M&A Law firm of the Year" by **VCCircle Awards 2020;** one of the most innovative law firms in Asia in the inaugural edition of **ALB Trailblazers 2020** and 'highly commended' in the **FT RSG Innovative Lawyers Awards 2020.**

ANNEXURE

DESCRIPTION OF TECHNOLOGIES

Description of Technologies / Solutions

Types of waste	Key Application	Demand Potential
Power	Battery Energy Storage Systems (BESS)	A Battery Energy Storage System (BESS) is a sophisticated technology that employs advanced lithium-ion batteries to efficiently capture, store, and release electrical energy. With a focus on high energy density and long-lasting performance, Li-ion BESS excels at quickly responding to changes in power demand, smoothing out renewable energy variability, and providing robust power during peak usage. Its modular design allows for flexible scaling to meet specific energy storage requirements. This technology is significantly appealing due to its pivotal role in bolstering grid stability, facilitating the integration of renewable sources, and offering promising applications in various sectors including grid management, renewable energy optimisation, and electric vehicle infrastructure.
Hydrogen	Electrolysers	Electrolysers are advanced devices pivotal to the emergence of hydrogen as a clean energy resource. Through the process of electrolysis, these devices utilize electricity to split water into hydrogen and oxygen gases. The produced hydrogen can be stored and utilized across diverse applications, including electricity generation through fuel cells, industrial processes, and fuel for hydrogen-powered vehicles. Electrolysers offer a means to balance renewable energy fluctuations by converting excess electricity into storable hydrogen, thus aiding in grid stability. As a cornerstone of the growing hydrogen economy, electrolysers are attractive with their potential to contribute to sustainable energy solutions, align with policy incentives promoting hydrogen technologies, and play a vital role in multiple industries seeking cleaner energy alternatives.
Material Circularity	Batteries and E-Waste	Battery and electronic waste (e-waste) recycling are essential pillars of a sustainable circular economy. Three primary recycling techniques come into play: pyrometallurgy, which employs high-temperature processes to separate materials by melting points; hydrometallurgy, involving chemical solutions to extract valuable metals with precision; and direct recycling, refurbishing components for extended use. These methods collectively salvage valuable resources, curbing environmental impact by reducing waste, conserving energy, and lowering the need for fresh raw materials.

Source: Author's Understanding

Description of Technologies / Solutions

Types of waste	Key Application	Demand Potential
Climate Smart Agriculture	Climate Smart Agri Inputs	Climate Smart Agriculture Inputs involve climate resilient seeds and low-carbon fertilisers, climate-resilient seeds are meticulously designed to withstand the challenges of extreme weather, fortifying crop stability, conserving water resources, and ensuring food security in the face of climate uncertainties. Simultaneously, low-carbon fertilisers, engineered to curtail greenhouse gas emissions throughout their life cycle, optimize nutrient delivery, bolster crop yields, and nurture soil health. These innovations collectively define the forefront of climate-smart agriculture, harmonizing the critical needs of adapting to a changing climate with environmental responsibility.
	Precision Agriculture & Robotics	**Precision Agriculture:** Precision agriculture employs sensor technology and data analytics to optimize crop management, conserving resources while fostering soil and crop health. This approach not only addresses climate-induced changes in soil nutrient balance, fertility, erosion, and degradation but also empowers informed and sustainable soil management practices. **Agriculture Robotics:** Agriculture robotics automates labor-intensive farming tasks such as planting seeds, weed control, spraying fertilisers, harvesting, and crop monitoring, alongside soil analysis. These robots, with their precision and efficiency, assist farmers in making more informed decisions to ensure climate-proofing of crops and optimal yields.
	RE Powered Storage & Processing	Cold Storage and Food process Solutions, fueled by sources like solar and wind power ensure the efficient preservation of agricultural produce and the processing of food with minimal environmental impact. Renewable-powered cold storage units safeguard the freshness of harvested crops while significantly reducing energy consumption compared to conventional refrigeration methods. Simultaneously, renewable-powered food processing equipment slashes the carbon footprint associated with traditional methods, underlining their role as vital components of sustainable agriculture while offering compelling investment opportunities in the eco-conscious agricultural sector.

Source: Author's Understanding

G-H2 production cost components

Sector - Technology	Metric	Data	Source
Hydrogen - Electrolyser (Alkaline)	TRL	9 (Market uptake)	*IEA*
	Fully installed costs (based on 20 MW capacity. Includes project design, planning, contingency, overheads, etc.)	$850/kW (2020, global average) $300/kW (2021, China) $475-$750/kW (2030)	*ETC, Making the Hydrogen Economy Possible (2021)*.
Hydrogen - Production	Capex (electrolyser)	$230-$380/kW	*ETC, Making the Hydrogen Economy Possible (2021).*
	Cost of electricity	$40-$60/MWh	
	Opex excluding electricity (% of Capex)	3 - 5 %	
	Capacity utilization	18 - 32%	
	Storage and transportation costs	$1-$2/kg	
	Total cost of delivered hydrogen (at 7% discount rate)	$3.94-$9.27/kg	

GLOSSARY

Glossary

Term	Description	Source
Adaptation	Climate adaptation means taking action to prepare for and adjust to the current and projected impacts of climate change.	https://gca.org/what-is-climate-adaptation/
Advanced / Alternate Cell Chemistry	New generation of advanced storage technologies that can store electric energy either as electrochemical or as chemical energy and convert it back to electric energy as and when required.	https://www.drishtiias.com/daily-news-analysis/national-programme-on-advanced-chemistry-cell-battery-storage#:~:text=Advanced%20Chemistry%20Cell%20(ACC)%3A,energy%20as%20and%20when%20required.
Agtech	Any agriculture technology that can streamline and automate farming processes while improving efficiency, sustainability and profitability.	https://www.ensync-corp.com/blog/what-is-agtech
Ancillary Services	Help maintain the proper flow and direction of electricity, address imbalances between supply and demand, and help the system recover after a power system event.	https://greeningthegrid.org/integration-in-depth/ancillary-services
Battery Energy Storage Systems	A type of energy storage system that uses batteries to store and distribute energy in the form of electricity.	https://www.carboncollective.co/sustainable-investing/battery-energy-storage-systems-bess
Battery Management Systems	Ensures the safety of the battery pack by continuously monitoring and regulating parameters like temperature & voltage.	https://robu.in/what-is-battery-management-system-bms-building-blocks-working/
Behind-the-Meter Applications	Provide energy directly to your home or business without going through an electric meter and interacting with the electric grid such as rooftop solar. Ex. Distributed RE Generation.	https://news.energysage.com/behind-the-meter-overview/
Blended Finance	The strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries.	https://www.oecd.org/dac/financing-sustainable-development/blended-finance-principles/
Built environment	The built environment includes all aspects of lives, encompassing the buildings we live in, the distribution systems that provides water and electricity, and the roads, bridges,and transportation systems we use to get from place to place.	https://www.epa.gov/smm/basic-information-about-built-environment
Capacity Building Programs	A structured initiative designed to enhance the knowledge, skills, and resources of individuals, organizations, or communities.	https://www.rightmanagement.co.in/blogs-articles/choosing-capacity-building-program#:~:text=A%20capacity%20building%20program%20is,and%20adapt%20to%20changing%20circumstances.
Carbon Contract for Differences	The government or institution agrees with an agent on a fixed effective carbon price to be granted for all emission reductions relative to a conventional technology over a given period. The agent then receives additional payments if the carbon price is below the strike price.	https://henrike-hahn.eu/files/upload/aktuelles/dateien/Study_CCfD_Henrike-Hahn_6.2022.pdf
Carbon Market	Carbon markets aim to reduce greenhouse gas emissions enabling the trading of emission units (carbon credits), which are certificates representing emission reductions. Trading enables entities that can reduce emissions at a lower cost to be paid to do so by higher-cost emitters.	https://www.indiancarbon.org/the-carbon-credit-market/

Glossary

Term	Description	Source
Carbon Sequestration	Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change.	https://www.usgs.gov/faqs/what-carbon-sequestration#:~:text=Carbon%20sequestration%20is%20the%20process,of%20reducing%20global%20climate%20change.
Cash Flow based Financing	An unsecured loan for a short duration based on a business's projected cash flow.	https://bridgeup.com/blog/cash-flow-based-lending/
Catalytic Capital	Defined as debt, equity, guarantees, and other investments that accept disproportionate risk and/or concessionary returns relative to a conventional investment in order to enable third-party investment that otherwise would not be possible.	https://www.macfound.org/press/article/catalytic-capital-work
Circular Economy	The circular economy is a system where materials never become waste and nature is regenerated. Products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting.	https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
Climate Resilience	Climate resilience is the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate.	https://www.c2es.org/content/climate-resilience-overview/#:~:text=Climate%20resilience%20is%20the%20ability,better%20cope%20with%20these%20risks.
Cool roofs	A cool roof is one that strongly reflects sunlight (solar energy) and also cools itself by efficiently emitting any heat that was absorbed. The roof literally stays cooler and reduces the amount of heat conducted into the building below.	https://coolroofs.org/resources/what-is-a-cool-roof
Credit Guarantees	A financial arrangement where a third party, often a government agency or financial institution, guarantees to repay a loan if the borrower defaults. It provides lenders with assurance and encourages them to extend credit to borrowers who may not otherwise qualify.	https://www.nabard.org/auth/writereaddata/tender/2501231152credit-guarantee-a-de-risking-tool-in-rural-finance.pdf
Derisking	Mitigating the risks of doing business in high-risk environments through concessionary finance or investment guarantee.	https://www.lawinsider.com/dictionary/de-risking
Desalination	Desalination is defined as the removing of salt and minerals from sea water to make it suitable for human consumption & industrial use.	https://pureaqua.com/blog/what-is-desalination-definition-meaning/
Downstream	Downstream refers to the last leg of value chain where products get produced and distributed.	https://universalinstitutions.com/what-are-the-main-bottlenecks-in-upstream-and-downstream-process-of-marketing-of-agricultural-products-in-india/#:~:text=Upstream%20in%20Indian%20agricultural%20marketing,products%20are%20made%20and%20delivered.
Early warning systems	An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.	https://www.undrr.org/terminology/early-warning-system

Glossary

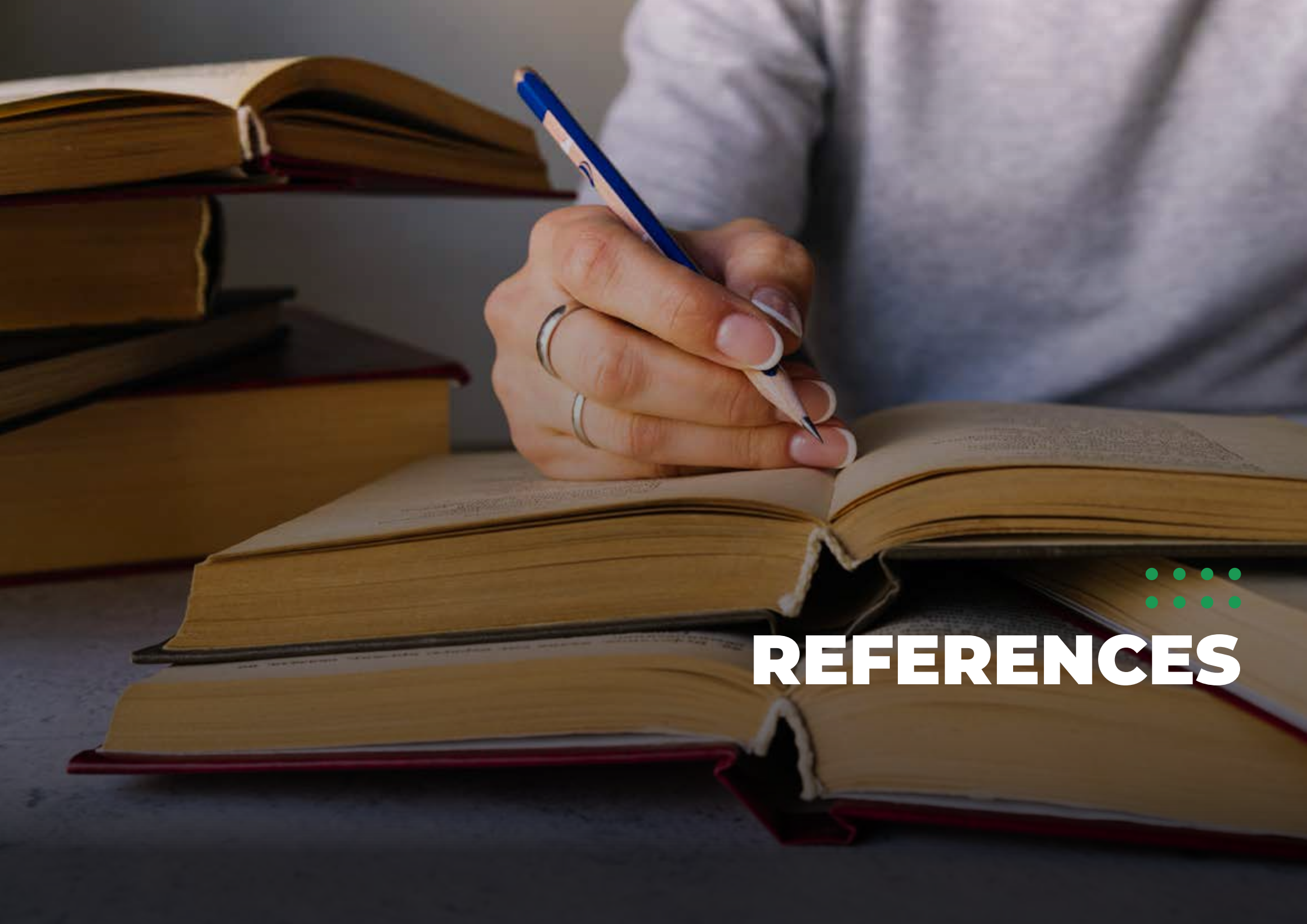
Term	Description	Source
Electrolysis	The process of using electricity to split water into hydrogen and oxygen.	https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis#:~:text=Electrolysis%20is%20the%20process%20of,a%20unit%20called%20an%20electrolyzer.
Electrolysers	A device used to conduct the process of electrolysis.	https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis#:~:text=Electrolysis%20is%20the%20process%20of,a%20unit%20called%20an%20electrolyzer.
Energy Storage Systems	A device or group of devices used to store energy and supply it for later use.	https://www.blackridgeresearch.com/blog/all-you-need-to-know-about-an-energy-storage-system-ess-components-technologies-benefits-risks-applications-bess-battery-energy-storage-system
Feedstock	Raw material to supply or fuel a machine or industrial process.	https://www.merriam-webster.com/dictionary/feedstock
First Loss Capital	Credit enhancement provided by an investor or grantmaker who agrees to bear first losses in an investment in order to catalyze the participation of co-investors that would not have otherwise entered the deal.	https://missioninvestors.org/resources/catalytic-first-loss-capital-research-and-case-studies#:~:text=Catalytic%20first%2Dloss%20capital%20refers,have%20otherwise%20entered%20the%20deal.
Front-of-the-Meter Applications	Provide energy to off-site locations (like a home or business), and that energy needs to pass through a meter before it can be used. Any energy that is delivered to your home or business from the electric grid comes from a front-of-meter system. Ex. Utility Scale RE generation.	https://www.bostonsolar.us/solar-blog-resource-center/blog/what-does-behind-the-meter-mean/
Grants	A grant is a quantity of money, i.e., financial assistance, given by a government, organization, or person for a specific purpose which need not be repaid.	https://marketbusinessnews.com/financial-glossary/grant-definition-meaning/
Green Hydrogen	Produced using electrolysis of water with electricity generated by renewable energy.	https://www.india.gov.in/spotlight/national-green-hydrogen-mission
Inter-state transmission charges	Fees associated with transporting electricity across state borders.	https://powermin.gov.in/sites/default/files/Waiver_of_inter_state_transmission_charges_Order_dated_21_June_2021.pdf
Lead Acid Batteries	A rechargeable battery that uses lead and sulphuric acid to function.	https://batteryaccessories.net/blogs/news/what-is-a-lead-acid-battery
Levelized Cost	The lifetime cost of an electricity plant, divided by the amount of electricity it is expected to generate over its lifetime.	https://ratedpower.com/blog/lcoe/
LiDAR	LiDAR, or light detection and ranging, is a popular remote sensing method used for measuring the exact distance of an object on the earth's surface.	https://www.geospatialworld.net/prime/technology-and-innovation/what-is-lidar-technology-and-how-does-it-work/
Lithium-ion Batteries	Rechargeable battery with cobalt, manganese, nickel and/or other metals as cathode and graphite anode.	https://energsoft.com/glossary

Glossary

Term	Description	Source
Market Linkages	Activity involving identification of the farmer's products and linking them with commercial and institutional buyers.	https://www.farmersprideinternational.org/market-linkages#:~:text=Market%20Linkage%20Activities,the%20aggregation%20of%20service%20providers.
Material Recovery Facility	A special facility for separating recyclables materials mechanically or manually. The waste is placed in different categories like glass, plastic, paper and metal.	https://www.rubbishplease.co.uk/waste-management-glossary/
Methane	A greenhouse gas emitted during the production and transport of coal, natural gas, and oil. Emissions also result from livestock and other agricultural practices, land use, and by the decay of organic waste in municipal solid waste landfills.	https://www.epa.gov/ghgemissions/overview-greenhouse-gases
Midstream	Midstream refers to agriculture activities involving logistics, processing, and wholesaling.	https://www.linkedin.com/pulse/food-systems-concept-midstream-explained-interview-dr-omamo/
Mitigation	Climate Change Mitigation refers to efforts to reduce or prevent emission of greenhouse gases.	https://www.unep.org/explore-topics/climate-action/what-we-do/mitigation
Net metering policies	Regulations allowing energy consumers to sell excess generated power back to the grid.	https://www.seia.org/initiatives/net-metering#:~:text=Net%20metering%20is%20a%20billing,home%20uses%20during%20daylight%20hours.
Net Zero Emissions	Balance between the greenhouse gases emitted into the atmosphere and those removed or offset, resulting in no additional contribution to global warming.	https://www.nationalgrid.com/stories/energy-explained/what-is-net-zero
Off-take Agreement	An arrangement between a producer and a buyer to purchase or sell portions of the producer's upcoming goods.	https://www.investopedia.com/terms/o/offtake-agreement.asp
Outcome-based funding	A financial model in which payments or investments are made based on the achievement of specific, predefined outcomes or performance targets.	https://investinresults.org/chapter/outcomes-based-funding-and-community-finance-ecosystem.html
Parametric insurance	Parametric insurance is an insurance type that pre-specifies the amount of payout based on concrete trigger events.	https://techcrunch.com/2023/04/07/insurtech-parametric-insurance/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAJkJXmrQP_EJ4fwMftSiGgFBXKvmhL6zBxjtbqmOsT_ary7OziTw87N5UYygqt1ycL-Ks7DxN_klZk82EDEpyPoaPAfqx5rnx6VWXgVetGDHyXFh9Pxbc8jllGYmkBOGZA11WHAq2Z0au4HTPKg_nEXR5lWSPFlhvooLY-NjSw6h
Patient Capital / Concessional Capital	Loans, grants, or equity investments that are provided on more favourable terms than those available in the market. These terms may include lower interest rates, longer repayment periods, grace periods, or partial guarantees.	https://www.linkedin.com/pulse/concessional-capital-catalyst-impactful-change-higher-leesa-soulodre#:~:text=Concessional%20capital%20refers%20to%20loans,grace%20periods%2C%20or%20partial%20guarantees.

Glossary

Term	Description	Source
Power-to-X	A collective term for conversion technologies that turn renewable energy into carbon-neutral synthetic fuels.	https://www.ramboll.com/en-apac/net-zero-explorers/power-to-x-explained#:~:text=Power%2Dto%2DX%20(also,%2C%20liquid%20fuels%2C%20or%20chemicals.
Primary Reserve Ancillary Services	Immediate power supply adjustments to maintain grid frequency.	https://cercind.gov.in/Regulations/Ancillary-Service-Regulations-2022.pdf
Recycling	The process of transforming materials into raw materials for manufacturing new products, which may or may not be similar to the original product.	https://www.gdrc.org/uem/waste/swm-glossary.html
Risk sharing facility	A financial arrangement where multiple entities collaborate to distribute and manage the financial risks associated with a project or investment, reducing the burden on any single participant.	https://www.lawinsider.com/dictionary/risk-sharing-facility
Secondary Reserve Ancillary Services	Additional power supply adjustments within a few minutes. Acts as a replenishment for primary reserves.	https://mercomindia.com/cerc-proposes-energy-storage-in-maintaining-grid-stability
Steam Methane Reformation	A process where methane reacts with steam in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide.	https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming
Tertiary reserve ancillary services	Further grid frequency control measures on a slightly longer timescale. Acts as a replenishment for secondary reserves.	https://posoco.in/draft-procedure-for-tertiary-reserve-ancillary-services-comments-invited-till-03rd-march-2023/
Upcycling	Upcycling converts waste and creates something new from it in its current state. During upcycling the original form is retained and proccessed to add value.	https://www.forgerecycling.co.uk/blog/what-is-the-difference-between-recycling-and-upcycling/
Upstream	Upstream in agricultural marketing refers to the raw materials required for production.	https://universalinstitutions.com/what-are-the-main-bottlenecks-in-upstream-and-downstream-process-of-marketing-of-agricultural-products-in-india/#:~:text=Upstream%20in%20Indian%20agricultural%20marketing,products%20are%20made%20and%20delivered.
Viability Gap Funding	A capital grant or subsidy or equity from the Central or State Governments to render a Public-Private Partnership (PPP) project financially viable and bankable.	https://prepp.in/news/e-492-viability-gap-funding-indian-economy-notes#:~:text=Viability%20Gap%20Funding%20means%20a,project%20financially%20viable%20and%20bankable.
Waste Aggregators	A middleman who buys recyclable materials from waste generators and itinerant buyers and sells them, after sorting and some processing, to wholesale brokers or recycling industries.	https://www.gdrc.org/uem/waste/swm-glossary.html



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