Net Zero 2070
Policy for Gujarat

Report submitted to

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Government of Gujarat

Report prepared by

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Indian Institute of Management Ahmedabad
Indian Institute of Technology Gandhinagar

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Preface

As the world grapples with the consequences of greenhouse gas emissions and environmental degradation, the Hon'ble Prime Minister Shri Narendra Modi through his tenets of the LiFE Mission has recognized the urgency to formulate comprehensive policies and implement strategic actions that align with the principles of climate responsibility. The specter of climate change poses unprecedented challenges to the world, demanding swift and decisive action to mitigate its impact. Gujarat, known for its industrial prowess and robust economic growth, recognizes the urgency to transition towards a low-carbon and sustainable trajectory. This whitepaper is a strategic blueprint that outlines a bold and transformative agenda aimed at achieving net-zero carbon emissions by 2070.

Gujarat has immense industrial prowess which is evident through its various sectors such as the automobile sector where investments rose 9 times in comparison to 2001; 75% contribution in India's dyes and intermediates manufacturing and the highest share in investment in Agro and food processing industry in the country. Moreover, it holds 50% share in medical devices manufacturing and about 80% share in Cardiac Stents manufacturing, processing of more than 70% of the world's diamonds, 80% contribution to India's diamond exports, and 90% share in the ceramic market of the country with about 10 thousand manufacturing. Thus, Gujarat's journey towards decarbonization requires a multidimensional approach that encompasses energy, industry, transportation, agriculture, and urban planning. It demands a collaborative effort undertaken by policymakers, industry leaders, environmentalists, and the wider community to usher in a new era of sustainability and resilience.

The whitepaper highlights Gujarat government's pioneer efforts in sustainable initiatives undertaken through a meticulous endeavor to map out climate policies aimed at Green House Gas (GHG) emissions mitigation, Impact, Vulnerability, and Adaptation (IVA), and Resilience. These policies, implemented and planned by the Gujarat Government, played a pivotal role in laying the foundation for achieving the 2070 Net Zero target. Estimations of GHG emissions from 2005 to 2030 were diligently conducted, providing a historical perspective crucial for evaluating progress. It highlights the way forward through short-term,

medium-term, and long-term climate policies, introducing innovations like offshore wind power, green hydrogen, green ammonia, battery energy storage system, carbon capture utilization and storage, and the transformative potential of Industry 4.0. These have been tailored for various sectors and businesses, aimed to encourage specific climate actions. Recognizing Gujarat's financial landscape, low-cost climate finance instruments, reflecting a commitment to making sustainability a feasible reality have also been studied. Moreover, it also delves into the initiatives undertaken by the state government, local communities, and various stakeholders to curtail carbon footprints, promote renewable energy sources, and build climate resilience.

Decarbonizing Gujarat Towards Net Zero 2070 is not only a response to the global call for climate action but also a testament to the state's commitment to fostering a greener and healthier environment for its citizens. It envisions a Gujarat where economic prosperity is harmonized with environmental stewardship, where innovative technologies drive sustainable practices, and where communities thrive in balance with nature.

We acknowledge senior officers from various departments of Government of Gujarat for their guidance and support over the years.

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Key Actionable Takeaways

Table 1 gives an overview of key actionable points which can be implemented by the government of Gujarat towards achieving the Net Zero by 2070 target. Focusing on these actionable points can ensure that the mitigation and adaptation efforts taken are structured, purposeful, and directed towards achieving tangible results. The table lists various initiatives that can be promoted at three levels, viz., City level, Village level and in Coastal Areas.

Table 1. Key Actionable Points at various implementation levels

Policy Intervention	Actionable Points	Implementing Entities
Implementation at City Level		
Vertical Farming • Traditional horizontal farming is resource intensive and consumes a lot of water, pesticides, and fertilizers. • Vertical farming can be practical solution to this challenge. • Currently the National Horticulture Board offers 20-25% credit linked subsidy for vertical farming projects involving the usage of hydroponics or aeroponics across India.[1]	• Tools like hydroponics and aeroponics are a sustainable and long-term solution for tackling resource scarcity as urban areas are becoming food deserts due to growing population, lack of nearby farms, etc. • Farming of vegetables and fruits should be prioritized for urban consumption to reduce their transportation carbon footprint, ensure food security and availability of fresh produce.	Agriculture & Co-operation Department Forest & Environment Department Urban Development & Urban Housing Department
SATAT Scheme • Efficient management of municipal solid waste resources requires a holistic approach that involves	• Urban areas generate large quantities of organic waste (food waste, sewage sludge, etc.). Biogas plants can process this organic	Energy & Petrochemicals Department Urban Development & Urban Housing

[1] https://nhb.gov.in/schemes/subsidy-claim-guidelines.html

multiple stakeholders, informed decision-making, and continuous improvement. • By prioritizing waste reduction, recycling, and responsible disposal practices, communities can contribute to a more sustainable and resource-efficient future.	waste to produce Compressed Biogas (CBG). • CBG can be used to replace Compressed Natural Gas (CNG) in automotive, industrial and commercial uses in the coming years.[2] • CBG can be used as a clean and renewable fuel for buses, taxis, and other public transportation vehicles.	Department
Algae Farming Policy • Algae can be grown in various settings, including urban environments, potentially even on buildings within city limits. • Algal biofuels hold significant promise as RE source due to their high productivity at various locations.	• Biofuels made from algal oil are very promising as a significant alternative to petroleum-based fuels. • They offer numerous benefits, such as higher productivity per unit of land compared to land-based oilseed crops, the ability to use low-quality water and marginal lands.(Milbrandt & Jarvis, 2010) • In the future, algal biomass could supply a significant portion of the world's transportation fuel needs (Ullah et al., 2014).	Agriculture & Co-operation Department Urban Development & Urban Housing Department Energy & Petrochemicals Department
AI integration • Artificial intelligence has great potential in addressing climate change challenges through its computational abilities which can enhance	• AI applications could also help design more energy-efficient buildings, improve power storage, and optimize renewable energy deployment by feeding solar and wind	Department of Science & Technology Energy & Petrochemicals Department Urban Development &

[2] https://satat.co.in/satat/#/about

climate modeling, optimize energy, and resource usage, manage waste and water more efficiently, minimize carbon emissions, and contribute to sustainable agriculture and biodiversity preservation.(Boele, 2024)	power into the electricity grid as needed. • From electricity grids to smart appliances, data and AI-driven software can be integral to predicting market behaviour, balancing operations in real-time, and maximizing energy yield.	Urban Housing Department
Implementation at Village Level		
SATAT Scheme • By leveraging the benefits of CBG at the village level, communities can improve energy access, promote sustainable development, and enhance overall quality of life while mitigating environmental impacts. • This initiative can be promoted through a collaborative effort between various stakeholders, including NGOs, and local communities.	• Villages can set up biogas plants to produce biogas from organic waste sources such as agricultural residues, animal dung, and food waste. • It has the potential to foster growth and entrepreneurship in rural economies whilst offering farmers additional streams of revenue.[3]	Energy & Petrochemicals Department Panchayat, Rural Housing & Rural Development Department
Algae Farming Policy • Algal biofuels hold significant promise as a renewable energy source due to their high productivity and potential to be produced in various locations.	• Algae can be grown using CO_2 generated from industrial or agricultural wastewater, providing a dual benefit of waste treatment and biofuel production. (Ali et al., 2022). • Cultivating algae on non-	Agriculture & Co-operation Department Panchayat, Rural Housing & Rural Development Department Energy & Petrochemicals Department

[3] https://satat.co.in/satat/assets/about.pdf

• Algal biofuels can offer numerous benefits, particularly in regions where access to traditional energy sources may be limited. (Hannon et al., 2010)	arable land enables the production of biofuel without competing for resources with traditional crops.	
Implementation in Coastal Area		
Linking Mangrove Plantation with Voluntary Carbon Market • Mangrove forests have immense potential of carbon mitigation. • The Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISHTI) scheme is a government-led initiative aimed at increasing the mangrove cover along the coastline and on saltpan lands. • By restoring and conserving mangrove forests, the MISHTI initiative is helping to reduce the amount of carbon in the atmosphere, thereby mitigating the impacts of climate change.[4]	• Gujarat state's coastline area (1 km x 1 km) could be mapped to analyze the efficacy of current mangrove regions and identify possible future plantation regions. • It is important to develop new mangrove habitats, which entails strategic planning while safeguarding their ecological functions. • Restoration and development efforts should be aimed for revitalizing degraded mangrove areas as they play a pivotal role in enhancing ecosystem health.[5] • With the help of the MISHTI scheme and its subsequent mangrove conservation and restoration, a valuable carbon sink is being created in the mangrove ecosystem. • Carbon mitigation resulting due to mangrove	Agriculture & Co-operation Department Energy & Petrochemicals Department Forest & Environment Department Gujarat Ecology Commission

[4] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2002625#:~:text=MISHTI%20envisages%20restoration%2Freforestation%20of,with%20the%20existing%20schemes%2Fprograms.
[5] https://www.indiascienceandtechnology.gov.in/programme-schemes/societal-development/mangrove-initiative-shoreline-habitats-tangible-incomes-mishti

	plantation which can be certified and traded to make money in the voluntary carbon market in future.	
Marine Algae Farming • Macroalgae (seaweed) is found and can be grown in coastal areas at the sea and be utilized as a biomass source for biofuel production. • Algae produced in the sea has lower investment needs as it does need land, irrigation systems and artificially added nutrients, hence, it is a great opportunity in coastal areas.[6]	• Certain species of marine algae can absorb nutrients and pollutants from seawater, thereby improving water quality and mitigating the impacts of eutrophication and pollution in coastal areas. • ICAR-Central Marine Fisheries Research Institute's seaweed farming feasibility studies have proven that harnessing seaweed like Kappaphycus alvarezii, is beneficial as it absorbs carbon dioxide to grow biomass before releasing it back into the atmosphere, thus, offering a sustainable approach to carbon sequestration.(Fakhraini et al., 2020)	Agriculture & Co-operation Department. Gujarat Ecology Commission Forests and Environment Department Energy & Petrochemicals Department

[6] https://icar.org.in/icar-cmfris-seaweed-farming-enterprise-lakshadweep-turns-huge-success#:~:text=The%20seaweed%20farming%20enterprise%20was,15%20tons%20in%2045%20days.

1. Introduction

Hon'ble Prime Minister Modi's "Panchamrit" pledges at COP26 in Glasgow during November 2021, India revised three of its Nationally Determined Contributions (NDCs) in August 2022 with the following targets[7]:

- Meet 50% of India's cumulative electric power installed capacity from non-fossil sources by 2030.
- Reduce the emission intensity of the GDP by 45% below 2005 levels by 2030.
- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including a mass movement for LiFE–Lifestyle for Environment as a key to combating climate change.
- India has also committed to make Indian Railways "Net Zero" by 2030 and
- The biggest commitment is achieving net-zero emissions by 2070.

1.1 Lifestyle for Environment (LiFE) Mission

India is the first country to include Lifestyle for Environment-LiFE mission in its NDCs to combat climate change. The mission "LiFE' was introduced by Prime Minister Narendra Modi at COP26 in Glasgow on 1st November 2021. It is a mass movement for "mindful and deliberate utilization, instead of mindless and destructive consumption" to protect and preserve the environment.

It aims to nudge individual, communities and institutions to practice a lifestyle that is synchronous with nature and does not harm it and those who practice such a lifestyle are recognised as Pro Planet People[8]. The strategy consists of three key phases of growth:

i) Globally promoting the practices that are simple and effective towards environment-friendly conduct by people in their daily lives.

ii) Large scale transformation of individual demand would lead to consequent response by industries and markets to tailor supply and procurement accordingly.

iii) global changes in demand and supply dynamics will promote long-term shifts in industrial and Government policies which can enhance sustainable consumption and production.

In Phase I, mission LiFE will focus on change in demand by practicing simple environment-friendly actions which is called LiFE actions in our daily lives which are as follows[2]:

[7] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1847812

[8] https://www.niti.gov.in/sites/default/files/2023-02/Brochure-10-pages-op-2-print-file-20102022.pdf

Actions for Energy Saving

- Use EE lights such as LED bulbs and tube-lights
- Use public transport and carpooling with friends & colleagues wherever possible
- Use bicycles for local or short commute
- Prefer CNG/ EV vehicle over petrol/ diesel vehicles
- Take the stairs instead of an elevator wherever possible
- Switch off vehicle engines at red lights and railway crossings
- Switch off irrigation pumps after use
- Drive in the correct gear. Keep your foot off the clutch when not changing gears
- Install and use solar water heater
- Keep electronic devices in energy-saving mode and switch off when not in use
- Use biogas and for solar cooker for cooking
- Keep temperature of Air Conditioners to 24 degrees
- Prefer using pressure cookers
- Use smart switches for appliances
- Install community earthen pots for cooling water
- Defrost fridge or freezer regularly
- Prefer to walk/run outdoors than on a treadmill

Actions for Water Saving

- Adopt cultivation of less water intensive crops such as millets and try crop diversification i.e. transit cultivation from rice/wheat to pulse/oil seed
- Recharge rural water bodies through Amrit Sarovar Scheme
- Use efficient water saving technologies such as micro-irrigation, bunding, farm ponds, zero tillage, direct seeded rice, alternate wetting and drying, etc.
- Develop rainwater harvesting system in home, schools, offices, etc.
- Turn off running taps when not in active use
- Reuse water from washed vegetables and water drained from AC/RO for cleaning of utensils, watering plants and other purposes
- Pre-soak heavy pots and pans before washing them
- Do not discard unused stored water every time there is fresh water coming in taps
- Use buckets instead of hose pipes to water the plants, floors, vehicles, etc.
- Use water-efficient fixtures for taps, shower and toilet flush units and repair their leakages, if any

- Install water meter to regularly measure water consumption in households
- Prefer a water purification system

Actions for Reducing Single Use Plastic

- Use cloth bag instead of plastic bags
- Carry your own water bottle to the extent possible
- Reuse glass containers/packaging plastic items
- Prefer use of non-plastic eco-friendly cutlery during gatherings and events
- Try to use drip irrigation systems made with waste materials
- Use recycled plastic over virgin plastic
- Use steel/recyclable plastic lunch boxes and water bottles
- Choose bamboo toothbrushes and neem combs
- Cut the packaging bags used for milk, buttermilk, etc. only partially to avoid plastic bits from mixing into biodegradable waste

Actions for Adopting Sustainable Food Systems

- Include millets in diets through Anganwadi, Mid-Day meal and PD scheme
- Compost food waste or create kitchen/terrace gardens at homes, schools, offices, etc.
- Make organic manure from cow dungs to be used in farms
- Prefer use of locally available and seasonal foods
- Reduce food wastage by use of smaller plates

Swachhata Actions by Waste Reduction

- Contribute waste from cattle, food, and agricultural to biogas plant (provided under GOBARDHAN)
- Practice segregation of dry and wet waste
- Use agricultural residue, animal waste for composting, manuring and mulching
- Recycle and reuse old newspapers, magazines, old furniture
- Buy paper products made from recycled paper
- Feed unused/uncooked vegetables to cattle
- Set printer default to double-side printing
- Donate/reuse old clothes and books
- Do not discard waste in water bodies and in public spaces
- Do not let pets defecate in the public places
- Use menstrual cups instead of sanitary napkins
- Participate in and organize participation for clean-up drives

Actions for Adopting Healthy Lifestyles

- Encourage use of millets in food for nutrition, indigenous herbs and medicinal plants for well being
- Plant medicinal plants such as neem, tulsi, giloy, mint, curry leaves, ashwagandha, etc. in households
- Practice natural/organic farming and prefer consumption of natural/organic products
- Plant more trees to reduce pollution
- Start biodiversity conservation at community level
- Avoid purchasing products/souvenirs made from skin, tuskers and fur of wild animals
- Create and volunteer at community food, cloth banks, and animal shelters
- Initiate and join green clubs in your residential area/ school/ office

Actions for e-Waste Reduction

- Repair and use electronic devices over dumping
- Discard electronic gadgets in nearest e-recycling units
- Use rechargeable lithium cells
- Prefer use of cloud storage than pen drive/hard drive

1.2 Elements of Long-term Low-Emissions Development Strategies (LT-LEDS)

Gujarat state's development strategies are greatly aligned with India's long term low emission development strategies which ensures inclusive growth and expansion across its different sectors. The low carbon options of some of the key sectors which should be valued effectively are listed as below[9].

Development of low carbon electricity systems

Development of low carbon electricity systems should enable industrial growth, increase in employment and incomes, and fulfil the ambition of Aatmanirbhar Bharat (Self Reliant India) through:

- Strengthening the traditional electric grid along with integration of renewable energy sources
- R&D for low carbon development technologies and assessing enablers for them
- Increased focus on demand-side management
- Reasonable utilization of fossil fuel resources
- Establishing green taxonomy and optimum energy mix

[9]https://unfccc.int/sites/default/files/resource/India_LTLEDS.pdf

Developing efficient and integrated low carbon transport system

The transport sector is one of the major contributor to India's GDP directly and indirectly. Low carbon systems in transport sector should be analysed to assist the need of significant expansion across passenger transport and freight transport by:

- Promoting growth in fuel efficiency
- Ensuring a phased transition to cleaner fuels
- Modal shift towards public and less polluting modes of transport
- Electrification across multiple modes of transportation
- Demand side management in transport sector
- Traffic management and intelligent transport systems

Low carbon building and urban structures

Within the building sector, promoting sustainable and low carbon adaptation in urban design, energy, and material-efficiency in buildings to encourage sustainable urbanisation is a crucial step. Exploring and aiding new adaptation techniques in urban design will be crucial in the context of growing urban areas, such as:

- Mainstreaming adaptation measures within the built environment and urban systems
- Promotion of resource efficiency in context of urban planning guidelines, policies, and bylaws
- Encouraging climate responsive and resilient building design, and operation in existing and future buildings and in urban systems
- Ensuring low-carbon municipal service delivery by resource efficiency and management of water, solid, and liquid waste

Low carbon emission methods for industries

It is needed to promote an economy-wide decoupling of growth from emissions. Industrial growth is a key element in developing the near, medium and long policies which will be directed at increasing the share of manufacturing in the GDP, including major policies like Aatmanirbhar Bharat and Make in India.

Moreover, increased focus should also be maintained on the informal sector and the development of the Micro Small and Medium Enterprises (MSME) sector. There are several hard to abate categories within these sectors, for which low carbon strategies need to be assessed, this can be done through:

- Enhancing energy and resource efficiency, with increased integration of natural and bio-based materials
- Incorporating process and fuel switching and electrification in manufacturing whenever viable
- Boosting material efficiency and recycling in order to strengthen circular economy

- Encouraging green hydrogen technology and infrastructure for various uses
- Exploring new technologies for sustainable growth of hard-to-abate sectors
- Developing low carbon and sustainable growth of micro, small and medium enterprises (MSMEs)

CO_2 removal and other related engineering solutions

This sector is being explored globally and should also be explored in the Indian context. This requires extensive transnational support through innovation, technology transfer, climate financing and capacity building through:

- Training, capacity building and planning to minimize socio-economic, livelihood and ecosystem impacts
- Exploring public-private partnership structures to aid the intensive resource requirements

Increasing forest and vegetation cover coherent with socio-economic and ecological interests

India's national commitment to the development of natural resources, conservation of resource heritage and promoting biodiversity will build the strategy in this sector. It will also be a comprehensive approach by analysing the livelihood, social and cultural dependence of the relevant population. This can be achieved by:

- Restoration, conservation, and management of forests and their plant, animal and microbial genetic resources
- Restoration, conservation, and management of trees outside forests
- Strengthening infrastructure of State Forest departments and upgradation of nurseries

Economic and financial aspects of low-carbon development

Low-cost international climate funding is crucial to achieving the goals of low carbon development given the priority of eradicating poverty, expanding jobs and incomes, enhancing climate change resilience, and reaching a new level of prosperity. Some ways to achieve this are:

- Assessments of financial requirements
- Organizing, accessing and delivering climate-specific finance, especially multilateral climate finance
- Mainstreaming of climate finance
- International climate finance, technology transfer and capacity building
- Linkages to international trade
- New multilateral mechanisms for supporting innovation, and technology development

1.3 Overview of Gujarat

Gujarat is one of India's most industrialized states, and is a leader in the petrochemical, crude oil refining and chemical industries. The state contributes to around 6% to India's land mass. The state's total population stands at 7.15 crores, among which 43% of its population lives in urban areas. Gujarat has contributed to about 8.3% in India's gross domestic Product (GDP) in 2022-23 and its GSDP growth rate was around 12% in the last seven years i.e. from 2016-17 to 2022-23. The State is power abundant with around 45 GW power generation capacity as against the average demand of 25 GW. With 22 GW of RE power, Gujarat contributes around 15.5% of India's total RE capacity and it ranks 1st in wind energy (10.9 GW) and 2nd in solar energy (10.1 GW). The state has also developed India's first 24x7 solar-powered village named "Modhera" in 2022. It is the only Indian state with an integrated state-wide operational gas grid of 2,700 kms connecting major industrial hubs. Also, the state's water grid connected through Narmada canal network is around 62,778 kms long. The state has more than 200 industrial estates with almost 100 being private industrial parks. To further strengthen the sector specific investments and infrastructure, the State has also announced several sector specific industrial parks which includes PM MITRA Park, Bulk drug park, Medical device park, Agro-food park, Sea-food park, Ceramics park, Vehicle scrappage park, Tribal park, etc[10].

Gujarat state, being India's most industrialized states, must contribute appreciably to meet India's revised NDC targets set up by our Honorable Prime Minister. This would require aligning and dovetailing the various policies such as policies leading to climate change mitigations, policies/actions leading to climate change adaptation, climate resilience, impacts and vulnerabilities, etc. Also, the state should promote clean and renewable energy policies, policy that endorse towards manufacturing low carbon technologies, etc. in the short term, medium term and the long term i.e. until the Net Zero target year of 2070. Also, these policies would require enhancing climate resilience of Gujarat from now onwards while simultaneously reducing its GHG emissions. Although Net Zero target cannot be achieved in next two, or three decades, development towards a "Net Zero Gujarat" can be stimulated by designing climate policies to gradually wean away Gujarat from GHG emissions through reducing use of fossil energy, strengthening non-fossil energy use while simultaneously enhancing energy efficiency across all sectors.

[10] https://www.vibrantgujarat.com/invest-gujarat

2. Research Objectives, Methodology, Assumptions and Data

2.1 Research Objectives

This white paper aims to deliver the following research objectives towards achieving "Decarbonizing Gujarat towards Net Zero 2070".

- Mapping climate policies for GHG emission mitigation, impact, vulnerability and adaptation (IVA), resilience, which are being implemented and/or planned by Gujarat Government to facilitate 2070 Net Zero target.
- Plan and enhance climate actions for GHG emission mitigation, impact, vulnerability and adaptation, resilience, etc.
- Estimate GHG emission for Gujarat from 2005 until 2030
- Estimate GHG emission mitigations for key policies from 2005 to 2019
- Projecting GHG emission mitigations for key policies from 2020 until 2030
- Climate finance and instruments available for low-cost climate finance
- Short term, medium term and long-term climate policies interventions
- Climate policies and best practices to be followed by various industries and businesses in Gujarat

2.2 Methodology

The current research maps the current climate policies for GHG emission mitigation, imapct, vulnerability, adaptation (IVA) and resilience which are being implemented and/or being planned by Government of Gujarat which would facilitate towards Net Zero target in 2070. It assesses the GHG emissions of Gujarat from 2005 to 2030. It estimates the GHG emission mitigation potential of the major key policies leading to GHG emission avoidance such as renewable energy policies (solar, wind, other renewables (biomass/bagasses), reduction in transmission and distribution losses, policies for EE LED lights (UJALA, SLNP), super critical power generation, Perform Achieve and Trade (PAT) scheme, Micro Irrigation System (MIS), policies for public transport (BRTS & Metro), ethanol blending policies, etc. being implemented by Gujarat since 2005 to 2019 and projects their mitigation potentials from 2020 till 2030 based on past trends/targets.

This paper briefly discusses the various instruments available which would enable low-cost climate finance (public funds and private investments). It discusses way forward for short term (3-5 years), medium term (5-10 years) and long term (>10 years) climate policies and climate actions for various sectors and businesses in Gujarat towards achieving Net Zero 2070 target.

2.3 Macroeconomic Assumptions and Data

National Gross Domestic Product (GDP)

Table 2 shows India's GDP growth rate projections following three different growth scenarios viz., baseline growth path, medium elevation growth path and high elevation growth path.

Table 2. Scenario-wise GDP growth rate for India from 2022-23 to 2031-2032

Year	Baseline growth path	Medium elevation growth path	High elevation growth path
2022-23	*7.10%*	*7.10%*	*7.10%*
2023-24	7.50%	7.50%	7.50%
2024-25	8.00%	8.00%	8.00%
2025-26	7.80%	8.50%	8.50%
2026-27	7.70%	9.00%	9.00%
2027-28	7.50%	8.80%	9.50%
2028-29	7.40%	8.70%	9.30%
2029-30	7.20%	8.50%	9.20%
2030-31	7.10%	8.40%	9.00%
2031-32	6.90%	8.20%	8.90%

Source: *(DEA)*

Gujarat's Gross State Domestic Product (GSDP)

Table 3 shows Gujarat's GSDP at current prices which have been indexed for the year 2018-19 and estimated GSDP at constant prices by taking 2018-19 as base year. While Table 4 shows Gujarat state's GSDP growth rate projections till 2030 at constant prices with base year of 2018-19 which is further aligned with India's GDP growth rate used for projection (refer table 2) for three separate growth rate scenarios viz., baseline growth rate, medium elevation growth rate and high growth rate.

Table 3. Gujarat GSDP at current prices and constant prices with 2018-19 as base year

Year	GSDP at Current Prices (Base 2011-12) in Million INR	Indexation	GSDP at Constant Prices (Base Year 2018-19) in Million INR
2004-05	2033730	13.6	277186.7
2005-06	2447360	16.4	401403.9
2006-07	2836930	19.0	539365.4
2007-08	3292850	22.1	726657.5
2008-09	3679120	24.7	907138.8
2009-10	4312620	28.9	1246431
2010-11	5215188.8	35.0	1822745
2011-12	6156060.7	41.3	2539754
2012-13	7244953.6	48.6	3517686
2013-14	8076232	54.1	4371227.6
2014-15	9217731.5	61.8	5694216.3
2015-16	10290097.4	69.0	7096183.3
2016-17	11671555.8	78.2	9129423.6
2017-18	13290947.7	89.1	11838529.3
2018-19	**14921557.1**	**100.0**	**14921557.1**

Source: *(Gujarat Finance Department)*

Table 4. Gujarat's GSDP (in billion INR) projections from 2019-20 till 2029-2030

Year	GSDP at baseline growth rate	GSDP at medium growth rate	GSDP at high growth rate
2004-05	277	277	277
2005-06	401	401	401
2006-07	539	539	539
2007-08	727	727	727
2008-09	907	907	907
2009-10	1246	1246	1246
2010-11	1823	1823	1823
2011-12	2540	2540	2540
2012-13	3518	3518	3518

2013-14	4371	4371	4371
2014-15	5694	5694	5694
2015-16	7096	7096	7096
2016-17	9129	9129	9129
2017-18	11839	11839	11839
2018-19	14922	14922	14922
2019-20	15966	15966	15966
2020-21	17084	17084	17084
2021-22	18280	18280	18280
2022-23	19577	19577	19577
2023-24	21046	21046	21046
2024-25	22729	22729	22729
2025-26	24502	24661	24661
2026-27	26389	26881	26881
2027-28	28368	29246	29435
2028-29	30467	31791	32172
2029-30	32661	34493	35132

Source: *Authors' estimates*

Kaya Identity

Kaya identity is a mathematical identity stating that the total emission level of the GHG can be expressed as the product of four factors: human population, GDP per capita, energy intensity, and GHG intensity. A commonly used mathematical formulation to decompose GHG emissions into its drivers is the Kaya identity (or the ImPACT identity):

$$GHG\ emissions(I) = Population\ (P) \times \frac{GDP}{Population}(A) \times \frac{Energy\ use}{GDP}(C) \times \frac{Emission}{Energy}(T)$$

3. Results and Discussions

3.1 GHG Emission for Gujarat

The figure 1 shows the year-wise estimated and projected GHG emission ($GgCO_{2e}$) from 2005 until 2030. The GHG emission projections have been prepared by analyzing the current trend in GHG emissions of the state and the various policies and interventions implemented by the state since 2005.

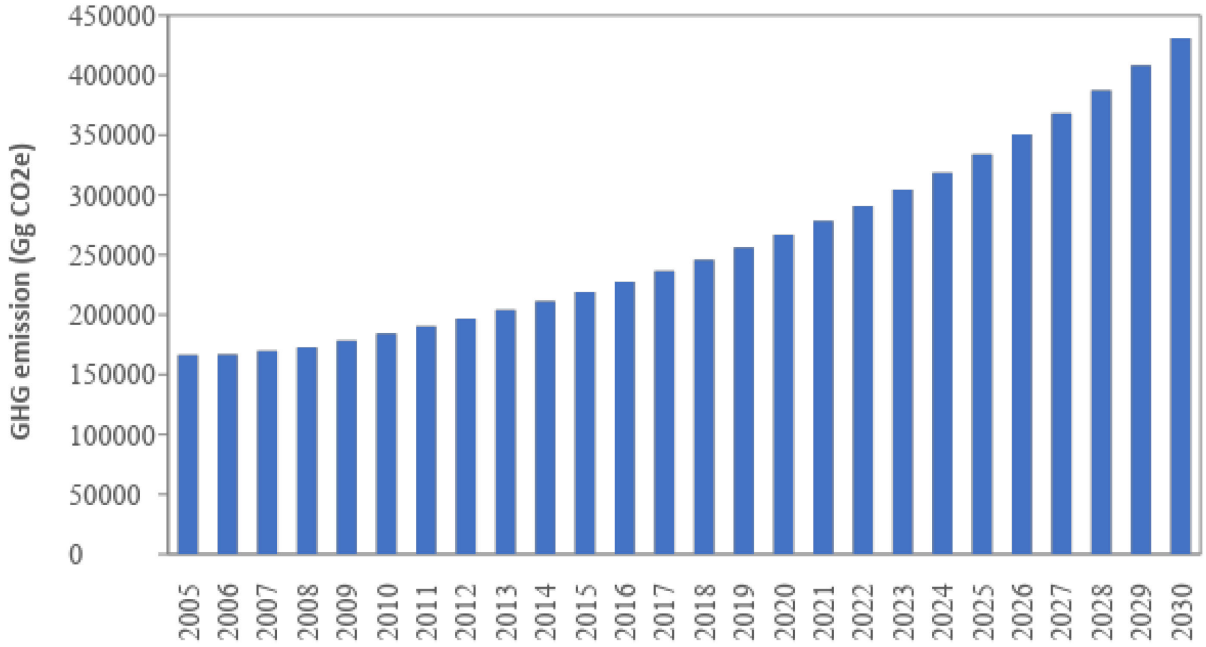

Figure 1. GHG emission projections for Gujarat till 2030

Source: Authors' estimates

3.2 GHG Emission Intensity for Gujarat

Figure 2 shows Gujarat's GHG emission intensity (GHG/GSDP (Kg/INR)) from 2005-2030 at medium growth rate. GHG emission intensity was estimated based on actual GSDP data available till 2019 year and estimated GHG emission for Gujarat (refer figure 1). While GHG emission intensity for Gujarat was projected based on projected GSDP at medium growth rate (refer table 3) from 2020 to 2030 and estimated GHG emission projections from 2020 to 2030 (refer figure 1).

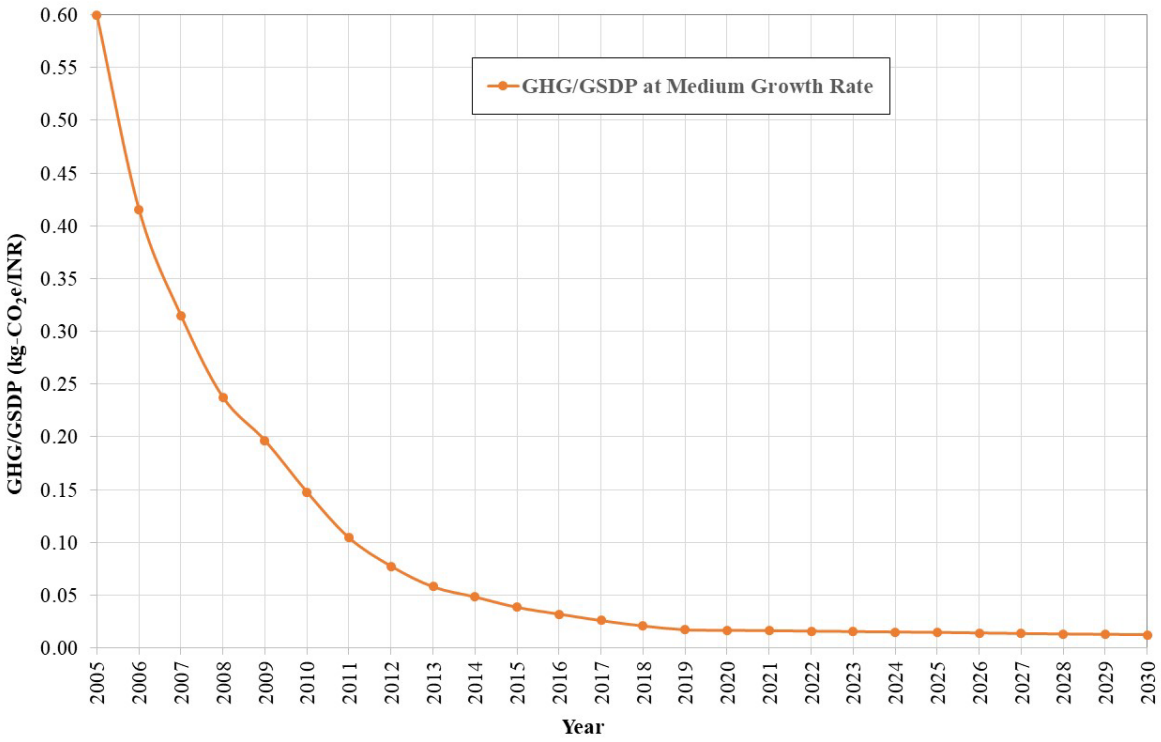

Figure 2. GHG emission intensity at medium growth rate from 2005 to 2030

Source: Authors' estimates

3.3 Mapping Existing Policies for GHG mitigation

This sub-section analyses the existing mitigation policies that are implemented or planned at national as well as Gujarat state level which would lead towards achieving NZ 2070 target. Several policies towards GHG emission mitigations being implemented across various sectors were mapped till 2022 and listed in table 5. These policies were mapped across various sectors such as renewable energy (RE), energy efficiency (EE), industry, building, transport, water and sanitation, waste, e-waste, green hydrogen, storage, agriculture and forestry, etc. These policies were also categorized into type of policy instrument viz., Economic, Regulatory, Information, etc., and their implementation level (Gujarat state, national, both), etc.

Table 5. Sector-wise existing policies for GHG mitigation being implemented/planned at Gujarat state and national level

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
1	Surya Urja Rooftop Yojana	Aims to promote large scale Solar Rooftop System on Private Residential roofs-terraces.	Economic	Gujarat	RE (Solar)
2	Gujarat Wind-Solar Hybrid Policy	To scale up installations of Wind & Solar Hybrid Power Projects to minimize the variability and strengthen the energy security of the state and country.	Economic	Gujarat	RE (Wind & Solar)
3	Solar Power Policy	Advancing the growth of solar energy to help position it as a mainstream source of energy supply and contribute to India's 100GW Solar Capacity target.	Economic	Gujarat	RE (Solar)
4	Gujarat Wind Power Policy	A conducive policy and investment framework to spur more competition and private sector participation for the development of Wind Projects.	Economic	Gujarat	RE (Wind)
5	Wind Repowering Policy	To promote optimum utilization of wind energy resources by creating facilitative framework for repowering.	Economic	Gujarat	RE (Wind)
6	Gujarat State Biotechnology Policy (2022-27)	To exert concerted efforts to drive innovation, create inter-sectoral synergy and make Gujarat a globally competitive destination for development of biotechnology products, processes and services.	Economic	Gujarat	RE
7	Policy for Development of Small Scale Distributed Solar PV Power Projects (2019)	The policy aims to facilitate the development of small-scale solar PV projects with sizes ranging between 0.5 and 4 MW.	Regulatory	Gujarat	RE (Solar)
8	5MW Gandhinagar Rooftop Programme	For installing 5 MW of rooftop solar power generation capacity on PPP model.	Economic	Gujarat	RE (Solar)
9	Suryashakti Kisan Yojana	To open the gates of economic growth for the farmers through use of solar energy in irrigation and farming.	Economic	Gujarat	Agriculture/ RE
10	Gujarat Industrial Policy	It envisions Gujarat as a global business destination for next-generation sustainable manufacturing and service	Economic	Gujarat	Industry

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
		industry that stimulates sustainable development, inclusive and a balanced regional growth.			
11	Gujarat State Electric Vehicle Policy	To support reduction in air pollution, oil import bill and to increase energy security of the state.	Economic	Gujarat	Transport
12	CNG Sahbhagi Yojana	To tackle environment pollution and promote clean energy Gujarat in addition to providing ease in the availability of CNG stations for vehicle owners.	Economic	Gujarat	Transport
13	Gujarat State Water Policy	To ensure the comprehensive multi- sectoral planning, development and management of the State's water resources, and effective, efficient, equitable and sustainable service deliveries for various water uses.	Economic	Gujarat	Water and Sanitation
14	Policy for Reuse of Treated Waste Water	To reuse 70 percent of treated waste water in Gujarat by 2025 and 100 percent by 2030 for non-potable uses.	Regulatory	Gujarat	Water and Sanitation
15	National Green Hydrogen Mission (2023)	Development of green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum with an associated renewable energy capacity addition of about 125 GW in the country.	Economic	Gujarat + National	RE
16	National Wind-Solar Hybrid Policy (2018)	To provide a framework for promotion of large grid connected wind-solar PV hybrid system for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.	Economic	Gujarat + National	RE (Wind & Solar)
17	National Offshore Wind Energy Policy	The policy aims to incentivize the development of offshore wind energy and make it on par with the conventional energy sources.	Economic	Gujarat + National	RE (Wind)
18	National Policy on Biofuels (2018)	The Policy aims at mainstreaming of biofuels and, therefore, envisions a central role for it in the energy and transportation sectors of the country.	Economic	Gujarat + National	RE (Bioenergy)

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
19	National Bioenergy Programme (2021-2026)	To promote the growth of bioenergy through sub schemes of Biomas Programme, Biogas Programme and Waste-to-Energy Programme.	Economic	Gujarat + National	RE (Bioenergy)
20	Green Hydrogen Policy	It aims to make India a Global Hub for production, utilization and export of Green Hydrogen and its derivatives.	Economic	Gujarat + National	RE/Industry
21	Energy Conservation Act	Efficient use of energy and its conservation and for matters connected therewith.	Economic	Gujarat + National	EE
22	Methanol Economy Programme	Is aimed at reducing India's oil import bill, greenhouse gas (GHG) emissions, and converting coal reserves and municipal solid waste into methanol.	Regulatory	Gujarat + National	RE (Waste)
23	Atal Jyoti Yojana (AJAY)	To illuminate dark regions through establishment of solar streetlights. It is a sub scheme under off –grid and decentralized solar application scheme.	Economic	Gujarat + National	EE
24	Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM)	Ensuring energy security for farmers in India, along with honouring India’s commitment to increase the share of installed capacity of electric power from non-fossil-fuel sources to 40% by 2030 as part of Intended NDC.	Economic	Gujarat + National	RE (Solar)
25	Waste to Energy Policy	To facilitate and promote utilization of Municipal Solid Waste (MSW) for generation of solid waste of electricity at affordable cost in a sustainable manner.	Economic	Gujarat + National	RE (Waste)
26	National Solar Mission	To promote solar power in India with a target of 1,00,000 MW by 2022 of grid-connected solar power by 2022.	Regulatory	Gujarat + National	RE (Solar)
27	E-Waste (Management and Handling) Rules (2011)	It aims to channelize the E-waste generated in the country to encourage recycling of all useful and valuable material so as to conserve the ever-depleting natural resources.	Regulatory	Gujarat + National	E-Waste

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
28	Renewable Purchase Obligation (RPO)	It is the requirement mandated by the State Regulatory Commission and is relevant to Distribution Licensee for ensuring a percentage of renewable energy sources in their total power supply.	Regulatory	Gujarat + National	RE
29	RPO and Energy Storage Obligation (2022)	This includes wind RPO, hydropower purchase obligation (HPO) and other RPO. The energy storage obligation is calculated in energy terms as a proportion of total electricity consumption.	Regulatory	Gujarat + National	RE (Hydro)
30	Unnat Jyoti by Affordable LEDs for All (UJALA)	To promote energy efficiency in all households. Aims to save 85 lakh kwh of electricity and 15,000 tonnes of CO2 by replacing traditional bulbs & CFLs and street lights with LEDs.	Economic	Gujarat + National	EE
31	Pradhan Mantri Ujjwala Yojana (PMUY)	It aims to safeguard the health of women & children by providing them with a clean cooking fuel – LPG.	Economic	Gujarat + National	EE
32	Renewable Energy Certificates (REC)	It is a market-based instrument to promote renewable sources of energy and development of the market in electricity.	Regulatory	Gujarat + National	RE
33	National Mission for Enhanced Energy efficiency (NMEEE)	To strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models to the energy efficiency sector.	Economic	Gujarat + National	EE
34	National Mission on Strategic Knowledge for Climate Change	Promotes research, knowledge generation and capacity building relating to climate science.	Informative	Gujarat + National	EE/RE
35	Solar cities development programme India	Solar cities around Solar City Cells promoting solar technologies and providing training activities.	Economic	Gujarat + National	RE (Solar)
36	Energy Storage Obligation (ESO)	The ESO specifies that energy storage should be set at 1% in the 2023-2024 and gradually rise to 4% by 2029-2030 of total energy consumed from solar and wind.	Regulatory	Gujarat + National	RE + Storage

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
37	Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)	To provide continuous power supply to the entire rural India.	Economic	Gujarat + National	EE
38	Clean Environment Cess	The Clean Environment Cess is levied as a duty excise on coal, lignite and peat in order to promote clear environment initiatives.	Regulatory	Gujarat + National	EE
39	Production Linked Incentive Scheme (PLI)	The scheme aims to give companies incentives on incremental sales from products manufactured in domestic units.	Economic	Gujarat + National	Industry
40	National Programme on Energy Efficiency and Technology Up Gradation of SMEs (BEE-SME)	Activities and interventions are organised within this programme, including situation analyses, energy audits, technology gap assessment, information dissemination, etc.	Informative	Gujarat + National	Industry
41	Steel Scrap Recycling Policy	Provide a framework for carrying out the activities in a scientific manner to have assured and regular supply of processed scrap for the downstream industry.	Economic	Gujarat + National	Industry
42	Perform, Achieve and Trade (PAT) Scheme	To reduce specific energy consumption in energy intensive industries,with an associated market-based mechanism to enhance the cost effectiveness through certification of excess energy saving which can be traded.	Regulatory	Gujarat + National	Industry
43	Carbon Capture, Utilization and Storage (CCUS)-Policy Framework and its Deployment Mechanism in India (2022)	CCUS as an emission reduction strategy to achieve deep decarbonization from the hard-to-abate sectors by outlining broad level policy interventions needed across sectors.	Informative	Gujarat + National	Industry
44	Draft 2030 Roadmap for Carbon Capture Utilization and Storage (CCUS) for Upstream E&P Companies	To provide a unified and practical strategy for the development and implementation of CCUS/CCS in the oil and gas sector which will help direct companies towards scaling up these techniques.	Regulatory	Gujarat + National	Industry
45	National Electric	It aims at promoting hybrid and	Economic	Gujarat +	Transport

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
	Mobility Mission Plan	electric vehicles. It sets out the target to achieve 6-7 million sales of hybrid and electric vehicles year on year from 2020 onwards by providing fiscal incentives.		National	
46	FAME Scheme (Phase I)	The FAME scheme was launched to encourage electric and hybrid vehicle purchase by providing financial support. Market creation through demand incentives was aimed at incentivizing all vehicle segments.	Economic	Gujarat + National	Transport
47	FAME Scheme (Phase II)	Only advanced battery and registered vehicles will be incentivized under FAME II. With greater emphasis on providing affordable & environment friendly public transportation options for the masses, scheme will be applicable mainly to vehicles used for public transport or those registered for commercial purposes.	Economic	Gujarat + National	Transport
48	National Bio-Diesel Mission	With the intention of further promoting biofuels, India has begun consultations on allowing 5% blending of biofuels in diesel that would be consumed by bulk users.	Regulatory	Gujarat + National	Transport
49	Roadmap for Ethanol Blending 2020-2025	The new Ethanol Blending Roadmap brings forward the 20% blending mandate from 2030 to 2025	Regulatory	Gujarat + National	Transport
50	Vehicles scrappage policy	This voluntary scheme aims to scrap vehicles 15 years or older to reduce pollution and road accidents.	Economic	Gujarat + National	Transport
51	Standards and Labelling Program (S&L)	Provide the consumer with an informed choice about the energy saving and consequent cost saving potentials of the respective products.	Regulatory	Gujarat + National	Building
52	Smart Cities Mission	Aims to drive economic growth and improve the quality of life of people by enabling local development and harnessing technology to create smart outcomes for citizens.	Economic	Gujarat + National	Building

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
53	Atal Mission for Rejuvenation and Urban Transformation	Development of basic infrastructure, in the selected cities and towns, in the sectors of water supply; sewerage and septage management; storm water drainage; green spaces and parks; and non-motorized urban transport.	Economic	Gujarat + National	Building
54	India Cooling Action Plan (ICAP)	Reduction of cooling and refrigerant demand across sectors by 20% to 25 % by year 2037-38; Reduction of cooling energy requirements by 25% to 40% by year 2037-38; Training and certification of 100,000 servicing sector technicians by year 2022-23.	Regulatory	Gujarat + National	Building/ EE
55	Smart Meter National Programme (SLNP)	The programme aims at replacing 250 million conventional meters with smart meters via bulk procurement.	Regulatory	Gujarat + National	Building
56	National Energy Efficient Buildings Programme	The programme aims at retrofitting 20,000 large public and private buildings with more efficient appliances and equipment by 2020.	Regulatory	Gujarat + National	Building
57	Energy Conservation and Building Code	To establish minimum energy performance standards for buildings in India. Buildings consume significant proportion of our energy resources and the ECBC is an essential regulatory tool to curb their energy footprint.	Regulatory	Gujarat + National	Building
58	Jal Jeevan Mission	To provide safe and adequate drinking water through individual household tap connections by 2024 to all households in rural India and to implement source sustainability measures as mandatory elements.	Regulatory	Gujarat + National	Water and Sanitation
59	Swachh Bharat Mission	To achieve an open defecation free (ODF) India in five years. It aims for adequate and equitable sanitation access for all.	Regulatory/ Informative	Gujarat + National	Water and Sanitation
60	Agriculture Demand Side Management (AgDSM)	Farmers receive revenue monthly by selling the excess power to the grid for a period of 25 years.	Economic	Gujarat + National	Agriculture

Sr. No.	Name of Policy/	Description	Type of policy instrument	Implementation level	Sector
61	National Agro-forestry Policy	Protect and stabilize ecosystems and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.	Regulatory	Gujarat + National	Agriculture/ Forestry
62	National Mission for Sustainable Agriculture	Enhancing food security and protection of resources such as land, water, biodiversity, and genetics.	Informative	Gujarat + National	Agriculture
63	Neem Coated Urea	100% Neem Coating on all subsidized agricultural grade urea in the country to increase the nutrient efficiency.	Regulatory	Gujarat + National	Agriculture
64	National Green India Mission (GIM)	Respond to climate change by a combination of adaptation and mitigation measures.	Regulatory	Gujarat + National	Forestry

Sources: *(MNRE, Niti Aayog, MoP, GEDA)*

3.4 Estimating and Projecting GHG Emissions from Key Mitigation Policies[11]

This sub-section discusses methodology for GHG emission mitigation potential of major key policies being implemented in Gujarat state during 2005-2019 and projects their GHG emission mitigations from 2020 till 2030.

Solar Mission

The data for solar power installed capacity has taken from monthly renewable report of Central Electricity Authority. The CO2 emission (CO2) factor numbers are the average carbon content of the national power grid and have been obtained from CEA CO_2 baseline database for the Indian power sector. The total CO2 saved during these years have been estimated using the following formula:

Total CO_2 saved = solar power generation from total installed capacity of solar power x baseline CO_2 emission factor

Example:

In 2019, Solar installed capacity = 2764 MW

Energy generation from solar = 3279500 MWh

Baseline emission factor = 0.82 tCO2/MWh

CO_2 saved = 3279500 x 0.82 =2689190 Tonne = 2.69 Million Tonnes

[11] This section is adapted from research report on "Revised Gujarat State Action Plan on Climate Change" prepared for Climate Change Department, Govt. of Gujarat and prepared by IIM Ahmedabad and IIT Gandhinagar during 2021.

We have taken assumption of 25 percent efficiency for calculation of solar power generation from the installed capacity. For 2020-2030 period, we have projected the mitigation numbers by applying 13.25% growth rate for solar power installed capacity data. Baseline emission number has been assumed on the basis of expert's judgement.

Wind Power Policy

The data for wind power installed capacity has taken from monthly renewable report of Central Electricity Authority. The CO2 emission (CO2) factor numbers are the average carbon content of the national power grid and have been obtained from CEA CO_2 baseline database for the Indian power sector. The total CO2 saved during these years have been estimated using the following formula:

Total CO_2 saved = Wind power generation from total installed capacity for wind power x baseline CO_2 emission factor

Example:

In 2019, Wind power capacity = 7492 MW

Energy generation from wind = 12910680 MWh

Baseline emission factor = 0.82 tCO2 /MWh

CO_2 saved = 12910680 x 0.82 = 10586758 Tonne = 10.59 Million Tonnes

For 2019-2030 period, we have projected the mitigation numbers by applying the 6% growth rate for wind power generation data. Baseline emission number has been assumed on the basis of expert's judgement.

Other Renewables

The data for Biomass, Bagasse and other power generation and installed capacity are not currently available for Gujarat. The formula to calculate the total CO2 saved during these years have been estimated using below following formula:

Total CO_2 saved = cumulative power generation from other renewable sources × baseline CO_2 emission factor

Example:

In 2019, energy generation from other renewable sources = 286000 MW

Baseline emission factor = 0.82 tCO2 /MWh

CO_2 saved = 286000 x 0.82 = 234520 Tonne = 0.23 Million Tonnes

Transmission and Distribution Losses

The estimation for CO2 savings from Transmission and Distribution (T&D) losses requires the values for power generation in India. Generation numbers are obtained from

Compendium of Selected Indicators published by Directorate of Economics and Statistics. The yearly T&D loss numbers are taken from monthly executive summary reports of CEA. The CO_2 emission factor have been obtained CEA CO_2 baseline database for the Indian power sector.

Total CO_2 saved in year (Yt)= Total electricity generation in present year (Yt) × (T&D loss in previous year (Yt-1)- T&D loss in present year (Yt)) × baseline CO2 emission factor

Example:

In 2019, gross electricity generation = 123595 GWh

T&D loss in 2018 = 20.88 %

T&D loss in 2019= 20.72 %

Baseline emission factor = 0.82 tCO_2/MWh

CO_2 saved in 2019 = 123595 x 1000 x ((20.88-20.72)/100) x 0.82 = 159494 Tonne = 0.16 Million Tonnes

For 2020-2030 period, we have projected the mitigation numbers by applying the CAGR number which has been calculated from 2015-2019 gross electricity generation and T&D losses. Baseline emission number has been assumed on the basis of expert's judgement.

LED Lights Distribution

The Honourable Prime Minister Shri Narendra Modi launched UJALA scheme is LED-based Domestic Efficient Lighting Programme (DELP) in 2014 and National Programme to convert conventional street and domestic lights with energy efficient LED lights in 2015. These programs aimed to promote efficient lighting, reducing energy consumption and energy. The primary data for the number of LEDs distributed during these years and the total CO2 emission saved from the scheme have been taken from the UJALA (2019) and SLNP (2019) dashboard of Ministry of Power, Government of India.

We have applied growth rate of 2 percent and 1 percent to UJALA LED and SLNP for the year 2020. Afterwards, we have assumed that the number will remain constant till 2030.

Perform, Achieve and Trade (PAT) Scheme

The results for the PAT cycle I have been taken from BEE report. The cumulative CO_2 mitigated data have been linearly distributed equally for the years PAT cycle I (2012-2015) and PAT cycle II (2016-2019).

Following set of equations are used in order to calculate the energy savings, using the data for above mentioned DCs. The production data of the baseline year of PAT Cycle II, i.e. 2014-15 has been taken into consideration, in line with PAT rules, and the M&V exercise conducted by BEE.

Step I: Obtain the Specific Energy Consumption (SEC) for the base year = SEC base year

Step II: Obtain the SEC for the latest year = SEC latest year

Step III: SEC base year – SEC latest year (Improvement in Energy Efficiency)

Step IV: In order to calculate the Energy Savings (ES) in Mtoe, the results of Step 3 to be multiplied by the total production of respective DCs for the year base year.

Formula = ES Plant 1= (SEC base year – SEC latest year) x Production base year

Step V: ΣES = ES Plant 1 + ES Plant 2+ ES Plant 3 + ES Plant 4 +----------+ ES Plant N

For 2020 onwards we have assumed that the number will remain constant. We will have improvised the numbers in the final report.

Metro Rail Transport

Before 2019, there is no metro rail transportation at any cities of Gujarat. The metro rail in Ahmedabad city was launched by Prime Minister Narendra Modi on March 4. It has started for 6.5 km stretch in Ahmedabad city between Vastral Gam and Apparel Park. Nearly, 76,000 people availed the free rides on the Metro between March 6-14 in 2019[12].

The total ridership of these metro rail system has been estimated using the draft report and we have assuming that ridership has stabilized after 2020. The average emission reduction (tCO2 per passenger) has been arrived at after factoring in baseline emissions (trip length, ridership, etc.), project emissions and leakages (nil). The total CO_2 saved have been estimated using the following formula:

Total CO_2 saved = Total passengers travelling in metro rail × Average emission reduced per passenger

Bus Rapid Transit System

During the period of 2011-2014, the Bus Rapid Transit System (BRTS) was operational only in 3 Gujarat cities, viz. Ahmedabad, Surat and Rajkot. The data for average daily ridership and total length of the corridor for these cities have been obtained from newspaper articles and city municipal reports. Total operational lengths for BRTS are 114 kms in Surat city, 101 kms in Ahmedabad city, and 10.5 kms for Rajkot city as of October 31, 2020. The CO2 emissions saved from the BRTS is estimated using the following formula:

Total CO_2 saved = Σ*City* Total passengers travelling in BRTS × Average emission reduced per passenger

The following are the assumptions taken for the calculations:

- The ridership will increase by 5 percent annually over period of 2020-2030 due to BRTS operation.

[12] https://www.dnaindia.com/ahmedabad/report-ahmedabad-metro-gains-traction-with-over-1k-passengers-daily-2746415.

- The value for average emission reduction (tCO2e/passenger) is assumed to be less in case of BRT. An average trip length in case of BRT is assumed to be 7 km. Hence, we assume emissions / passenger would reduce by half to that of Delhi metro.

Figure 3 shows GHG emission mitigation potential ($MtCO_2e$) in Gujarat due to implementation of some of the key policies between 2005 to 2030.The chart represents the actual emission mitigation from 2005 to 2019 and mitigation projections from 2020 to 2030 due to implementation of major key policies which include: solar power policy, wind power policy, other renewables, supercritical power generation, T & D losses reduction, PAT scheme, micro irrigation system (MIS), street light national programme (SLNP), UJALA programme and urban transport (Metro & BRTS), ethanol blending policy, etc. Table 6 represents the year-wise mitigation potential for each of these key policies from 2005-2019 (estimated based on actual data available) and 2020-2030 (projections estimated based on past trends/targets).

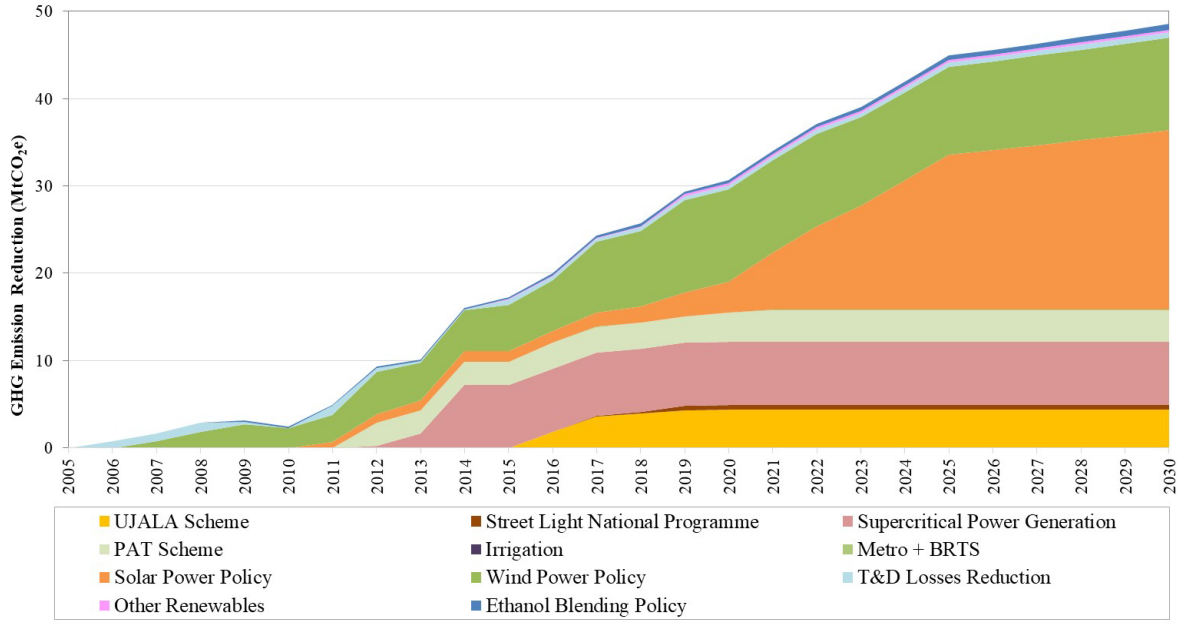

Figure 3. GHG emission mitigation (2005 to 2019) and mitigation projections (2020 to 2030) due to some key policies

Source: Authors' estimates

Table 6. GHG emission mitigation ($MtCO_2e$) from 2005 to 2019 and emission mitigation projections from 2020 to 2030 due to some key policies

Year	Solar Power Policy	Wind Power Policy	Other Renewables	T&D Losses Reduction	Supercritical Power Generation	UJALA Scheme	Street Light National Programme	PAT Scheme	Irrigation	Metro + BRTS	Ethanol Blending Policy
2005					0.00	0.00	0.00	0.00	0.0000	0.00	0.00
2006				0.78	0.00	0.00	0.00	0.00	0.0000	0.00	0.00
2007		0.74		0.89	0.00	0.00	0.00	0.00	0.0000	0.00	0.00
2008		1.87		1.02	0.00	0.00	0.00	0.00	0.0000	0.00	0.00
2009		2.69		0.31	0.00	0.00	0.00	0.00	0.0000	0.00	0.13
2010	0.01	2.27		0.00	0.00	0.00	0.00	0.00	0.0000	0.01	0.15

2011	0.65	3.12		1.03	0.00	0.00	0.00	0.00	0.0001	0.01	0.16
2012	0.95	4.86		0.39	0.28	0.00	0.00	2.63	0.0001	0.01	0.17
2013	1.12	4.31		0.21	1.68	0.00	0.00	2.63	0.0001	0.01	0.17
2014	1.21	4.64		0.08	7.23	0.00	0.00	2.63	0.0002	0.01	0.20
2015	1.23	5.29	0.05	0.62	7.23	0.00	0.00	2.63	0.0002	0.01	0.23
2016	1.29	5.84	0.03	0.46	7.23	1.83	0.05	2.96	0.0002	0.03	0.25
2017	1.64	8.08	0.08	0.35	7.23	3.56	0.09	2.96	0.0003	0.03	0.27
2018	1.84	8.61	0.11	0.49	7.23	3.93	0.19	2.96	0.0003	0.04	0.29
2019	2.69	10.59	0.23	0.48	7.23	4.29	0.53	2.96	0.0003	0.04	0.32
2020	3.48	10.59	0.24	0.49	7.23	4.40	0.53	3.29	0.0003	0.04	0.35
2021	6.50	10.59	0.25	0.50	7.23	4.40	0.53	3.62	0.0004	0.04	0.37
2022	9.53	10.59	0.26	0.51	7.23	4.40	0.53	3.62	0.0004	0.05	0.40
2023	11.95	10.07	0.25	0.50	7.23	4.40	0.53	3.62	0.0005	0.05	0.43
2024	14.83	10.07	0.26	0.51	7.23	4.40	0.53	3.62	0.0006	0.05	0.46
2025	17.71	10.07	0.27	0.52	7.23	4.40	0.53	3.62	0.0006	0.05	0.49
2026	18.24	10.17	0.27	0.53	7.23	4.40	0.53	3.62	0.0007	0.06	0.52
2027	18.79	10.27	0.28	0.55	7.23	4.40	0.53	3.62	0.0008	0.06	0.56
2028	19.35	10.38	0.29	0.56	7.23	4.40	0.53	3.62	0.0009	0.06	0.60
2029	19.93	10.48	0.30	0.57	7.23	4.40	0.53	3.62	0.0011	0.07	0.64
2030	20.53	10.58	0.31	0.58	7.23	4.40	0.53	3.62	0.0012	0.07	0.68

Source: Authors' estimates

3.5 Mapping Impact, Vulnerability and Adaptation (IVA) in Gujarat

3.5.1 Observed changes and impacts of climate change

Climate change is significantly impacting Gujarat, particularly in terms of its water resources. Despite possessing only 2% of the country's water resources, the State heavily relies on water for irrigation, with limited availability for drinking and industrial purposes (GIDB). Rainfall serves as the primary source of water, but there is notable variation across the region. Southern areas receive approximately 1500 mm of rainfall, while the northwest experiences less than 500 mm. Climate change alters rainfall patterns, affecting water availability and the environment directly. Gujarat has encountered various water-related challenges, including groundwater depletion in North Gujarat, groundwater pollution in South Gujarat, droughts in Kutch and Central Gujarat, and floods in Saurashtra and South Gujarat. These issues underscore the State's Vulnerability to the impacts of climate change.

Furthermore, the consequences of climate change extend to Gujarat's coastal areas. Rising sea levels and the heightened frequency of extreme weather events, such as cyclones and storm surges, pose significant threats to coastal communities, infrastructure, and ecosystems. These events contribute to coastal erosion, the loss of habitats, and damage to coastal infrastructure, thus impacting industries like fisheries and tourism.

To address these challenges effectively, it is crucial to understand both the present water availability and the projected future changes. This understanding will facilitate the development of adaptation strategies aimed at mitigating the impact of climate change. Gujarat must prioritize the close monitoring and management of water resources, the

implementation of sustainable practices, and the integration of climate change considerations into planning and policy-making processes. By doing so, the State can enhance its resilience and minimize the adverse effects of climate change on water availability, infrastructure, human well-being, and biodiversity. Coupled Model Intercomparison Project Phase 6 (CMIP6; Taylor et al., 2012) provided an opportunity to examine the climate change impacts on the occurrence and severity of droughts (Aadhar and Mishra, 2020), climate change impacts on hydropower production (Chuphal and Mishra, 2023), and flood risk assessment (Pokhrel et al., 2020; Pandey et al., 2022).

In this study, we evaluated the changes in precipitation and temperature extremes in the observed period 1951–2019. Further, we estimated the change in precipitation and temperature extremes under different warming levels (1.5°C, 2.0°C, 2.5°C and 3°C) for each GCMs of CMIP6 against the reference period of 1995-2014. We selected the decades for each GCM that were 1.5 (1.3-1.7), 2 (1.8-2.2), 2.5 (2.3-2.7), and 3 (2.8-3.2) °C warmer than the corresponding GCM baseline period (pre-industrial era: 1851-1900) for all SSPs (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). We estimated the decadal average extreme precipitation and temperature change corresponding to 1.5, 2, 2.5 and 3 °C global warming levels by averaging the results across all SSPs.

3.5.2 Data and Methods

To analyze the water availability conditions in the observed period we use observed datasets from the Indian Meteorological Department (IMD) with a 0.25 x 0.25-degree resolution. The data is available from 1951 to 2019 for both daily precipitation and temperature. The temperature data consist of the maximum, mean, and minimum temperature for the chosen study period and for future projections, we used climate model projections from five Climate Model Inter-comparison Project (CMIP6) models. These models[13] are CanESM5, FGOALS-g3, IPSL-CM6A-LR, MIROC6, and MRI-ESM2-0 and are presented in Table 7. To align the resolution of the CMIP6 models data with the IMD dataset, we performed re-gridding using bi-linear interpolation, resulting in a resolution of 0.25°.

[13] https://esgf-node.llnl.gov/search/cmip6/

Table 7. Specifications of data used and their sources

Observed data			
Sl. No.	**Variable**	**Period/resolution**	**Source**
1	Precipitation	1951-2019/ 0.25 x 0.25-degree	Indian Meteorological Department (IMD)
2	Tmax		
3	Tmin		

Data for the projected period				
Sl. No.	**Model Name**	**Resolution (km) [lon × lat]**	**Institute**	**Reference**
1	CanESM5	309 x 311	CCCMA/Canada	Swart et al. (2019)
2	FGOALS-g3	250 × 250	The Earth System Grid Federation (ESGF)	Zhang et al. (2022)
3	IPSL-CM6A-LR	140 x 277	IPSL/France	Boucher et al. (2018)
4	MIROC6	256 × 128	MIROC/Japan	Tatebe et al. (2019)
5	MRI-ESM2-0	124x 124	MRI/Japan SS	Yukimoto et al. (2019)

3.5.3 Methodology for Assessing Climate Change-Induced Risks and Vulnerabilities

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change, i.e., IPCC-AR5 (IPCC, 2014), defines the risk of climate change at the intersection of 'Hazard', 'Exposure', and 'Vulnerability'. This information can guide decision-making processes and help prioritize adaptation and mitigation efforts to reduce the impacts of climate change. Exposure is the measure of the likelihood that a system or community will come into contact with climate hazards. To assess urban exposure to extreme heat and heavy rainfall in Gujarat state, we calculate the number of person-days per year for each grid. This calculation takes into account the population of each grid (Nij) multiplied by the number of days in a given year (Yi) where the threshold for extreme heat (99th percentile of Tmean) and heavy rainfall (99th percentile of precipitation excluding days with no rainfall during the summer months of May-June) is exceeded for that particular grid. In simpler terms, instead of solely estimating the hazard, we quantify the term (Hazard x Exposure).

Climate change vulnerability provides valuable insights into the vulnerabilities of natural or socio-economic systems and the underlying factors contributing to these vulnerabilities. This

assessment serves as a foundation for developing strategies to address these weaknesses and adapt to the drivers of Vulnerability. By reducing Vulnerability to current climate variability, we can take an essential step towards minimizing losses and building resilience for future climate change scenarios. The methodology for developing state-level vulnerability indices (VI) is based on the risk assessment framework outlined in the IPCC-AR5 report. A comprehensive discussion of the methodology can be found in the Common Vulnerability Framework and Guidelines developed under the IHCAP. The vulnerability assessment utilized a set of 14 indicators, capturing both sensitivity and adaptive capacity of the districts. These indicators cover socio-economic and livelihood-based factors, biophysical aspects, and institution and infrastructure-related variables. Normalization of the indicators is based on their functional relationship with Vulnerability, allowing for a standardized comparison across districts. Equal weights were assigned to all indicators, and vulnerability indices were constructed by taking the arithmetic mean of the normalized scores.

For indicators positively related to Vulnerability, where Vulnerability increases with an increase in the value of the indicator, the following formula was used:

$$xP\ ij = (Xij - Min\ \{Xij\})/(Max\ \{Xij\} - Min\ \{Xij\})$$

For indicators negatively related to Vulnerability, where Vulnerability decreases with an increase in the value of the indicator, the following formula was used:

$$xN\ ij = (Max\{Xij\} - Min\{Xij\})/(Max\{Xij\} - Xij)$$

Where Xij is the value of jth indicator for ith district, Mini {Xij} is the minimum value of the jth indicator across districts and Maxi {Xij} is the maximum value of the jth indicator. xPij and xnij are the normalized values of the indicators, respectively, for positively and negatively related indicators. Normalized values of an indicator will lie between 0 and 1. The value 1 will correspond to a district with maximum Vulnerability, and 0 will correspond to a district with minimum Vulnerability with respect to a particular indicator. By employing the hazard, exposure, and Vulnerability map, we have assessed the level of risk using the following relationship.

$$Risk = f\ (Hazard, Exposure, Vulnerability)$$

This equation allows us to analyse and quantify the overall risk by considering the interplay between the hazard, exposure, and vulnerability factors.

3.5.4 Changes in the observed period (1951 - 2019)

During the period of 1951-2019, certain districts of Gujarat, including Girsomnath, Surendranagar, Ahmadabad, Sabar Kantha, and Aravalli, experienced a significant increase in the frequency of extreme rainfall (wet) events. In contrast, the rest of the State witnessed normal changes in the frequency of such events, particularly in the southern districts like Dang, as depicted in Figure 4d. These districts not only received higher levels of precipitation but also encountered an increase in the number of extreme wet events, as shown in Figures 4b and 4d.

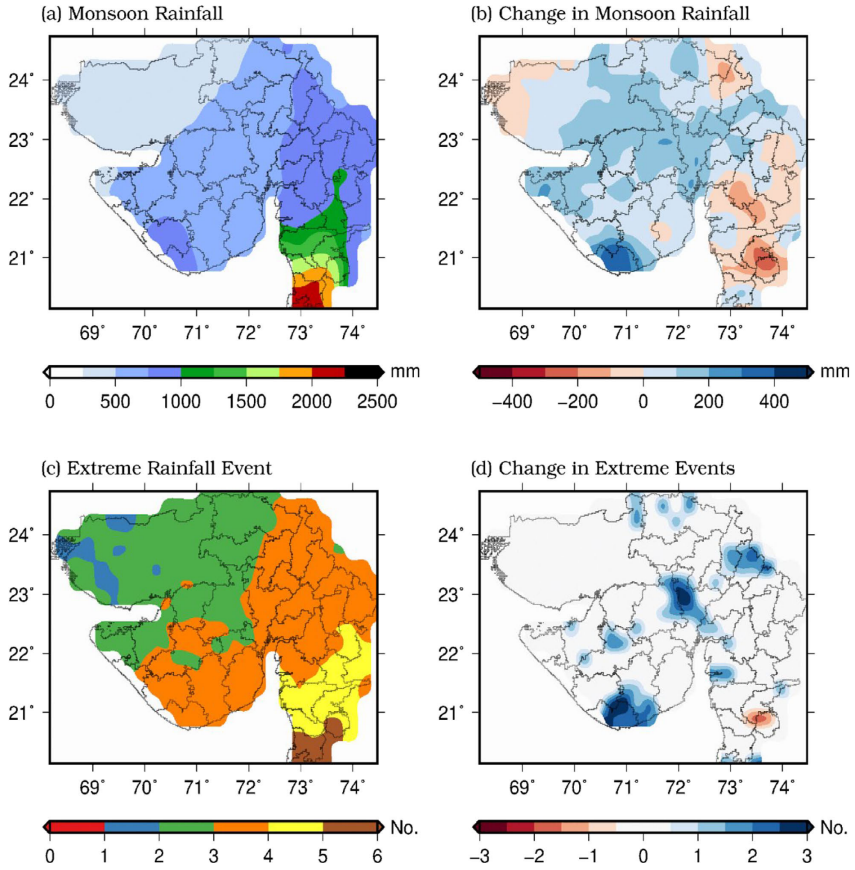

Figure 4. (a) Observed mean monsoon season precipitation, (b) Change in monsoon season precipitation, (c) Observed number of extreme precipitation events, and (d) Change in number of extreme events during the period of 1951 – 2019

Using the Mann-Kendall test and Sen's slope values obtained on a grid basis, we analyzed the trends in monsoon rainfall, extreme rainfall, and rainy days in Gujarat. Our findings revealed that the western part of Gujarat is experiencing a higher trend in extreme rainfall and an increase in monsoon rainfall (Figure 5 a-b). However, the number of rainy days has decreased in these regions (Figure 5c). Additionally, we observed an increase in precipitation above the 95th percentile in Gujarat, indicating a rise in the frequency of extreme rainfall events (Figure 5d). These findings suggest that the western part of Gujarat is becoming more vulnerable to floods and related disasters due to increased extreme rainfall events. This highlights the need for appropriate measures to manage such risks.

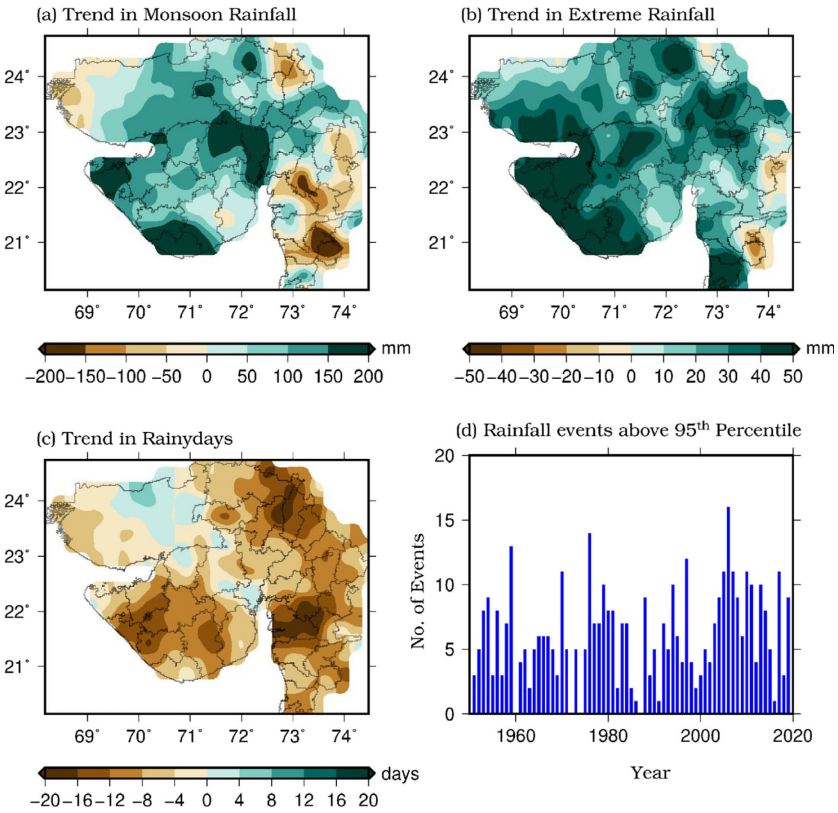

Figure 5. (a) The trend in monsoon rainfall, (b) Trend in extreme rainfall, (c) Trend in rainy-day, and (d) Number of rainfall events exceeding the 95th percentile during the period of 1951 – 2019.

We also analyzed the daily maximum, mean, and minimum temperatures. Mean annual temperatures vary across the State, with maximum temperatures ranging from 30-35 °C, mean temperatures from 23-29 °C, and minimum temperatures from 16-22 °C (Figure 6 a, b, and 6e). The districts of Valsad, Navsari, Surat, Bharuch, Vadodara, and some parts of Tapi and Narmada have a mean annual daily maximum temperature above 31°C, while the rest of the State experiences temperatures below this threshold. Banas Kantha, Sabar Kantha, Patan, Mehsana, and Aravalli districts have minimum temperatures ranging from 23-25 °C.

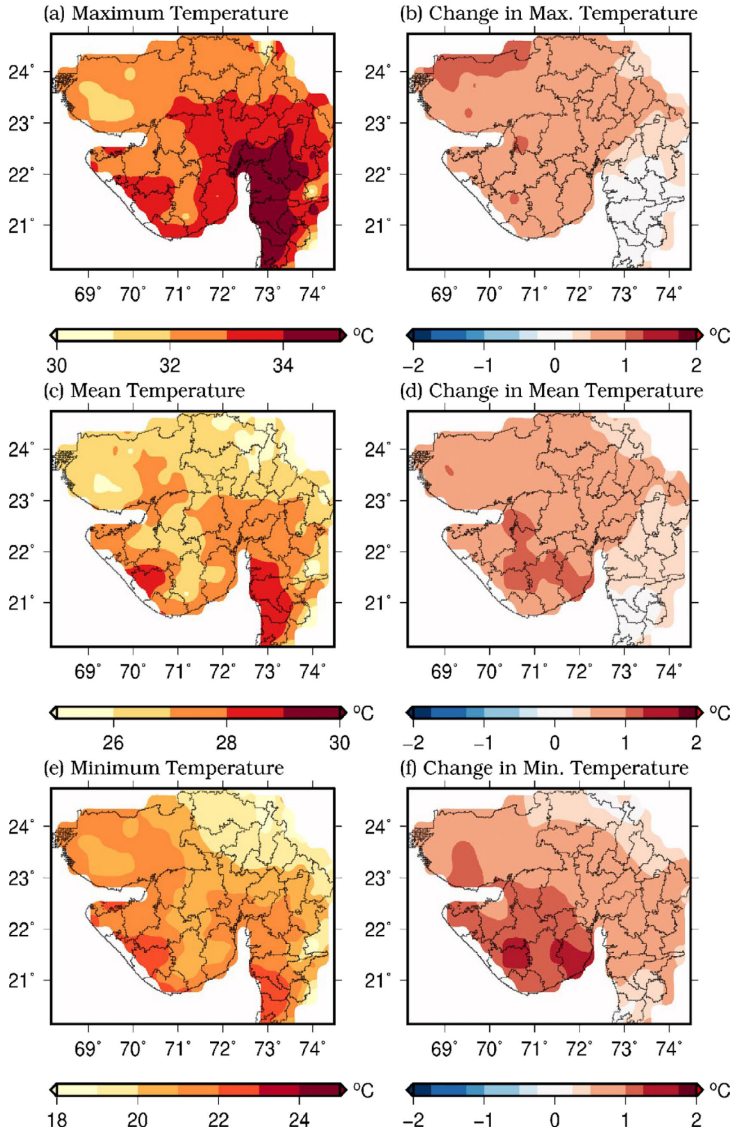

Figure 6. (a), (c), and (e) Observed annual mean of daily max, mean, and min temperatures

The trend in pre-monsoon, post-monsoon, and during monsoon temperatures was analyzed based on Sen's slope values obtained on a grid basis (Figure 7 a-c). We found that districts of Bhavnagar, Amreli, Junagarh, Rajkot, Morbi, and some parts of Kutch in Gujarat are experiencing a higher trend in temperature. On the other hand, the southern districts of Valsad, Navasari, Tapi, and Surat have been found to have a lower trend in temperature (Figure 7 a-c). However, we have noticed an overall increase in the number of days with temperatures exceeding 40 degrees Celsius (Figure 7d). This indicates a concerning trend for these regions, as the rise in temperature may have detrimental effects on the environment and public health.

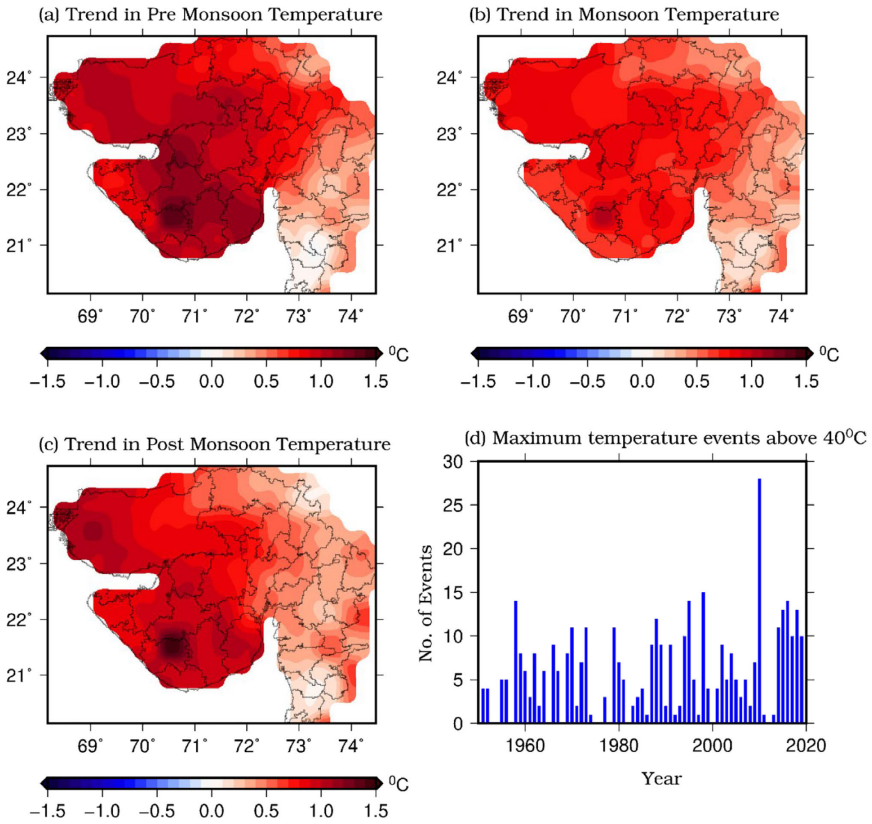

Figure 7. (a) The trend in pre-monsoon temperature, (b) Trend in monsoon temperature, (c) Trend in post-monsoon temperature and (d) Number of temperature events exceeding 40°C during the period of 1951 – 2019.

3.5.5 Projected changes and impacts of climate change

Projected changes in precipitation

We estimated the potential changes in the frequency of precipitation across different warming levels (1.5°C, 2.0°C, 2.5°C, and 3°C) compared to the reference period of 1995-2014 (Figure 8). Results indicate that under the 1.5°C warming, there would be an increase in precipitation ranging from approximately 8-16% compared to the reference period. Similarly, 2°C shows a projected increase of 8-24%. The majority of the region under 2.5°C is expected to experience a more significant increase of about 32-40% in precipitation. Notably, there is a substantial spike in precipitation under 3°C, with nearly all regions showing an increase of about 40-64%. These projections reveal a wide range of precipitation variations across Gujarat. Specifically, the 3°C scenario indicates higher precipitation values, resulting in an overall increase in precipitation throughout the State. The southern parts of Gujarat are anticipated to undergo more pronounced increases in precipitation compared to the northern regions.

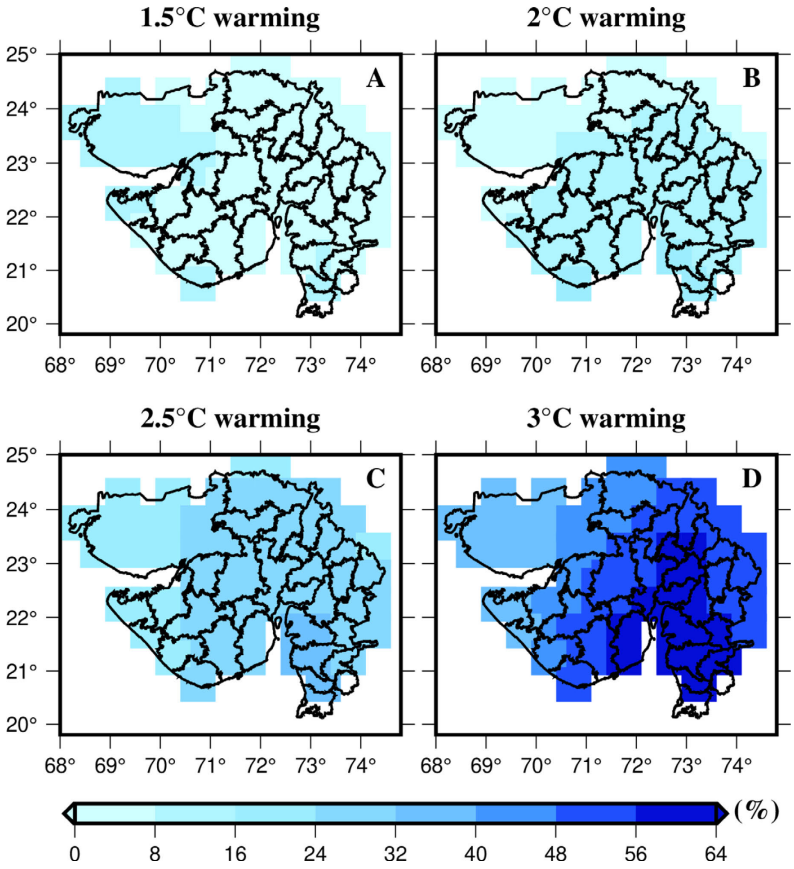

Figure 8. The multi-model ensemble mean projected changes (mm) in monsoon season precipitation for the Near, Mid and Far term temporal range. Changes were estimated against the historical mean for the reference period (1995 - 2014).

Projected changes in Temperature

The findings indicate that different warming scenarios have distinct impacts on temperature in Gujarat compared to reference period of 1995-2014 (Figure 9). In the 1.5°C warming, temperatures are projected to rise by approximately 0.6-1.5 °C compared to the rseference period. Under 2°C warming, the expected increase is slightly higher, ranging from 1.5-1.8 °C. However, the most significant temperature rise is anticipated under 2.5°C, where a majority of the region could experience a substantial increase of about 2.1-3.0 °C. Notably, the 3°C warming shows a remarkable spike in temperatures, with almost all regions indicating an increase of about 2.4 - 4.2 °C.

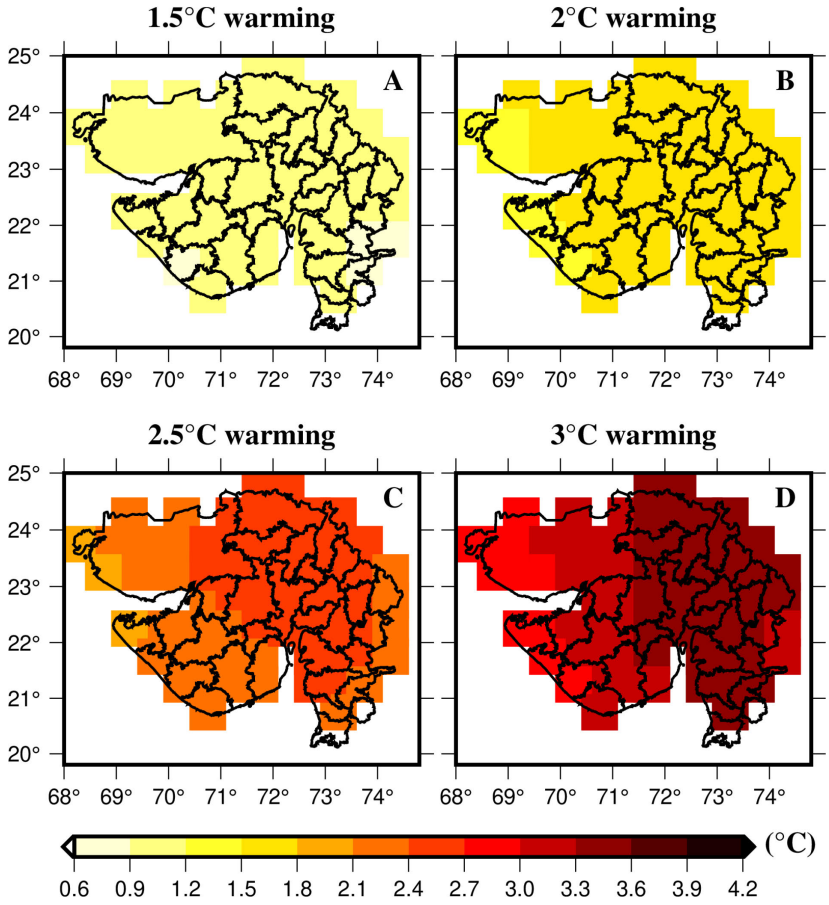

Figure 9. Ensemble mean projected change in the mean of an annual mean of daily mean temperature from the reference period (1995-2014)

These projections highlight a wide range of temperature variations across Gujarat. Specifically, 3°C warming indicates a more significant deviation from the reference period, resulting in an overall temperature increase throughout the State. The southern and eastern parts of Gujarat are expected to experience more pronounced temperature increases compared to the northern regions.

3.5.6 Assessing Climate Change Vulnerability and Risk in Gujarat

Climate change impact on Population exposure

The impact of climate change on population exposure to extreme precipitation and temperature events is expected to intensify as warming levels increase (Figure 10). However, the rate of change in population exposure due to extreme precipitation is notably faster, affecting almost every State. On the other hand, population exposure to extreme temperature events is primarily concentrated in a few states, specifically the southwestern districts of Gujarat. In these districts, the change in population exposure ranges from 20-35%, while in all other districts, the change remains within the range of 0-15%. It is important to note that the impact of climate change on population exposure will continue to escalate as we progress from 1.5 to 3 degrees Celsius of warming.

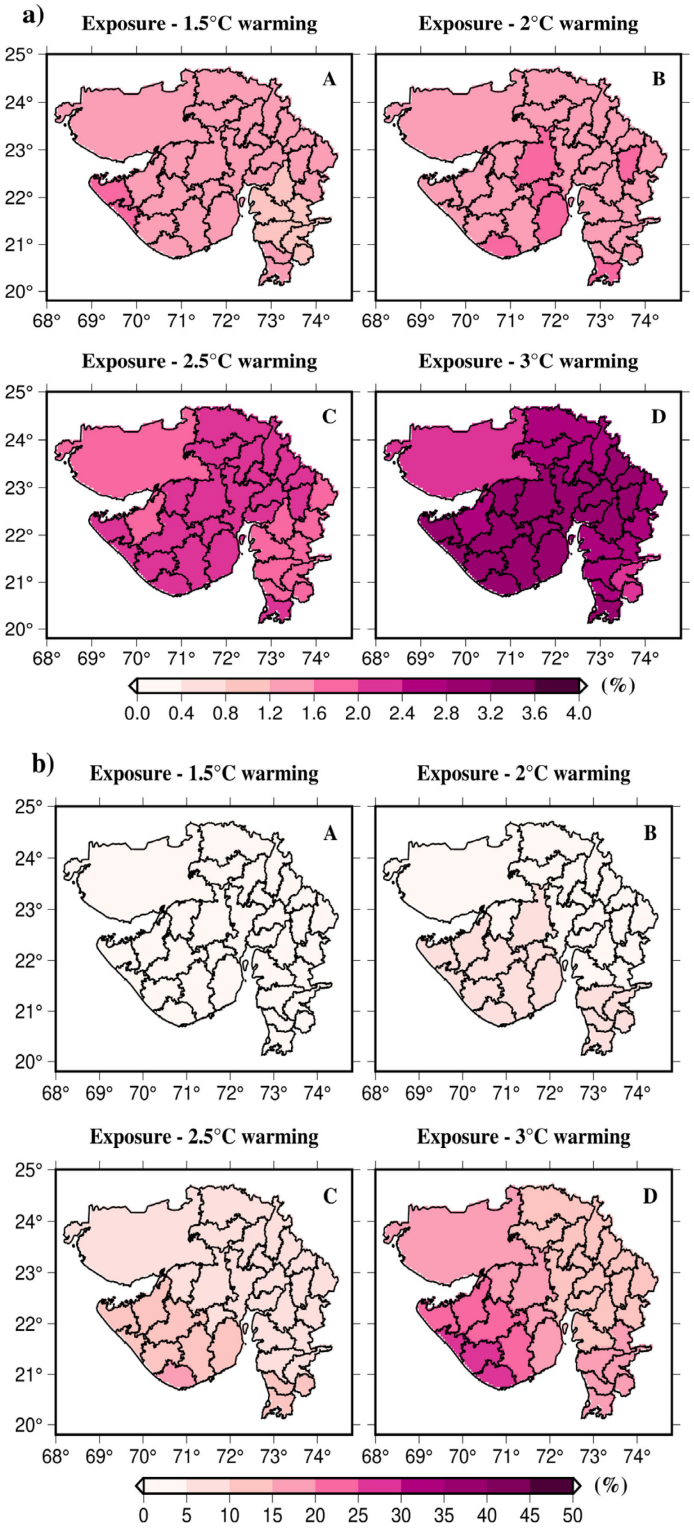

Figure 10. Population exposure to climate hazard (a) extreme rainfall, (b) extreme temperature. The percentage values indicate the percentage of the population exposed to the respective hazard. Hazard is the probability of exceeding the 99th percentile threshold value of rainfall and temperature per year under different warming levels. The 99th percentile threshold value is calculated based on the observed rainfall and temperature. It considers four different warming levels (1.5, 2, 2.5, and 3 degrees Celsius) derived from the CMIP6 model.

Climate change impact on Vulnerability

By implementing the vulnerability assessment methodology described in the IPCC-AR5 report, we have identified that the majority of regions in the study are highly susceptible to the consequences of climate change. The vulnerability index (VI) values range from 0% to 70%, with higher values indicating greater Vulnerability (refer to Figure 11). To improve clarity, the vulnerability index (VI) values, initially ranging from 0 to 1, have been converted to a percentage scale of 0-100. These vulnerability index values are a crucial measure for evaluating the level of risk resulting from climate change impacts, encompassing various extreme events. Utilizing the vulnerability index allows for a comprehensive assessment and quantification of potential risks associated with climate change-induced extremes. Among the districts, Kutch exhibits the least Vulnerability, while the most vulnerable districts include Ahmedabad, Porbandar, Bhavnagar, Patan, and Vadodara.

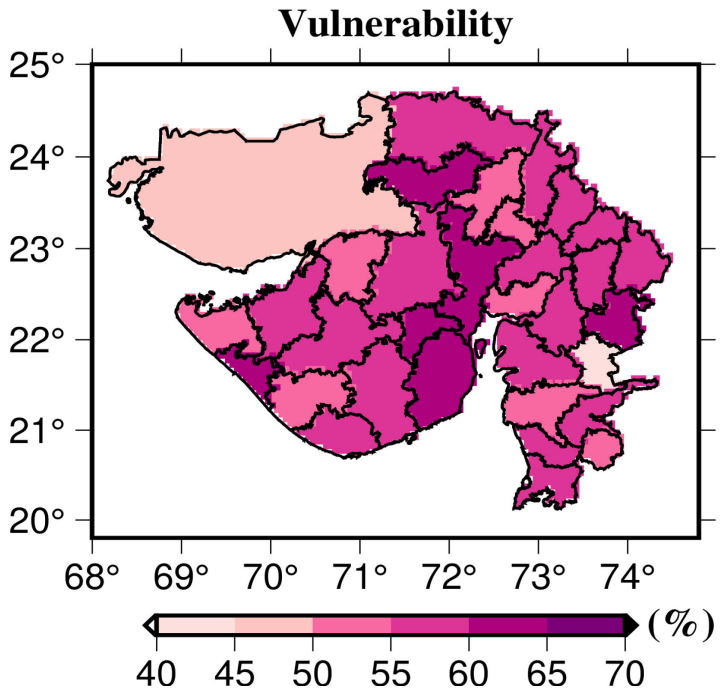

Figure 11. Vulnerability Map of Different Districts in Gujarat based on the Common Vulnerability Framework and IHCAP Guidelines. The map showcases vulnerability levels ranging from 0 to 100% across districts. Higher percentages correspond to increased Vulnerability, as determined by selected indicators and the established methodology.

3.5.7 Risk assessment of Gujarat state due to climate change

The risk assessment process involves quantifying the probability and potential consequences of increasing warming levels in the state of Gujarat. It examines how precipitation and temperature extremes are affected by rising temperatures. Our observations indicate a significant increase in the risk of extreme precipitation as warming levels rise. For example, in several states (Surendranagar and Ahmedabad), this risk increases from approximately 0.3-0.6% at 1.5°C to 2.1-2.4% at 3°C, representing a considerable escalation of about seven to eight times. Gujarat, in particular, stands out as a region with numerous districts highly at risk from precipitation extremes, as depicted in Figure 12.

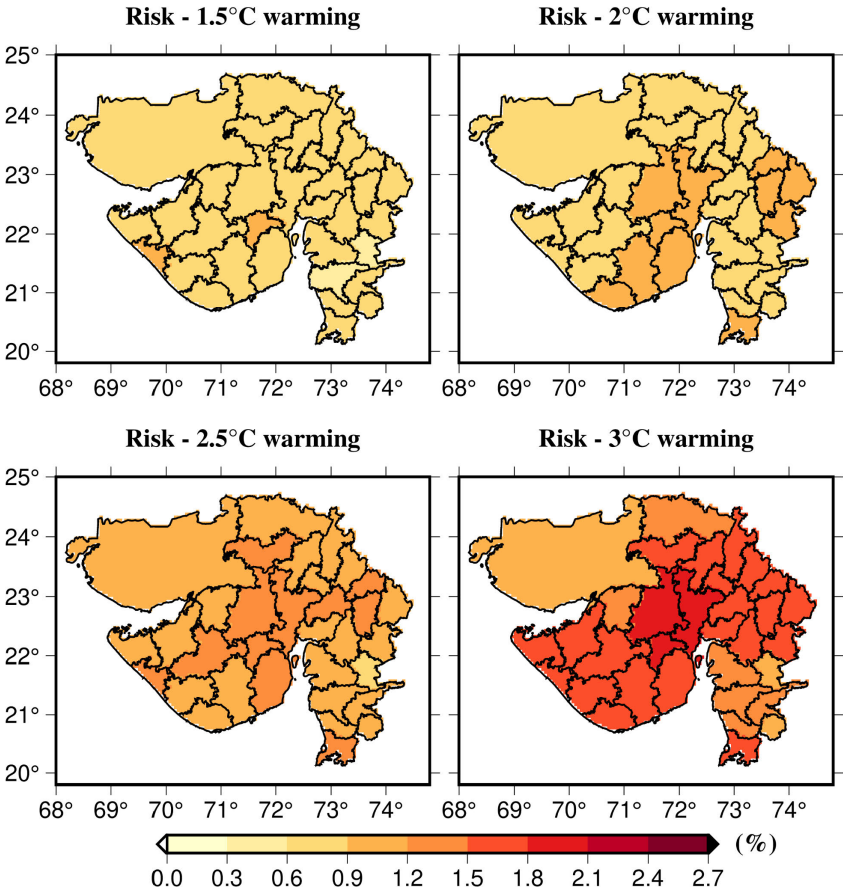

Figure 12. Risk of Extreme precipitation under Different Warming Scenarios (CMIP6) for Various Districts of Gujarat. Darker shades on the map represent districts with a higher risk of extreme precipitation events.

On the other hand, the risk of extreme temperatures is primarily concentrated in specific southwestern districts of Gujarat, namely Jamnagar, Porbandar, Junagarh, Amreli, Bhavnagar, and Rajkot, as depicted in figure 13. At a warming level of 1.5°C, the risk due to extreme temperatures remains relatively low, ranging from 0-4%. However, as the warming level increases to 3°C, the risk escalates significantly, ranging from 8-18%. Among the southwestern districts, Porbandar and Junagarh exhibit the highest risk, around 16-18%, while Amreli, Bhavnagar, Rajkot, and Jamnagar face risk of approximately 10-14%.

These findings provide valuable insights into the potential risks of climate change in Gujarat. They highlight the increasing likelihood of extreme precipitation events as temperatures rise and identify the specific districts at more risk to extreme events. Such information is crucial for policymakers and stakeholders in developing effective strategies to mitigate and adapt to the risks posed by climate change in Gujarat.

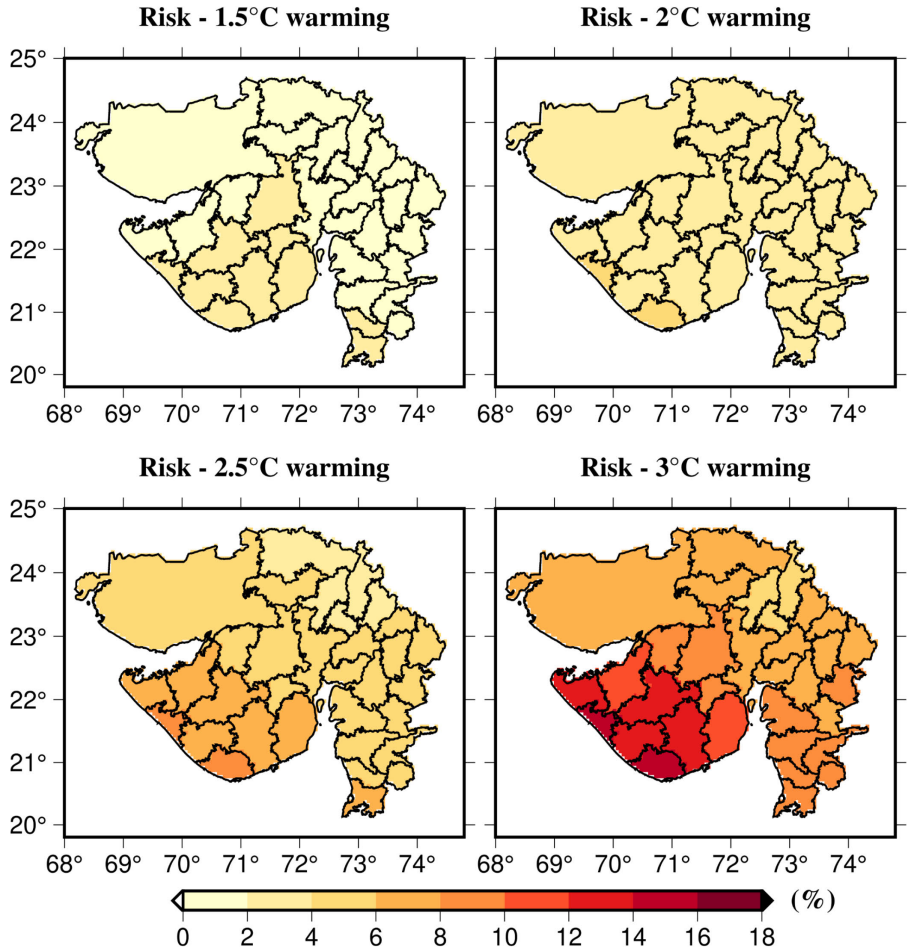

Figure 13. Risk Assessment of Extreme Temperature (Tmean) under Different Warming Scenarios (CMIP6) for Various Districts of Gujarat. Darker shades on the map indicate districts with a greater risk to extreme temperature events.

The findings reveal that as warming levels increase from 1.5°C to 3°C, there will be a noticeable rise in the risk of extreme precipitation and temperature events. This heightened risk will have a more significant impact on several states, particularly in the western and southern regions of Gujarat. These areas are projected to experience more number of rainfall and temperature extremes as the warming levels continue to increase in the future.

Our findings provide policy makers with insights into the diverse rates of climate change risks across Gujarat's districts, aiding in prioritizing policies and strategies. This can include enhancing infrastructure resilience, implementing flood control measures, preparing for heat waves, and adopting region-specific adaptation strategies. Engaging stakeholders is pivotal in fostering a resilient and sustainable future.

4. Climate finance and instruments

Climate finance can be understood as financial resources that support mitigation and adaptation actions to address climate change. These resources can originate from various sources like public funds (such as funds from governments or multilateral financial institutions) and private investments.

There are several estimates of resources required for climate action to meet the Net zero targets set down by countries. It is estimated that USD 4 trillion per year needs to be invested in renewable energy up until 2030 to be able to reach the goal of net zero emissions by 2050, and investment of at least USD 4–6 trillion per year will be required for a global transformation to a low-carbon economy. The OECD estimates that USD 6.9 trillion a year is required up to 2030 to meet global climate and development objectives4. Further, it is estimated that adaptation could require yearly investments of USD 160-340 billion by 2030 and USD 315-565 billion by 2050.

The public sector, represented by domestic, bilateral and multilateral sources, has vital roles in financing climate mitigation and adaptation. It has a role to not only directly finance climate action but also catalyse private finance through mechanisms that de-risk and unbundle complex projects. The scale of financial resources required to meet global challenges necessitates exploring innovative ways to mobilise private sector financial resources through a mix of concessional and non-concessional loans, equity participation, guarantees, dedicated trust funds as well as other blended financing and de-risking mechanisms. Therefore, resources for climate action have to be from a mix of public and private capital with various disbursement channels to ensure the sustainability of financing.

The challenges in attracting private capital entails a discussion on enhancing grant and concessional financing, including from philanthropies and pension funds, enhanced blended financing through various instruments and guarantees, a discussion on innovative mechanisms like Collective Investment Vehicle structured fund and risk mitigation mechanism that can pool risks across projects and geographies to lower the risk profile, focusing on sector specificity.[14]

4.1 Financial Incentives offered by Policies in Gujarat

The table 8 lists several policies and their provision of subsidies and financial incentives to industries and individuals by government of Gujarat. The purpose of financial incentives and subsidies offered by these policies or schemes introduced by government is to boost their adoption among industries and individuals which will lead towards decarbonisation**.**

[14] Adapted from Input Paper on "Mechanisms for mobilisation of timely and adequate resources for climate finance" prepared for G20 Presidency of India 2023, available at https://g20sfwg.org/wp-content/uploads/2023/04/Mechanisms-for-mobilisation-of-timely-and-adequate-resources-for-climate-finance-G20-Presidency-of-India.pdf

Table 8. Provision of financial subsidy /incentives by policies/ schemes of Government of Gujarat

Sr. No.	Name of policy/ scheme	Provision of financial incentives/ subsidies
1	Surya Urja Rooftop Yojana	• State subsidy of 40 % shall be available for solar rooftop systems up to 3 kW. • 20 % for solar rooftop systems beyond 3 kW up to 10 kW, installed and commissioned by private residential consumers.[15]
2	Gujarat Wind-Solar Hybrid Policy	• To promote a voluntary shift to green energy, the DISCOMs will supply 100% renewable power if requested by a consumer. • The electricity will be provided at a green power supply tariff, which will be determined by the GERC. For projects installed through competitive bidding, the RE developer can avail and retain the green credits.[16]
3	Gujarat Wind Power Policy	• Electricity generated and consumed for self/sale to third party shall be exempted from payment of electricity duty as per the Electricity Duty Act 198 and its amendments. • Exemption from demand cut to the extent of 50% of installed capacity of wind power project for captive consumption and third-party sale within state.[17]
4	Gujarat State Biotechnology Policy (2022-27)	• The Policy offers several attractive incentives to companies setting up operations in the state. This policy will provide 25% CapEx support, 15% OpEx support for 5 years, 7% Interest Subsidy and many such incentives; with a special support for Mega/ Special/ Ecosystem Strengthening Projects. • Eligible applicants will be given the benefit for claim upto 50% of CTC with a ceiling not exceeding INR 50,000 per male employee and not exceeding INR 60,000 per female employee. ● Eligible applicants shall be entitled to an interest subsidy on Term Loan at the rate of 7% for borrowings up to INR 100 Crores within a ceiling of INR 7 Crores per annum, plus additional 3% for borrowings above INR 100 Crores within an overall ceiling of INR 20 Crores per annum or the actual interest paid whichever is lower.[18]

[15] https://www.svnit.ac.in/Unnat_Bharat/PI/pdf/Sustainabe%20Energy/Schemes%20by%20Government%20of%20Gujarat/Surya%20Urja%20Rooftop%20Yojana%20Gujarat/SURYA-Gujarat%20Surya%20Urja%20Rooftop%20Yojana.pdf

[16] https://indextb.com/files/2020/10/8c6da74e-969b-4658-afd2-3b8601addc14_Gujarat%20Wind-Solar%20Hybrid%20Power%20Policy%202018.pdf

[17] https://www.cbip.org/policies2019/PD_07_Dec_2018_Policies/Gujarat/2-Wind/2%20Order%20Gujarat_Wind_Power_Policy-2016.pdf

[18] https://indextb.com/files/2022/3/ad13de62-edfa-4461-bae0-ba8bfc412704_BT-Policy-2022.pdf

Sr. No.	Name of policy/ scheme	Provision of financial incentives/ subsidies
5	Gujarat Industrial Policy (2020)	• The government will facilitate industries in getting "Government Land" on lease to industrial enterprises at 6% of market rate for long term upto 50 years for setting up an industrial project. • The policy will provide fiscal support upto 50% of fee payable to Recognized International Certification Authority and 50% cost of testing equipment and machinery required for that certification, totaling upto maximum amount of INR 10 lakhs. • Between Category 1, Category 2 and Category 3 Taluka, Capital subsidy of 25% of loan amount, 20% of loan amount and 10% of loan amount will be provided respectively. • Moreover, interest subsidy in Category 1, Category 2 and Category 3 Taluka will be of 7% of loan amount p/a for 7 years, 6% of loan amount p/a for 6 years and 5% of loan amount p/a for 5 years, respectively.[19]
6	Gujarat State Electric Vehicle Policy	• The incentives for all types of electric vehicles shall be based on the electric vehicle battery capacity (i.e. energy content measured in kWh). • 2-wheeler (2kWh)- Subsidy of Rs. 10000 per kWh capped at Rs. 1.5 lakhs • 3-wheeler (5kWh)- Subsidy of Rs. 10000 per kWh capped at Rs. 5 lakhs • 4-wheeler (15kWh)- Subsidy of Rs. 10000 per kWh capped at Rs. 15 lakhs • Commercial public EV charging stations for 2 wheel ers, 3 wheelers, 4 wheelers will be eligiblefor 25 % c apital subsidy on equipment/machinery (limited up to Rs. 10 lakhs per station) for the first 250 commercial public EV charging stations.[20]
7	CNG Sahbhagi Yojana	To increase the number of PNG users to 18 lakhs from the current 13.5 lakhs, the government has reduced the amount of the lump deposit to 1,000 for families with an annual income of 2 lakhs and families with an annual income of more than 2 lakh rupees for cash, must deposit 5,000 rupees.[21]
8	Gujarat state water policy	Incentives should be given to those users who take actions for conservation of water. Incentives should be given for water charges for water being utilized for drip and sprinkler systems of irrigation and water for crops having lesser water requirements. Incentives should be given to those who pay

[19] https://www.nsws.gov.in/s3fs/2021-08/Gujarat%20Industrial%20Policy%202020.pdf
[20] https://pnt.gujarat.gov.in/Downloads/2021-06-23-GR-GujaratE-VehiclePolicy-2021.pdf
[21] https://sarkarireader.com/cng-sahbhagi-yojana-gujarat/

Sr. No.	Name of policy/ scheme	Provision of financial incentives/ subsidies
		the water charges regularly. If dues are not paid in time, then they shall be collected on the line of land revenue or in the manner prescribed in the relevant act.[22]
9	Suryashakti Kisan Yojana (SKY)	• 60 % subsidy on the cost of Projects will be given by the State and Central Governments, 35% of the Project cost will be provided to him through loan with the interest rates of 4.5% to 6% and remaining 5% of the Project cost will be borne by Farmers. The total duration of the Scheme is 25 years which is split between 7-year period and 18-year period. • As per the Scheme, the Farmers will get per unit rate of Rs 7 (Rs 3.5 by GUVNL + Rs 3.5 by State Govt.) for the first 7 years and succeeding 18 years, Farmers will get the rate of Rs 3.5 for each unit sold. Total 12,400 Farmers of 33 Districts will be beneficial under this Scheme SKY.[23]

4.2 Instruments for low-cost climate finance

There are several instruments that are already in existence at the global and regional/domestic levels, operating through the widely recognised concepts of concessional and blended financing, including de-risking. Several of these instruments include equity funds, bonds, risk-sharing facility, first-loss capital, outcome-based sustainability-linked loans/bonds, structured funds, etc.[24]

Grants

Grants are generally mobilised through established funds or through bilateral or multilateral agreements and do not place any financial burden on the recipients. They are generally awarded to finance or reimburse activities that meet the recipient government's priorities and objectives at that time. The Adaptation Fund Board has so far allocated USD 998 million to 139 adaption projects. Further, several developed countries also provide grant support for climate action projects. The recent commitment by the Swedish International Development Cooperation Agency (Sida) and the Food and Agriculture Organization in Iraq (USD 10.2 million for climate resilience of vulnerable agriculture households) is illustrative9. Similarly,

[22] https://guj-nwrws.gujarat.gov.in/downloads/draft_state_water_policy_eng_2015.pdf
[23] https://www.gprd.in/sky.php
[24] Adapted from Input Paper on "Mechanisms for mobilisation of timely and adequate resources for climate finance" prepared for G20 Presidency of India 2023, available at https://g20sfwg.org/wp-content/uploads/2023/04/Mechanisms-for-mobilisation-of-timely-and-adequate-resources-for-climate-finance-G20-Presidency-of-India.pdf

another is Egypt's programme on Nexus of Food, Water and Energy (NFWE) in which the European Bank for Reconstruction and Development (EBRD) is Egypt's lead partner. Apart from its lead role, the EBRD has committed US$ 1 billion in private renewable finance, US$ 300 million in sovereign finance and grants of US$ 3 million from its Shareholder Special Fund.

Concessional finance

It is finance at below-market-rate provided by developed countries, and institutions, such as development banks and multilateral funds, to developing countries to fast-track development objectives, including climate actions. Concessional finance leverage the limited pools of public sector funding to attract the much larger private sector funds. It includes a range of products such as loans with interest rate below the conventional market rates, grants and, to some extent, equity investments. The Climate Investment Funds (CIF) is a case in point. This is a multilateral fund working with the multilateral development banks that deploys concessional finance for climate action projects. Climate Investment Funds has, so far, mobilized finance for more than 375 projects in 72 countries and has pledged USD 11.1 billion as climate finance11. For example, the Mocuba Solar project in Mozambique was supported by a USD 55 million financing package from IFC. By blending CIF financing from two CIF windows – USD 9 million from the Clean Technology Fund and USD 10 million from the Pilot Program for Climate Resilience – with its own commercial funds and mobilized funds from private sector lenders, IFC is helping to diversify and decentralize Mozambique's energy system. Blended concessional finance helped the sponsor offer affordable tariffs to consumers.

Equity Funds

Investment in the equity securities (i.e. shares) of firms/companies expected to benefit from the transition to a low-carbon environment or driving the reduction of greenhouse gases and/or adaptation to climate change, or which are in the process of making their business models more resilient to the long-term climate risks - provides direct capital to such firms. Equity funds created by the MDBs signal the due diligence on projects done by the MDBs, thereby reducing information asymmetries for private investors and creating an enabling environment for the latter.

Collective Investment Vehicle Structured Funds

Structured funds are multi-tiered equity funds with a waterfall equity structure. Structured funds consist of three-tier equity investments. MDBs can provide specialised structured funds to support Emerging markets and developing countries to meet the target specified in the respective country's NDCs and Long Term Strategies (LTS). These funds allow MDBs to multiply the investment amount by attracting private investors for projects and policy implementations towards NDCs and LTS by a country, duly establishing performance evaluation from time to time either under UNFCCC stock takes or any other convenient method.

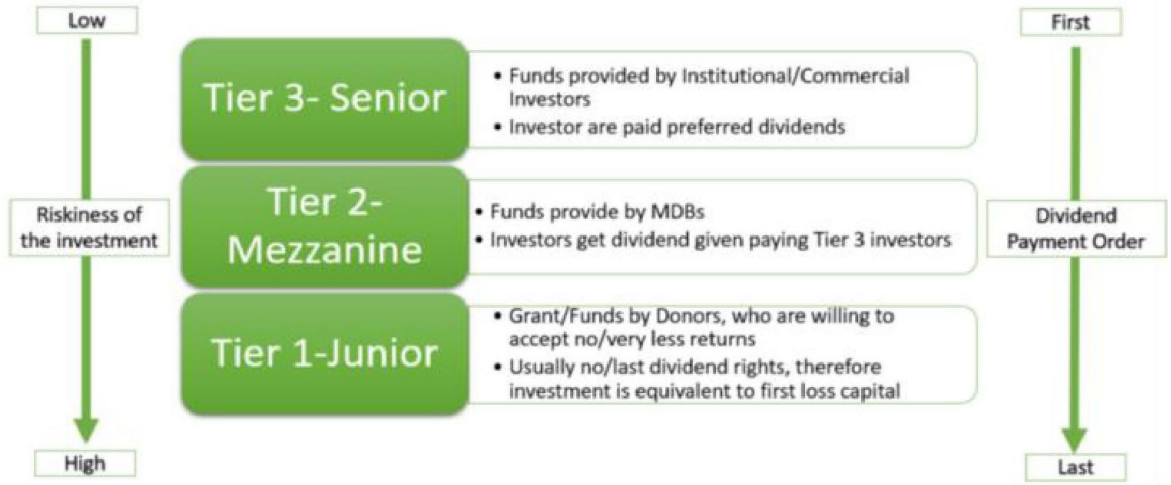

Figure 14. Utilizing Structured Fund for climate finance

First Loss Capital

MDBs can provide initial first-loss capital in the form of junior debt/grant/equity by creating a waterfall structure. In this instrument, funds supplied by private investors will be accorded the status of the senior-most debt – they are paid first in the event of default. First loss capital primarily acts as a catalyst to crowd-in private investment by improving the project risk profile and reducing technological and political risks. The presence of MDBs reduces information asymmetry for private investors based on the expected due diligence by the MDBs providing first-loss capital. This mechanism is particularly useful in facilitating funding for new technologies.

Outcome-based Sustainability Linked Loans/Bonds

These are loans where interest rates are linked to achieving pre-decided measurable intermediate targets or outcomes. Initially, loans are offered at higher rates. However, on achievement of the pre-decided outcomes, rebates on interest rates are offered, thereby reducing the cost of financing. MDBs can provide outcome-based sustainability-linked loans to incentivise investment in green and sustainable projects. These instruments are still nascent in emerging markets, representing only 5 per cent of total issuance (more than USD 809 billion) until December 2021.]

Syndicated Loans (Co-financing)

Syndicated loans allow for spreading the risk over multiple lenders. Co-financing will enable borrowers to access more considerable capital for a longer tenor. Usually, one of the lenders acts as a lead banker in the group of lenders and negotiates the contract terms with the borrower. There can be multiple modes of syndicate formation. Multiple MDBs can provide a syndicated facility or with the private investor(s) and other development finance institutions (DFI), or Multiple MDBs can form a syndicate with the private investor(s). Governments can also act as a co-financer in such loans, thereby adding to the confidence of private investors.

Guarantees

Governments and MDBs can also play the role of a guarantor by agreeing to bear the partial or total loss in the event of default, loss of value, or any other occasion. Guarantees will reduce the default risk for private investors, allowing them to charge a lower interest rate. MDBs need to disburse funds only in the event of default by the borrowing entity. By carefully building a basket of projects using a robust actuarial analysis, MDBs can guarantee projects worth significantly more than the provision kept for guarantee. Guarantees can take forms such as partial credit guarantees, partial risk guarantees, political risk guarantees, private equity fund guarantees and project-based guarantees.

Securitisation

MDBs can use securitisation for financing climate action in two ways. First, MDBs can facilitate the creation of a special vehicle to purchase green loans, create tranches and issue asset-based securities in the capital market. Second, MDBs can sell their portfolio of green loans to third-party SPV and redeploy the capital to fund new projects. MDBs should play the role of facilitators in identifying worthy assets for securitisation by leveraging their expertise and experience in project funding, which is difficult for private investors. Securitisation reduces costs and risks for the initial originator of green loans, allowing them to provide low-cost climate financing.

Low Carbon Investment Trusts (LCITs)

The risk profile of green infrastructure projects differs during the construction and operation phases. Projects are generally riskier during the construction phase compared to the operation phase when revenue streams are stable and visible. Initial investment should come from less risk-averse investors. These Investment Trusts offer an exit mechanism to initial investors and an entry mechanism to investors willing to take lesser risks during the operation phase, significantly reducing risks faced by initial investors. Therefore, the opportunity to exit later will allow initial investors to charge less interest due to lower risks associated with long-tenor debt and refinancing risk.

MDBs can sponsor LCITs by deploying their initial capital and taking over operational green assets. LCITs can raise equity capital from other investors by selling units in an IPO for purchasing assets and leverage equity capital to raise debt from investors such as insurance funds, pension funds, debt mutual funds etc. Like shares, units are traded on stock exchanges, and unit holders get regular dividends, allowing even MDBs to recover their capital from investing in new projects. MDBs can later exit the trust by selling their stakes to private investors.

Bonds

- ***Green bonds*** - Green bonds are financial instruments that fund projects aligned with environmental and climate objectives while providing investors with regular or fixed-income payments. The proceeds are exclusively applied to green projects, assets, and expenditures, aligned with the four core components of the Green Bond Principles (use of proceeds; process for project evaluation and selection; management of proceeds; and reporting). Green bonds can help attract investors who primarily look to invest in low-carbon and sustainable infrastructure projects, thereby taking advantage of possible

'greenium'. MDBs can raise funds from the market through Green Bonds using their top-notch credit ratings.

- ***Putable bonds*** - In climate financing, putable bonds can be designed so bondholders can exercise the option if borrowers do not invest in green projects. These bonds will address the risk of green washing. At the same time, borrowers who invest in green projects will not have to worry as the put option will not be exercised, and they can access the finances at a lower rate.
- ***Convertible bonds*** - Convertible bonds allow bondholders to convert debt into common equity at an exchange price defined in the bond covenant. This option will enable borrowers to issue bonds at a lower coupon rate than option-free bonds. The intention to finance green projects with convertible bonds would signal the firms' growth potential and help improve the project's risk profile. Convertible bonds are especially useful in supporting projects based on nascent and unproven technology in emerging and developing countries, thereby managing project risk and technology risk. MDBs can create specialised debt funds by pooling funds from other MDBs and private investors to invest in green/sustainable convertible bonds.

Green Loan

A green loan enables borrowers to use the proceeds to fund climate action projects including from governments or through multilateral institutions as per the green loan principles. Considering the higher transaction costs of bond issuance, the requirement of a minimum bond size to be tradable, and the fact that only bonds above a specific size are tracked by various indices, potential issuers in emerging markets with small green portfolios may consider receiving a green loan instead of issuing a green bond.

Risk Sharing Facility

In this facility, MDBs do not directly invest in green projects but support local financial institutions in de-risking their investments to fund local projects by providing irrevocable and unconditional obligations to bear or share the loss. Support from MDBs can be in the form of co-financing or guarantee, as per the requirements of the local financial institutions. MDBs can provide additional paid-in capital to local financial institutions to increase their borrowing capacity, with the mandate to leverage and utilise additional capital to fund green projects. This allows local financial institutions to manage liquidity and capital constraints. Risk sharing facilities can also more broadly target non-project specific risks (such as currency, political and off-taker risks). This facility can provide long-term finance to small and medium enterprises (SMEs) for undertaking green projects.

Besides underwriting risk for local financial institutions in specific countries, another method of de-risking involves the pooling together of risks across both projects and countries. Such an approach offers the benefits of scale and diversification and thereby helps lower the cost of de-risking.

Insurance and Re-insurance mechanism

To cover and diversify various climate change risks, MDBs can design insurance products in consultation with local insurance agencies. With the local insurance agency providing insurance to investors and lenders of particular green and climate-resilient projects, MDBs

can facilitate the re-insurance of insurance offered by local insurance by giving a second-loss guarantee to the global re-insurance agencies, who are capable of further diversifying the risk. This would increase the capacity of the local insurance agencies, providing funds at a low cost for a longer tenure. Further, given that different countries are characterised by varying levels of vulnerability to climate shocks, mechanisms that pool together and mitigate climate risks across countries could help lower risk curves for each country. This mechanism can be helpful to countries where risk perception due to political instability and project execution capability is higher.

Credit Default Swaps (CDS)

There are other examples of instruments which can mobilise resources with de-risking components. One such example is Credit Default Swaps which have not been specifically used for climate action but can be utilised for the purpose. In this mechanism, private investors provide debt funding to green projects through loans or bonds. However, to reduce default and political risks, MDBs can purchase CDS on behalf of private investors from international CDS sellers by deploying funds provisioned for grants. Thus, private investors are incentivised to provide debt-based climate financing at a lower rate. Buying CDS for private investors secures them from default risk, thereby incentivising private finance flows into the projects.

5. Way Forward

5.1 Existing Policies and Programmes

Mentioned below are policies and programmes that hold great mitigation potential; however, their potential has not been mapped yet due to their newer presence. There should be increased focus upon these emission reduction strategies in the future:

- **National Mission on Transformative Mobility and Battery Energy Storage (2019)**

  There should be increased focus to streamline the approval processes for setting up charging infrastructure and battery manufacturing facilities and a push to develop a training program that cover areas such as EV manufacturing, battery technology, charging infrastructure management, and EV maintenance and repair.

  Best practices: India's first Battery Storage and Solar Power based 'Suryagram' - "Modhera" has been set up in Gujarat itself, with Round the Clock Renewable Power Supply. It is India's first village to be (i) Powered by MWh scale Battery Storage; (ii) Have solar based EV charging stations; (iii) Net electricity production with solar rooftops on all feasible household & Govt buildings, generating renewable energy higher than consumption, thus greening grid & paying villagers.[25]

- **Methanol Economy Programme (2021)**

  NITI Aayog's 'Methanol Economy' programme is aimed at reducing India's oil import bill, greenhouse gas (GHG) emissions, and converting coal reserves and municipal solid waste into methanol. Methanol is a low carbon, hydrogen carrier fuel produced from high ash coal, agricultural residue, CO2 from thermal power plants and natural gas. Blending of 15% methanol in gasoline can result in at least 15% reduction in the import of gasoline/crude oil. In addition, this would bring down GHG emissions by 20% in terms of particulate matter, NOx, and SOx, thereby improving the urban air quality. India is producing all its methanol from imported natural gas, it must use coal for methanol production which is expected to make it economically viable to produce methanol in India.[26]

  Best practices: World's first commercial-scale CO2-to-methanol plant started production in Henan Province in China.[27] It creates methanol fuel from carbon captured during lime production and hydrogen recovered from coke-ovens. The methanol produced is used as a vehicle fuel in blends ranging from five percent to 100 percent ('M5' to 'M100'), with a view to encouraging the take-up of entirely methanol-powered vehicles.

[25] https://pib.gov.in/PressReleasePage.aspx?PRID=1885147
[26] https://www.niti.gov.in/sites/default/files/energy/Indias-Leapfrog-to-Methanol-Economy.pdf
[27] https://www.ief.org/news/heres-why-china-is-betting-big-on-methanol

- **PLI Scheme for National Programme on Advanced Chemistry Cell (ACC) Battery Storage (2022)**

  There should be increased support towards the development of a robust and sustainable supply chain for ACC battery manufacturing. This can be achieved by encouraging the localization of critical raw materials, such as lithium, cobalt, and nickel, by providing incentives to domestic suppliers. It is important to promote the establishment of battery component manufacturing units and recycling facilities to ensure a consistent and environmentally friendly supply chain. Finally, a robust monitoring and evaluation mechanism should be established to track the progress and impact of the PLI scheme.

  Best Practices: As of December 2020, the majority of U.S. large-scale battery storage systems were built as standalone facilities, i.e., they were not located at sites that generate power from natural resources. 30% of the total capacity to generate power from large-scale battery storage sites was co-located specifically with generation from renewable resources, such as wind or solar PV. These co-located projects offer an arbitrage application, which allows common on-site infrastructure to store renewable-generated energy produced during periods of low electricity prices and low demand. Solar generators can particularly benefit from battery storage because of their relatively predictable generation patterns.[28]

- **2030 Roadmap for Carbon Capture Utilization and Storage (CCUS) for Upstream E&P Companies:**

  The CCUS roadmap for Gujarat state should be developed aligned with the national programme or policy. It should incorporate CCUS implementation and progress into E&P companies' ESG strategies and reporting. It should encourage companies to disclose their CCUS initiatives, emissions reduction targets, and progress in their annual sustainability reports. It can foster partnerships that facilitate the exchange of knowledge, expertise, and best practices in CCUS implementation.

  Best Practices: As part of its commitment towards Net Zero by 2070, NTPC Ltd, has captured its first CO2 on 15th August 2022 from flue gas stream of 500 MW coal-based power plant at Vindhyachal Super Thermal Power Station (VSTPS). The plant is designed to capture 20 tonnes of CO2 every day. This initiative will pave the way for scaling up CO2 capture technology and greening the coal power generation.[29]

5.2 Intended Plan for New Policies and Programmes

Integration of technologies like solar photovoltaic, biogas, etc., has contributed greatly towards realizing low GHG emission targets. Mentioned below are upcoming technologies across various sectors and their best practices which should be included in framing new policies and programmes to accelerate the GHG emissions mitigation in the state.

[28] https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage_2021.pdf

[29] https://www.business-standard.com/article/companies/ntpc-starts-capturing-co2-from-flue-gas-stream-at-vindhyachal-plant-122081900642_1.html

- **Urban Vertical Farming**

  Traditional horizontal farming is resource intensive and consumes a lot of water, pesticides, and fertilizers. Moreover, urban areas are becoming food deserts due to growing population and unavailability of farms nearby. Thus, vertical farming through measures tools like hydroponics and aquaponics are a sustainable and long-term solution to tackling resource scarcity, food security and can reduce Indian agriculture's water usage significantly. Currently the National Horticulture Board offers 20-25% credit linked subsidy for vertical farming projects across India.[30]

  Best Practices: Singapore has been releasing tenders to convert its government building rooftops to urban farm landscapes since 2021. This has been done to increase the country's food security and self-reliance by contributing to their ambitious "30 by 30" initiative of producing 30 percent of Singapore's nutritional needs locally by the year 2030.[31]

- **Fuel Cell Electric Vehicles**

  A Hydrogen fuel cell vehicle (HFCEV) is powered by hydrogen and just water vapor and warm air come out as emissions from the vehicle. Energy is stored as hydrogen and is converted to electricity by a fuel cell. It is especially useful for long haul trucks and buses as it takes up less space than a traditional EV propulsion system does. As green hydrogen can be produced from renewable energy and abundant biomass, the adoption and deployment of technologies that unlock the potential of green hydrogen will play a major role in ensuring that there is clean and affordable energy in future of India.

  Toyota along with government's testing agency International Centre for Automotive Technology to study FCEVs for Indian roads and climatic conditions[32]. NTPC has invited Global Expression of Interest to provide 10 Hydrogen Fuel Cell (FC) based electric buses[33].

  Best Practices: US is in the lead for usage of FCEVs with around 15000 hydrogen powered cars on the street and a goal of almost 100 refuelling stations.

- **Lab Grown Diamonds (LGD)**

  The world's largest diamond mines have matured and are past their peak production levels, and several of the largest diamond mines are expected to close by the end of 2025. As these mines are depleted, global production is expected to decline in quantity. LGD are manufactured in laboratories, as opposed to naturally occurring diamonds. However, the chemical composition and other physical and optical properties of the two are the same. However, the environmental footprint of a diamond grown in a laboratory is much lesser than that of a naturally occurring diamond. Globally, the market stood at $1 billion in 2020, the lab-grown diamond jewellery market is expected to rapidly rise to $ 5 billion by 2025 and exceed $ 15 billion by 2035. The 2023 Union Budget aimed to reduce the basic customs duty on seeds used in the manufacture of lab-grown diamonds in a bid to

[30] https://nhb.gov.in/schemes/subsidy-claim-guidelines.html
[31]https://www.straitstimes.com/singapore/tenders-awarded-to-turn-9-hdb-carpark-rooftops-into-urban-farming-sites
[32] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1806563
[33] https://www.pib.gov.in/PressReleasePage.aspx?PRID=1618378

popularise their production in India, the duty on seeds for rough LGDs will be reduced from 5% to nil.

Best Practices: Between six and seven million carats of lab-grown diamonds were produced worldwide in 2020. Of that amount, China manufactured between 50 and 60 percent, using mainly the high-pressure, high-temperature technology.

- **AI Integration**

  Predictive AI can forecast future carbon emissions based on current data on carbon footprint. AI tools and data optimization techniques can improve efficiency in production, transportation, etc. thereby reducing carbon emissions and cutting costs. AI applications could also help design more energy-efficient buildings, improve power storage and optimize renewable energy deployment by feeding solar and wind power into the electricity grid as needed. From electricity grids to smart appliances, data and AI-driven software can be integral to predicting market behaviour, balancing operations in real-time, and maximizing energy yield.

  Best Practices: Several solar plants in Europe use computers to better analyze data from a large number of neighboring PV systems to help quantify their short- and long-term performance. These machine-learning methods are used to overcome data-quality issues affecting individual plants.

5.3 Prioritizing Policies and Following Best Practices for Decarbonizing Key Industry Sectors

Gujarat is home to a diverse range of industries that contribute significantly to its economic growth. Listed below[34] are some key industries within Gujarat and some low carbon suggestion to align them with climate change mitigation and adaptation goals towards decarbonising Gujarat towards Net Zero 2070.

5.3.1 Prioritizing Policies for Decarbonising Industry and Businesses

- **Bio-CNG and Electric Vehicles**

  EVs have garnered tremendous support from central as well as state government. It is important to keep this momentum going through proper subsidy schemes, adequate charging infrastructure and usage of renewable energy to power EVs. Moreover, proper utilisation of urban, industrial, and agricultural waste should take place to promote production of Bio-CNG to use as fuel for CNG vehicles.

- **Biomass Briquettes or Pellets as a substitute for Coal**

  These are made from a variety of biomass, including husks, shells, bagasse, and agricultural and municipal solid waste depending upon availability. The raw material is compressed into briquettes for ease of burning and transportation. Biomass briquettes have mostly been used as cooking fuel in developing countries due to their low cost and easy availability in rural areas. Biomass briquettes have also found use as biofuel which is co-fired with coal for electricity generation in thermal power plants. Their use in coal firing should significantly increase to lower carbon emissions and renewability.

[34] https://www.gidb.org/Document/2022-5-14_439.pdf

- **Offshore Wind Power**

  Assessment by NIWE identifies the state's 1,600 km long coastline offering a potential of 36 GW of offshore wind energy potential. Onshore wind projects in Gujarat have helped the state in reducing its carbon footprint, promoting clean energy, and achieving its renewable energy goals. Gujarat has moved to the second spot with a total capacity of 18,867 MW. However, Offshore wind projects are also important for diversification of energy assets so that a region is not entirely reliant on one source of energy.

- **Green/Blue Hydrogen and Ammonia**

  Green hydrogen and ammonia is produced using renewable energy sources, contributing to decarbonization efforts and has the potential to provide a long-term energy storage solution for intermittent renewable energy sources like solar and wind. Blue hydrogen can leverage existing natural gas infrastructure, making it potentially easier to implement at scale. It reduces CO2 emissions compared to traditional hydrogen production methods. Both green and blue hydrogen play a role in the transition to a low-carbon economy, with green hydrogen being the ultimate goal due to its renewable and zero-emission nature. However, blue hydrogen can serve as a steppingstone to reduce emissions in the interim while the infrastructure for green hydrogen develops. Green hydrogen requires significant investment in infrastructure and technology. Green ammonia is a more mature technology that can be implemented quickly with a lower initial cost than green hydrogen production.

- **Metal Scrap Recycling**

  Recycling has numerous business advantages in addition to the environmental advantages- saves energy, keeps waste out of landfills and incinerators, and provides raw materials for new product manufacturing. Adequate government support in the form of simplified policies and regulations can provide a boost to these environmentally conscious organisations. It is cutting-edge, cost-effective, promising, and profitable.

- **Increasing Energy Efficiency and Integrating RE in MSMEs**

  MSMEs play a crucial role in economic development and employment generation. However, they often face challenges related to high energy costs and limited access to reliable electricity. By embracing renewable energy solutions, MSMEs can mitigate these challenges and create a more sustainable and competitive business environment. This integration offers several benefits, including cost savings, reduced reliance on fossil fuels, environmental sustainability, and enhanced energy security. A decentralised RE setup can help small industries save electricity costs and become self-sufficient.

- **Developing Battery Energy Storage Systems (BESS)**

  In order to utilize the full potential of renewable energy sources there needs to be in place an efficient BESS to ensure the generated energy is not wasted. It can also ensure grid stability whilst enabling higher renewable energy integration. However, energy storage solutions can be an expensive investment and hence need sufficient policy incentives and market push.

- **CO_2 capture, utilization, and storage (CCUS) policy at State level**- CCUS policy is a critical component of efforts to mitigate climate change, as it enables the capture and storage of large amounts of CO2 emissions from industrial processes and power generation. With the right policies in place, CCUS can play an important role in reducing

greenhouse gas emissions and promoting the transition to a low-carbon economy with quick adaptation results to climate change.

- **Application of Nano Urea**

  Nano Urea is produced by an energy efficient environmentally friendly production process with less carbon footprints. Its availability to crop i.e. more than 80% can result in higher nutrient use efficiency. Nano urea liquid will increase the production of crops with improved nutritional quality. Cheaper than conventional urea, it is also expected to reduce the environmental pollution caused by the granular form, by reducing its excessive application that exacerbates soil, water, and air pollution with climate change problems.

- **Efficient Waste Management**

  Waste needs to be recognised for its tremendous worth. Wastewater is and should be considered a valuable resource from which water can be recycled and energy/nutrients can be extracted. Solid waste and its several uses such as energy generation and biofuels production should be given focus. Moreover, e-waste and its proper management needs to be prioritised for resource recovery. Efficient waste management is a key step in achieving a circular economy.

5.3.2 Following Best Practices for Decarbonizing Key Industry Sectors

Petrochemicals and Chemicals

Background: Gujarat is known as the "Petrochemical Capital of India" due to its thriving petrochemical and chemical industry. Major industrial clusters like Vadodara, Ankleshwar, and Dahej have attracted national and international investment in this sector[35]. Gujarat is leading the way with a turnover of US$ 31.5 Billion, in the Chemical Industry and US$ 50.8 Billion, in the Coke & Petroleum Industry.[36] Some major companies in the sector are Reliance Industries, ONGC, GPSC, Shell, TATA Chemicals ltd., OPAL, etc.

GHG Emissions: CO_2, NO_2

Limitations and Suggestions: It is a significant contributor to greenhouse gas emissions and air pollution and minimizing the environmental impact of chemical waste and by-products. Industries can adopt cleaner production techniques and promote the use of renewable energy sources and reducing reliance on fossil fuels can help in decarbonizing the industry. Implementing proper waste management and recycling practices can also minimize the environmental footprint.

Best Practices: BASF Chemicals in Belgium have set up an offshore wind farm to power their biggest chemical production plant. Due to this development, BASF is able to apply innovative, emission-free technologies at several production sites all over Europe.

[35] https://www.investindia.gov.in
[36] https://www.vibrantgujarat.com/assets/img/Sectors/Chemicals-Petrochemicals.pdf

Textiles and Apparel

Background: Gujarat has a strong presence in the textiles and apparel industry. The state is a major hub for cotton production and textile manufacturing, with cities like Ahmedabad, Surat, and Vadodara being major textile centers. The industry encompasses textile mills, garment manufacturing units, textile processing, and printing industries. The sector contributes to around 3% of the country's GDP.

GHG Emissions: CO_2

Limitations and Suggestions: The textiles and apparel industry faces challenges in reducing its carbon footprint and addressing water consumption and pollution. The industry is resource-intensive and contributes to water scarcity and pollution through dyeing and finishing processes. Emphasizing sustainable practices in the supply chain, such as using organic and recycled fibers, reducing water consumption, and implementing eco-friendly dyeing and finishing processes, can contribute to climate change mitigation.

Best Practices: H&M started its old cloth collection and recycling initiative in 2017. Since then 24% of the materials used in their products have been recycled and the aim is to reach 30% by 2025.[37]

Engineering and Automobiles

Background: Gujarat has emerged as a significant manufacturing base for engineering and automobile industries as it houses major automobile manufacturing plants and ancillary units. Companies like Tata Motors, Maruti Suzuki, Ford, and Honda have established their manufacturing facilities in Gujarat. The engineering industry includes machinery manufacturing, metal fabrication, and heavy equipment production.

GHG Emissions: CO_2

Limitations and Suggestions: The industry relies heavily on fossil fuels and emits significant greenhouse gases. Adapting to electric vehicles (EVs) and investing in the infrastructure required for EV charging stations present challenges in terms of technological advancements, market demand, and the need for supportive policies and incentives. Encouraging the development and adoption of electric vehicles (EVs) can significantly reduce carbon emissions. Investing in research and development of alternative fuels and lightweight materials can also make vehicles more energy efficient. Additionally, implementing energy management systems and adopting renewable energy sources in manufacturing facilities can help reduce greenhouse gas emissions.

Best Practices: Readily available charging infrastructure in public places and battery swapping stations need to be set up to further incentivize the usage of EVs. Currently, such policies have seen tremendous success in North America with through different service models like subscription model and pay per use model.

[37] https://hmgroup.com/sustainability/circularity-and-climate/recycling/

Gems and Jewelry

Background: Gujarat is a leading hub for the gems and jewellery industry in India. Cities like Surat and Ahmedabad are known for diamond cutting, polishing, and jewellery manufacturing. The state contributes significantly to India's exports in this sector and has a strong presence in both domestic and international markets[38]. More than 450 organised jewellery manufacturers, importers & exporters are based in Surat city of Gujarat, making it the jewellery manufacturing hub of the world. Gems and Jewellery industry contributes about 7% of India's total GDP & employs the largest skilled and semi-skilled workforce of more than 50 lakh workers.

GHG Emissions: CO2

Limitations and Suggestions: The industry relies on mining for precious stones, which can have adverse environmental and social impacts. Moreover, processing of gems requires great energy utilisation and a formal machinery setup. Promoting transparency and traceability in the supply chain, particularly for diamonds and other precious stones, can help ensure ethical and sustainable sourcing. Usage of cleaner fuels and energy sources while manufacturing gems can mitigate the sector's emissions efficiently.

Best Practices: Surat Diamond Bourse uses radiant cooling system and sustainable architecture to accelerate the diamond sector of Gujarat.

Pharmaceuticals

Background: Gujarat has a well-developed pharmaceutical industry, with several large and small-scale pharmaceutical companies operating in the state. The industry encompasses the production of generic drugs, formulations, APIs (Active Pharmaceutical Ingredients), and contract manufacturing.[39] Ahmedabad, Vadodara, and Ankleshwar are major pharmaceutical manufacturing centres. Gujarat has over 3,300 pharmaceutical manufacturing units, which contributed 30-35% to India's pharma sector's turnover and around 28% to India's pharma export during 2018-19.

GHG Emissions: CO_2

Limitations and Suggestions: The industry leads to environmental degradation through chemical usage and excessive energy utilisation due to cold storage needs. **E**mphasizing on green chemistry practices, including the reduction of waste and the use of environmentally friendly solvents, can contribute to sustainability. Promoting responsible waste management and proper disposal of pharmaceutical residues can also minimize the industry's impact on the environment.

Best Practices: Continuous manufacturing of pharmaceuticals as practiced abundantly in the US, helps firms eliminate hold times and utilize the full capacity of their manufacturing lines which makes manufacturing much more energy efficient.

[38] https://gujaratindia.gov.in/business/major-indus.htm
[39] https://www.vibrantgujarat.com/home#InvestInGujarat

Agro and Food Processing

Background: Gujarat has a thriving agro and food processing industry due to its rich agricultural resources. The state produces a variety of crops and is a major player in sectors such as dairy processing, fruit and vegetable processing, grain milling, and oilseeds processing. Companies like Amul, PepsiCo, and Adani Wilmar have significant operations in Gujarat. The state produces a variety of crops and is a major player in sectors such as dairy processing, fruit and vegetable processing, grain milling, and oilseeds processing. Gujarat has more than 30,000 Companies in the Food Processing sector. Gujarat's share in the total processed foods & dairy products exported from India increased from 22% in 2012-13 to 28.62% in 2018-19.

GHG Emissions: CO_2, CH_4

Limitations and Suggestions: It is a highly water intensive and energy intensive industry due its need for packaging and storage facilities. The industry needs to adapt to climate variability, adopt sustainable farming practices, and ensure food security while minimizing water consumption and waste throughout the supply chain.

Best Practices: Decentralised small energy grids can be utilised in rural agro-processing industries to make them self-reliant and promote their growth as done abundantly to promote small agro industries in Greece.

5.4 Policies to be Targeted for Short Term and Medium Term

The short term policy suggestions are those which should be prioritized in the next 3-5 years due to their high growth potential in the near future while medium term policy suggestions mention areas which should be targeted in the nest 5-10 years for contributing towards India's Net Zero targets.

Expanding PAT Scheme across Various Sectors

- **Sectoral Coverage-** Industry
- **GHG Emission-** CO_2, CH_4
- **Description-** Expanding the PAT scheme to achieve net-zero goals would involve setting more ambitious energy efficiency targets for current industries covered and incentivizing them to adopt more sustainable practices. The scheme can also be expanded to include other sectors such as commercial buildings (institutions, hospitals, retail, etc.), transportation, and agriculture, which are major sources of greenhouse gas emissions. The scheme can be extended to include medium and small-scale industries, as they also contribute to energy consumption and emissions. It can also be used to speed up Green Hydrogen and Green Ammonia production. It would also require the development of a robust monitoring and evaluation framework to track progress and ensure accountability.
- **Limitations and Suggestions-** Accurate monitoring and verification of energy consumption and emissions are crucial for the success of the PAT scheme. However, the current limitations in data collection, measurement, and reporting systems can hinder the effectiveness of the scheme. To overcome this challenge, investments can be made in

improving data infrastructure, establishing standardized measurement methodologies, and promoting the use of advanced monitoring technologies.

- **Best Practices-** Expansion of Chlor Alkali industry by increasing it designated consumers (DCs) can increase the production of hydrogen as a clean fuel alternative within the industry[40]. Expanding PAT to include Gujarat centric industries like brass, ceramic, dairy, etc., can help streamline and incentivize low carbon practices within these industries.

Bio-Pellets and Bio-Briquettes in MSMEs

- **Sectoral Coverage-** Renewable Energy, Sanitation
- **GHG Emission-** CO_2, CH_4
- **Description**- Bio-pellets and bio-briquettes are great substitutes for coal in MSMEs and can help achieve some decentralisation of power generation especially in rural MSMEs where agricultural waste is made into bio-pellets. These can further be used for electricity generation and reduce costs whilst promoting a circular economy. It is a cost-effective energy solution that aligns with environmental goals and can contribute to sustainability and competitiveness of businesses.
- **Limitations and Suggestions-** Bio-pellets or bio-briquettes generally have a lower energy density, to overcome this limitation, advancements in pelletization technology can focus on improving the energy density of pellets. The combustion of bio-pellets produces ash, nitrogen oxides (NOx), sulfur dioxide (SO2), and volatile organic compounds (VOCs). Hence, it is important to use high-quality pellets with low moisture content and controlled ash content.
- **Best Practices-** The UK incentivized biomass cofiring by issuing Renewable Obligation Credits (ROCs), i.e., the UK's version of Renewable Energy Credits (RECs) as present in India. With the introduction of ROCs, co-firing rates nearly doubled every year with an all-time high of 2964 GWh (Roni et al., 2017). Co-firing accounts for almost 6.45% of renewable electricity generation in the UK.

Green and Clean Charging Infrastructure for EVs

- **Sectoral Coverage**- Renewable Energy
- **GHG Emission**- CO_2
- **Description-** Electric vehicles will reach their full potential of greenhouse gas mitigation when they become powered through electricity generated by renewable power. Hence, to ensure maximum benefits of EVs more renewable energy needs to be integrated into the grid or at EV charging stations.
- **Limitations and Suggestions-** Possible unavailability of renewable energy due to any reason can cause challenges for EV users, hence, it is crucial to have smart charging solutions that optimize charging times based on grid conditions and renewable energy availability.

[40] https://beeindia.gov.in/sites/default/files/Chlor-Alkali-1-44.pdf

- **Best Practices-** ATUM Charge, a solar powered EV charging station company has set up 250 solar charging stations across India[41]. Such initiatives need to be identified by the government and incentivized through benefits to attract increased investments in renewable energy powered EV charging stations in Gujarat.

Waste Segregation and Waste to Energy Plants

- **Sectoral Coverage-** Renewable Energy, Sanitation
- **GHG Emission**- CH_4, CO_2
- **Description-** Proper waste segregation helps in efficient waste management by facilitating recycling, reducing the volume of waste going to landfills, and minimizing the negative impact of waste on the environment. Waste-to-energy (WtE) plants convert waste materials into usable energy, such as electricity, heat, or fuel. In order to utilize the full potential of power obtained through waste, efficient segregation is a key requirement. WtE technologies are becoming increasingly popular as they provide an alternative to traditional fossil fuels while also reducing the volume of waste going to landfills.
- **Limitations and Suggestions-** Variations in waste composition, moisture content, and calorific value can impact the energy recovery and overall performance of the plant. Waste management practices should prioritize waste sorting and recycling to maximize the recovery of valuable materials and ensure a consistent and suitable feedstock for energy generation. WtE plants can emit air greenhouse gases, particulate matter, and potentially hazardous substances. To mitigate these impacts, strict emission control regulations and monitoring systems should be implemented and enforced. Continuous R&D should focus on improving pollution control technologies and optimizing combustion processes.
- **Best Practices-** Only 1% of Sweden's trash is sent to landfills. 52% of their trash is burnt and converted into energy and the remaining 47% gets recycled. This energy generated from waste provides heating to one million homes and electricity to 250,000. Swedish government has implemented a series of effective policies aimed at reducing waste generation, raising awareness among manufacturers and citizens as well as drastically cutting emissions. Their Extended Producer Responsibility (EPR) policy makes producers responsible for handling all costs associated with the collection and disposal of their products. Moreover, Sweden also targeted households directly by applying a weight-based waste charge in a bid to incentivise recycling.[42]

[41] https://auto.economictimes.indiatimes.com/news/industry/atum-charge-installs-250-solar-power-charging-stations-in-india/90658000

[42] https://earth.org/sweden-waste-to-energy/

Zero Liquid Discharge in Large Cities

- **Sectoral Coverage-** Water and Sanitation
- **GHG Emission**- CH_4, CO_2
- **Description-** Zero Liquid Discharge Cities represent an innovative and sustainable approach to water management that could help cities to become more resilient and environmentally friendly. This approach helps to conserve water resources, reduce the strain on natural water sources, and prevent pollution of water bodies.
- **Limitations and Suggestions-** Implementing ZLD systems can be financially challenging due to the high upfront investment and operational costs. Financial incentives, government support, and public-private partnerships can help alleviate the financial burden and promote the adoption of ZLD in cities. Moreover, ZLD systems involve complex treatment processes and advanced technologies, requiring specialized knowledge and expertise for design, operation, and maintenance. Collaboration between researchers and industry professionals can drive technological advancements and knowledge sharing.
- **Best Practices-** Australia holds the world's largest coal seam gas-produced water treatment plant, i.e., Kenya Central Water Treatment Plant (CWTP)[43], which is a model example of maximising water resources while minimising environmental impact. The plant includes an RO system of five trains designed for a water recovery of 83-91% to meet stringent quality, recovery, and reliability requirements whilst being flexible enough to allow for varying feed water quality.

Usage of Package Sewage Treatment Plants in Rural Areas

- **Sectoral Coverage-** Water and Sanitation
- **GHG Emission**- CH_4, CO_2
- **Description-** Package sewage treatment plants are a cost-effective solution for rural communities or remote areas where conventional wastewater treatment systems may not be practical or cost-effective. These plants are designed to occupy a smaller footprint and require less capital investment making them an efficient and cost-effective solution for decentralized wastewater treatment.
- **Limitations and Suggestions-** PSTPs can consume significant energy for the treatment processes, including aeration, mixing, and sludge handling, hence, exploring renewable energy options, such as solar or wind power, for powering PSTPs can enhance their sustainability. PSTPs generate sludge as a byproduct of the treatment process, which needs to be properly managed. Thus, implementing effective sludge management strategies, such as sludge drying beds, sludge thickening, or anaerobic digestion, can facilitate its proper disposal or reuse.
- **Best Practices-** Changshu City in China works on a public private partnership model for collecting 4,192.4 tons of sewage per day. This helps the city achieve their Town and

[43] https://www.watertechonline.com/process-water/article/16201736/the-global-push-for-zero

Village Sewage Treatment Special Plan (2010-2030) involving 330 villages and 12,268 farmer households.[44]

Policy for Green Building Materials and Energy Positive Buildings

- **Sectoral coverage**- Building, Energy Efficiency
- **GHG emissions coverage**- CO_2, CH_4
- **Description-** Green building materials are sustainable, environmentally friendly, and resource-efficient, and are used in the construction, renovation, and retrofitting of buildings to minimize the environmental impact of the construction industry by reducing energy consumption, conserving natural resources, and minimizing waste generation. Moreover, these buildings can be energy positive by generating more energy than they consume and can offset the carbon emissions associated with their construction, operation, and maintenance, and even contribute clean energy to the grid.
- **Limitations/suggestions-** Such buildings might cost more and have limitations to their design flexibility. However, increased investment in manufacturing of green building materials will help decrease the cost curve and collaboration between architects and material manufacturers can lead to innovative designs that merge sustainability with aesthetics.
- **Best Practices-** Taiwan established the Green Building Material (GBM) Evaluation and Labelling System under their Building Technique Regulation Act. They ensured that all GBM were non-hazardous to the environment, non-toxic to human health, and be in accordance with the national specifications/standards.[45] Currently, about 75% of the building in Taiwan are labelled as healthy GBM occupied in the market.

5.5 Policies to be Targeted for Long Term

Long term policy should be prioritized in the next 10-15 years i.e. after 2035 due to their expected growth potential in the future years for achieving NZ 2070 target.

Nuclear Energy through Small Modular Reactors

- **Sectoral Coverage**- Renewable Energy
- **GHG emissions coverage**- CO_2
- **Description-** India is working on new technologies such as the small modular reactors that can be factory-built and help make clean energy transition. Small Modular Reactors (SMR), with up to 300 MW capacity by nature are flexible in design and require smaller footprint. Being mobile and agile technology, SMR can be factory-built unlike the conventional nuclear reactors that are built on–site. Thus, SMRs offers significant savings in cost and construction time. SMR is a promising technology in industrial de-carbonization especially where there is a requirement of reliable and continuous supply of

[44] https://www.adb.org/sites/default/files/publication/798661/adbi-case-study-2022-1.pdf

[45] https://mdpi-res.com/d_attachment/environments/environments-05-00004/article_deploy/environments-05-00004.pdf?version=1514438366

power.[46] India's current installed nuclear power capacity is 6780 MW and it plans to add 21 more atomic power generating units with a total installed capacity of 15,700 MW by 2031.

- **Limitations/Suggestions-** Financial and economic issues such as the perceived investment risk and availability of cheaper technologies to generate electricity are the main barriers for SMR construction. Government support for financing the first-of-a-kind and developing a supply chain could allow overcoming these barriers. Time, cost and risk of the licensing process are critical elements for SMR construction; therefore, policies should be in place to support stakeholders.[47]
- **Best Practices-** The IAEA has an initiative bringing together policy makers, regulators, designers, vendors, and operators to develop common regulatory and industrial approaches to SMRs called The Nuclear Harmonization and Standardization Initiative (NHSI). It aims to facilitate the safe and secure deployment of SMRs and other advanced nuclear technologies to maximize their contribution to achieving the goals of Agenda 2030 and the Paris Agreement.[48]

Green Hydrogen in Transport (FCEV) and Storage

- **Sectoral Coverage**- Renewable Energy
- **GHG Emission**- CO_2
- **Description**- Green Hydrogen production needs to be strengthened for various uses. However, key focus needs to be maintained on up-and-coming technologies like usage of GH2 for transportation in Fuel Cell Electric Vehicles and as a Battery Storage System.
- **Limitations and Suggestions**- The production of green hydrogen is currently more expensive compared to traditional fossil fuel-based hydrogen. To enhance its economic viability, efforts should be directed towards reducing the cost of electrolyzers, increasing their efficiency, and scaling up production. Hydrogen, in its gaseous form, presents safety considerations that need to be addressed for FCEVs and BESS applications. Safety standards, regulations, and best practices should be established and enforced for hydrogen production, storage, transportation, and usage.
- Best **Practices**- In developing an ecosystem for a hydrogen economy, South Korea is focused on increasing the production and use of hydrogen vehicles. The government's vision of "FCEV Vision 2030" is also to build 100 new hydrogen refuelling stations in South Korea by 2022. If South Korea's vision is successful, it expects hydrogen to account for 5% of its projected power consumption in 2040, to see its economy grow by 43 trillion won, 420,000 new jobs created, and significant reductions in both fine dust and greenhouse gas emission. (Stangarone, 2021)

[46] https://pib.gov.in/PressReleasePage.aspx?PRID=1879298

[47] https://read.oecd-ilibrary.org/nuclear-energy/small-modular-reactors_18fbb76c-en#page12

[48] https://www.iaea.org/newscenter/news/accelerating-smr-deployment-new-iaea-initiative-on-regulatory-and-industrial-harmonization#:~:text=The%20Nuclear%20Harmonization%20and%20Standardization,Agenda%202030%20and%20the%20Paris

Offshore Wind Power and Floating Offshore Wind Power

- **Sectoral Coverage**- Renewable Energy
- **GHG Emission**- CO_2
- **Description-** Offshore wind power policy can help drive the growth of the offshore wind industry, creating new jobs and economic opportunities while reducing reliance on fossil fuels and mitigating climate change. Floating offshore wind technology is still emerging, and its commercialization is in its early stages. The development of floating offshore wind farms can create new jobs whilst reducing GHG emissions for the state.
- **Limitations and Suggestions-** Offshore wind power plants require huge capital investments for their setup and maintenance; hence, they require tremendous policy as well as industry push through incentives to mitigate their costs. Moreover, they can also face transmission losses which can be tackled through efficient BESS technologies.
- **Best Practices-** The UK is the second largest offshore wind (OSW) market in the world. They set the ambition to achieve up to 50 gigawatts (GW) of offshore wind by 2030[49], including 5 GW from innovative floating technology. This ambition could support up to 90,000 direct and indirect jobs in the UK and is part of the investment required to meet the UK's net zero goal.

Low-Cost Battery Energy Storage Systems (BESS)

- **Sectoral Coverage-** Energy Efficiency, Industry
- **GHG Emission**- CO_2
- **Description-** Developing BESS requires significant investment, but it has the potential to provide many benefits, such as increasing the reliability and resilience of the electrical grid, reducing emissions, and enabling the integration of more renewable energy sources into the energy mix. With appropriate incentives, the development of BESS can accelerate the transition to a cleaner, more sustainable energy system.
- **Limitations and Suggestions**- The cost of battery energy storage systems can be significant, limiting their economic viability, hence, to promote cost-effective deployment, continued research and development are crucial to drive down the cost along with government incentives & subsidies to further incentivize the adoption of BESS. The production, use, and disposal of batteries have environmental implications, thus, proper recycling and disposal of batteries at the end of their lifecycle are essential to minimize environmental harm.
- **Best Practices**- The UK houses Europe's largest front-of-the-meter (FTM) battery energy storage system which can store up to 196 MWh of electricity in a single cycle**.** It is particularly effective when combined with solar or wind energy as energy storage mitigates the intermittent nature of these renewable sources and guarantees a steady supply of electricity. The BESS is also combined with software, which couples the energy storage capacity of batteries with the intelligence needed to deliver advanced

[49] https://www.great.gov.uk/international/content/investment/sectors/offshore-wind/#:~:text=The%20UK%20is%20the%20second,GW%20from%20innovative%20floating%20technology.

management of energy consumption by harnessing AI, Machine Learning and data-driven solutions.

5.6 Integration across various State Departments for Effective Implementation

Effective integration across various departments is crucial for any policy to be fully operative. Table 9 lists some policies, programmes or schemes and various departments of Government of Gujarat which should be integrated towards effective implementation of these policies leading towards decarbonisation. This requires efficient plan or strategy that lays down departmental integration roles effectively for the state. Moreover, suitable guidelines should also be maintained on policy related interaction and effective integration between the state and central government including Niti Aayog.

Table 9. Integration across various state departments for effective implementation of policies

Sr. No.	Name of Policy/ Scheme	GoG Department	Roles and Responsibility
1	Gujarat State Electric Vehicle Policy (2021)	Climate Change	Setting up charging stations and providing EV manufacturing and purchase incentives.
		Energy and Petro Chemicals	Supplying power to EV stations.
2	Gujarat Industrial Policy (2020)	Industries and Mines	Promoting industrial growth through fiscal incentives.
		Energy and Petro Chemicals	Supplying power to industries.
		Science & Technology	Promoting R&D
3	Surya Urja Rooftop Yojana (2019/2020)	Climate Change	Incentivizing solar usage for individual consumers.
		Urban Development & Urban Housing	Setting up regulations and their monitoring for solar panel usage in urban areas.
4	Suryashakti Kisan Yojana (2018)	Agriculture	Supply of solar energy for irrigation needs in farms.
		Social Justice and Empowerment	Help farmers navigate selling excess power.
		Climate Change	Setting up of solar panels in farms.
		Panchayat, Rural Housing & Rural Development	Setting up regulations and their monitoring for solar panel usage in rural areas.

Sr. No.	Name of Policy/ Scheme	GoG Department	Roles and Responsibility
5	Gujarat Wind-Solar Hybrid Policy (2018)	Climate Change	Incentivizing set up of wind and solar power stations.
		Science and Technology	R&D for adequate utilization of energy from these power stations.
6	Gujarat Solar Power Policy (2021)	Climate Change	Incentivizing set up of solar power panels and stations.
		Science and Technology	R&D for adequate utilization of energy from these power stations.
7	Gujarat Wind Power Policy	Climate Change	Incentivizing set up of wind power mills and stations.
		Science and Technology	R&D for adequate utilization of energy from these power stations.
9	National Green Hydrogen Mission (2023)	Climate Change	Incentivize the growth of GH2 production.
		Science and Technology	Find best solutions and cheapest ways to produce GH2.
		Energy and Petro-Chemicals	Analyze the various uses of GH2 and its application as energy source.
10	National Wind-Solar Hybrid Policy (2018)	Climate Change	Incentivizing set up of wind and solar power stations.
		Science and Technology	R&D for adequate utilization of energy from these power stations.
11	National Offshore Wind Energy Policy (2015)	Climate Change	Incentivizing set up of offshore wind power mills and stations.
		Science and Technology	R&D for adequate utilization of energy from these power stations at cheapest costs.
12	National Policy on Biofuels (2018)	Climate Change	Analyze and incentivize uses of various biofuels.
		Science and Technology	Producing biofuels without environmental harm and studying its various uses.
		Energy and Petro-Chemicals	Helping use biofuels as an energy source in industries.
13	National Bioenergy Programme (2021-2026)	Climate Change	Analyze and incentivize uses of various bioenergy sources.
		Science and Technology	Producing bioenergy without environmental harm and studying its various uses.

Sr. No.	Name of Policy/ Scheme	GoG Department	Roles and Responsibility
		Energy and Petro-Chemicals	Helping use bioenergy as an energy source in industries.
14	National Green Hydrogen Mission (2023)	Climate Change	Incentivize the growth of GH2 production.
		Science and Technology	Find best solutions and cheapest ways to produce GH2.
		Energy and Petro-Chemicals	Analyze the various uses of GH2 and its application as energy source.
15	Carbon Capture, Utilization and Storage (CCUS)-Policy Framework and its Deployment Mechanism in India (2022)	Climate Change	Preparing regulations for CCUS and its monitoring.
		Science and Technology	Devising best possible solutions for cost effective CCUS technologies.
		Energy and Petro-Chemicals	Utilizing captured carbon as an energy source.
16	Energy Conservation and Building Code (2017)	Climate Change	Adopting climate friendly materials and technologies within buildings.
		Science and Technology	New solutions to building challenges to make it more energy efficient.
		Urban Development & Urban Housing	Promoting usage of green building materials.
		Roads and Buildings	Monitoring and evaluation of energy efficiency in buildings.
	17	Ethanol Blended Petrol (EBP) Programme	Incentivizing its usage.
		Science and Technology	Finding adequate solutions to maximize ethanol blended petrol utility.
		Energy and Petro-Chemicals	Ensuring adequate supply.
26	Production Linked Incentive Scheme (PLI)	Science and Technology	Promoting r&d in industries to make them more sustainable.
		Industries and Mines	Incentivizing high growth and high potential industries.
18	Methanol Economy Programme	Climate Change	Collection of various residues to help produce methanol.
		Science and Technology	Developing cost effective technologies to utilize methanol.

Sr. No.	Name of Policy/ Scheme	GoG Department	Roles and Responsibility
		Energy and Petro-Chemicals	Promoting methanol usage as replacement for fossil fuels.
19	Atal Jyoti Yojana (AJAY) (2016)	Climate Change	Mitigating GHGs through LED setups
		Social Justice and Empowerment	Electrification of public places through streetlights.
		Science and Technology	Promoting new technology of LEDs.
20	Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM KUSUM) (2017)	Agriculture	Ensuring adequate irrigation supply through pumps.
		Climate Change	Incentivizing solar unit setups.
		Narmada, Water Resources, Water Supply and Kalpsar	Ensuring adequate water distribution in rural areas.
		Panchayat, Rural Housing & Rural Development	Aiding farmers in setting up their own solar powered pumps.
		Social Justice and Empowerment	Educating farmers regarding the scheme.
21	Waste to Energy Policy (2016)	Climate Change	Mitigating methane through WtE plants setup
		Science and Technology	Using best technologies to reduce GHGs while converting waste to power.
		Urban Development & Urban Housing	Teaching adequate waste segregation to individuals.
22	Unnat Jyoti by Affordable LEDs for All (UJALA)	Climate Change	Mitigating GHGs through LED setups
		Science and Technology	Promoting new technology of LEDs.
		Social Justice and Empowerment	Electrification of houses through streetlights.
		Urban Development & Urban Housing	Promoting usage of LEDs in all housing.
23	Pradhan Mantri Ujjwala Yojana (PMUY)	Climate Change	Mitigating GHGs by ensuring LPG connections.
		Women & Child Development	Ensuring access to LPG connections to all beneficiaries for improving their health.

Sr. No.	Name of Policy/ Scheme	GoG Department	Roles and Responsibility
		Social Justice and Empowerment	Educating beneficiaries on the scheme and helping them avail it.
24	Perform, Achieve and Trade (PAT) Scheme	Science and Technology	Incentivizing the newest technologies to mitigate GHGs.
		Industries and Mines	Promoting setup of industries covered under PAT and promoting EC sales.
25	FAME India Scheme	Climate Change	Setting up charging stations and providing EV manufacturing and purchase incentives.
		Science and Technology	Developing new technologies in EVs to maximize their efficiency.
		Energy and Petro-Chemicals	Supplying power to EV stations.
26	Swacch Bharat Mission (2014)	Urban Development & Urban Housing	Ensuring proper waste collection from households.
		Panchayat, Rural Housing & Rural Development	Setting up of toilets to make ODF villages.
		Social Justice and Empowerment	Educating people regarding features of scheme that they can avail.
27	Atal Mission for Rejuvenation and Urban Transformation	Urban Development & Urban Housing	Ensuring adequate water supply, drainage and transportation in urban areas.
		Roads and Buildings	Developing buildings and roads with newest technologies to ensure climate change mitigation.
28	Smart Cities Mission	Urban Development & Urban Housing	Setting up energy positive urban structures.
		Climate Change	Mitigation and adaptation through adoption of climate friendly technologies in cities.

Source: *(MNRE, Niti Aayog, MoP)*

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Annexures

Annexure 1

Stakeholder Engagement Workshop on

Sustainable Decarbonisation Pathways for Gujarat

सत्यमेव जयते
Government of Gujarat

Co-organising institutions: IIMA and IDDRI under the aegis of Industries & Mines Department, Climate Change Department and Forests & Environment Department, Government of Gujarat

Event Date: November 01, 2023

Location: JSW-SPP, New Campus, IIMA, Gujarat

Provisional Agenda

Context and objective

India's Nationally Determined Contributions to the UNFCCC give impetus to energy transition towards renewable sources for achieving India's targets of becoming energy independent by 2047 and Net Zero (NZ) by 2070. Hon'ble Prime Minister of India, Shri Narendra Modi, announced the need to follow the mantra of LiFE, i.e., Lifestyle For Environment – A global movement to affect paradigm shift from mindless and destructive consumption to deliberate utilization at COP26. LiFE mission should be seen as a guideline by India as well as the world, towards achieving its objective of Net Zero emissions.

Gujarat has been experiencing significant climate change impacts such as rise in temperature, rise in sea level, change in precipitation patterns, etc. Increase in temperatures give rise to heatwaves and affect agriculture yields, while altered monsoon patterns can disrupt water availability and significantly impact crop yields. Gujarat has 1600 km long coastal region which is vulnerable to risk of flooding and coastal erosion due to rise in sea level. These climate change related impacts necessitate to work towards various sustainable measures such as, accelerating clean energy transitions, enabling sustainable decarbonisation pathways for hard to abate sector, shift towards LiFE mission and circular economy, taking appropriate adaptation measures for reduced climate change impacts, and need for climate finance for low-carbon energy transitions.

Being a leading industrialized state of India, Gujarat must contribute appreciably to meet the NDC as well as Net Zero targets set up by India and can turn these commitments into concrete economic opportunities. This would require aligning and dovetailing various policies such as policies leading to climate change mitigations, adaptation, and resilience, promoting clean energy policies, policies that lead to the transformation of the energy system, the decarbonisation of hard to abate sectors, developing policies that lead to circular economy, policies for ensuring that these transformations result in socially-robust transitions, creating awareness to shift towards LiFE mission, etc. in short term (till 2030), medium term (2031-2047) and the long-term (2048-2070).

The objective of this stakeholder event is to discuss the current trends and elicit feedback from key stakeholders to enhance the understanding of the implications and opportunities emerging from Government of India Net Zero and NDC commitments for Gujarat. The event aims to promote an open and meaningful deliberations between policymakers, industry leaders and researchers on the following:

- What are the various ways for accelerating clean energy and industrial transition in Gujarat?
- What are the financial challenges involved for decarbonisation of hard to abate industrial sectors?
- What impact and adaptation measures are needed to address the adverse impact of climate change in short and medium term in Gujarat?
- What are the sustainable ways towards climate resilience?
- How should Gujarat move forward to contribute to India's targets of being energy independent by 2047 and NZ by 2070?
- What is 2024 sustainability story of Gujarat for the world?

Programme Details

Wednesday, November 01, 2023	
09:30 – 10:00	**Registration**
10:00 – 10:45	**Inaugural Session** ● *Welcome Address and Context Setting for Gujarat:* Prof. Amit Garg, NIIF Chair in ESG at IIMA ● *Global Context Setting:* Ms. Marta Torres Gunfaus, Senior Researcher, IDDRI Paris ● *Address by Guest of Honour:* Shri Ajay Prakash, Director, Gujarat Energy Development Agency, GoG ● *Address by Chief Guest:* Shri Sanjeev Kumar, Principal Secretary, Forest & Environment and Climate Change Department, GoG ● *Vote of thanks:* Dr. Jyoti Maheshwari, Post Doctoral Researcher, IIMA
10:45 – 11:30	**Tea/Coffee Break**
11:30 – 12:30	**Session 1: Accelerating Clean Energy Transitions** **Chair: Ms. Meg Argyriou, Independent Strategic Advisor, Australia** ● *Clean energy transition for NZ 2070 in India:* Prof. Amit Garg, NIIF Chair in ESG at IIMA ● *Role of Biomass for energy transitions:* Mr. Sudip Nag, Executive Director (Biomass), NTPC Ltd and Mission Director (National Biomass Mission) ● *Opportunities and Challenges for Clean Energy Transitions:* Prof. Divyesh Desai, Visiting faculty, IIMA ● Discussions
12:30 – 13:30	**Session 2: Technical and Financial Challenges involved in Decarbonisation** **Chair: Dr. Daniel Buira, Tempus Analitica, Mexico** ● *Decarbonization through Green Hydrogen:* Dr. Vinod Kumar Shahi, Senior Principal Scientist, CSMCRI, Gujarat ● *Challenges and Opportunities in Electrolyser Manufacturing:* Mr. Anil K Agrawal, Founder, Airox Nigen Equipment Pvt Ltd, Gujarat ● Discussions
13:30 – 14:30	**Photo Session followed by Lunch**

Wednesday, November 01, 2023	
14:30 – 15:30	**Session 3: Assessing Opportunities for Impact, Vulnerability, Adaptation and Climate Resilience** **Chair: Ms. Marta Torres Gunfaus, Senior Researcher, IDDRI Paris** ● *Assessing Impact and Vulnerability Measures:* Ms. Apporva R, Manager, Climate Program, WRI India ● *Assessing Adaptation Measures:* Dr. Vidhee Avashia, Post Doctoral Researcher, IIMA ● *Climate Resilience:* Prof. Rizaldi Boer, Bogor Agriculture University, Indonesia ● Discussions
15:30 – 15:50	**Concluding Session followed by Vote of Thanks** ● Prof. Amit Garg, NIIF Chair in ESG at IIMA ● Ms. Marta Torres Gunfaus, Senior Researcher, IDDRI Paris
15:50 – 16.10	**Tea/Coffee**

Session-wise Summary of the Event

Inaugural Session

- ***Welcome Address and Context Setting for Gujarat:*** **Prof. Amit Garg, NIIF Chair in ESG at IIMA**

Gujarat is at the forefront of India's renewable energy sector by spearheading initiatives in solar, wind, green hydrogen, and widespread energy efficiency initiatives like LED usage. With a current economy of 230 billion, the state contributes 11-12% to the nation's economy and aims to reach 500 billion by 2026, concurrently targeting a 50% reduction in greenhouse gas emissions by 2030. Recognizing the necessity of decoupling emissions and GDP growth, Gujarat has pledged a substantial commitment of 30 gigawatts in the next two years towards a statewide energy transition. With a 1600km coastline, Gujarat holds a lot of vulnerability to climate change. We need to think global and act local. Hence, Gujarat's efforts are crucial for India to achieve its decarbonization goals and, consequently, aid the world in achieving global decarbonization success.

- ***Global Context Setting:*** **Ms. Marta Torres Gunfaus, Senior Researcher, IDDRI Paris**

Over the past decade, IDDRI has been working towards developing decarbonization pathways for societies to achieve their goals by collaborating with over 20 partners to foster collective thinking to address climate challenges and emphasize the importance of linking on-the-ground analyses with policies. Gujarat qualifies as front runner state in India which comes with a lot of complexities and responsibilities, thus, it is important for the state to stay ahead of the game and discover different markets.

Amidst the global call for radical climate changes by the IPCC, bilateral discussions are essential to showcase Gujarat's competitive advantages and its commitment to reaching international targets. This workshop provides insights into the specific support required to navigate present challenges, leveraging international perspectives for target attainment.

- ***Address by Guest of Honour:*** **Shri Ajay Prakash, Director, Gujarat Energy Development Agency, Government of Gujarat**

India has set a target of achieving a 5 trillion economy by 2030. There is a need to sustain growth without increasing emissions. This can potentially be fulfilled through several interventions such as turning coal plants from sub to supercritical, CCS technology, carbon sequestration through afforestation, etc. However, the best solution to meet global climate goals is a significant focus on renewable energy is. This requires substantial financial support through a fund of approximately 40-50 billion dollars. Currently, most climate finance is in mitigation as they have a clear stream; much more fund flow is needed in climate adaptation. Gujarat is home to around 100 global companies; it holds nearly 1/3 of exports of the country and 9% of GHG emissions in India are by Gujarat. The state also aims to lead in electric vehicles, targeting 35 lakh EVs on the road by 2030 and addressing challenges through initiatives like battery swapping. There should also be an increased focus on FCEV and hybrid vehicles as their running cost is very low even though the upfront investment cost is higher. Promoting green buildings should be a priority. They are seen as not profitable due to upfront costs, but the operational cost of a green building is 35% less in the long term. Additionally, Gujarat aims to become a leader in renewable energy, with a target of installing 80GW of renewables by 2030

and to keep increasing that capacity by 10GW every 10 years. The state plans to achieve this through large-scale solar and offshore energy projects, green hydrogen production, and a focus on nuclear energy as a cleaner alternative. The state's comprehensive policies, driven by stakeholder deliberations, underscore the collective urgency to act against climate change. The focus should be on acting as a collective unit because climate change will affect everyone.

- ***Address by Chief Guest:*** **Shri Sanjeev Kumar, Principal Secretary, Forest & Environment and Climate Change Department, Government of Gujarat**

Gujarat, as a pioneer, established the first state Climate Change Department in recognition of its significance. Prime Minister Shri Narendra Modi outlined 5-point targets for Net Zero India at COP26, reinforcing the state's commitment to climate action. Niti Aayog's ranking of Gujarat as the top state in the climate change and renewable energy index reflects the proactive measures taken, including the new Renewable Energy Policy targeting 50% non-fossil fuel energy by 2030.

With nearly half the population residing in urban areas, the government has increased its focus on decarbonizing large cities. Almost 38% of Gujarat's GDP comes from manufacturing, as it is the hub of pharmaceuticals and chemical sector. Hence efforts have been made to decarbonize this sector through schemes such as the Perform, Achieve and Trade (PAT) scheme. The state's emphasis on green hydrogen is evident, with plans for a dedicated policy despite its cost challenges. The state balances economic growth with environmental conservation, exemplified by the LiFE mission discussed at the previous COP. This can be seen in Gujarat's efforts at recognizing the importance of preserving ecosystems through policies like MISHTI which aims to protect mangroves. The upcoming Vibrant Gujarat Summit seminar underscores the state's commitment to achieving Net Zero through decarbonization and carbon trading efforts.

- ***Vote of thanks: Dr. Jyoti Maheshwari, Post Doctoral Researcher, IIMA***

Special gratitude and thanks extended to the Chief Guest, Shri Sanjeev Kumar, and the Guest of Honour, Shri Ajay Prakash, for gracing us with their presence and insightful perspectives, providing valuable guidance and inspiration. Prof. Amit Garg and Ms. Marta Gunfaus's expertise was instrumental in shaping the intellectual fabric of this event, and we express our sincere gratitude for your profound contributions. Our heartfelt thanks extend to all our international colleagues who joined us and brought diverse perspectives.

We would also like to thank the dedicated media team for ensuring that the insights shared today will reach a wider audience. Last but not the least, immense appreciation to our colleagues from IIMA for their unwavering support, collaboration, and hard work in making this event a resounding success.

Session 1: Accelerating Clean Energy Transitions

- Energy frequency serves as a crucial indicator for the energy sector, with India successfully stabilizing its previously unstable energy frequency, providing a foundation to pursue energy transition objectives.
- Acknowledging the unsustainable usage of energy over the past century, there is a pressing need to increase production and consumption of sustainable energy in the long term by effectively utilizing the country's available resources.
- Recognizing the unique paths each country and region must carve for sustainable development and energy transformation, active participation of businesses is imperative for effective energy transitions.
- Currently, businesses may not find immediate financial incentives in transitioning; however, fostering a proper business case for sustainability, wherein new ventures become more profitable than conventional ones, will inherently drive sustainability.
- The promotion of biomass co-firing in thermal power plants is advocated, given India's abundance of crop residue. As thermal power plants contribute over 52% to the country's power generation, incorporating biomass co-firing doesn't require additional investment, presenting income opportunities for farmers.
- Despite the lack of profitability in newer renewable energy technologies, substantial support from sustainable financing and private equity agencies is crucial for achieving financial viability.
- Government-led initiatives, including policy support, capital grants, and risk financing, are essential for advancing energy transition.
- Gujarat, a pioneering force in industrial activities, has effectively harnessed solar, wind, and biomass potential to propel its prosperity. An entrepreneurial-led energy transition in the state not only aligns with climate goals but also contributes to financial growth.
- Advantage of GoI's initiatives such as "Make in India" should be emphasized more for manufacturing Solar PV panels/cells in India.
- Pumped Hydro storage should be promoted as it might be a low-cost solution for energy storage and utilization. It is possible to promote the same in a decentralised manner like KUSUM yojana.
- The ideal course of action for India could be an increased focus on solar as primary source of energy and shifting a little bit to coal or nuclear as and when needed. This would ensure less dependence on imports of oil and gas in India.
- Periodical review/revision of relevant policy/program to ensure efficient implementation.

Session 2: Technical and Financial Challenges involved in Decarbonisation

- Navigating the complexities of shifting energy pathways poses a challenging task, with the modeling of energy systems considered straightforward while the actual transformation proves difficult.
- Emphasizing the significance of hydrogen as the fundamental element, there is a call to focus on its future applications.
- Although India manufactures electrolysers crucial for producing green hydrogen, awareness about their production is lacking among the government and the public. The tenders associated with manufacturing are deemed expensive for Indian companies, leading the industry to seek alternatives in China.
- Recognizing the existing demand and market for hydrogen, it is suggested that governments create local-level roadmaps to facilitate the establishment of hydrogen units.
- Stressing the importance of clean hydrogen production through electrolysis, there is a call for increased indigenous components and the use of seawater as feedwater for sustainable green hydrogen production.
- Addressing safety concerns, especially in hydrogen transportation, is highlighted as a priority, with a focus on developing safe cylinders to facilitate the safe transport of hydrogen. It is proposed that resolving these safety challenges will pave the way for the development of large hydrogen vehicles.
- R&D support by the Government of India is needed to compete with international players in the market, especially for domestic manufacturing of electrolysers and fuel cells.
- It is important for developing countries to be included in green hydrogen discussions as the decisions linked to green hydrogen should not by developed countries only.
- We should preplan the integration of all stakeholders to make the green hydrogen plus solar set up and gradually move away from coal over the next couple of decades.
- There is a need and opportunity for collaboration between academic institutions and industry for more research & development in green hydrogen space. There is certain patented research, which is available with various institutions on renewable energy, Hydrogen production etc.
- Both the Institutions and Industries should come forward for commercialization of technology. This practice is followed in European countries like Germany and Netherlands, will both motivate the students and indigenization of technology.
- Develop Bioenergy Roadmap for India, with specific focus on Gujarat, through consultation of various ministries and relevant businesses.

Session 3: Assessing Opportunities for Impact, Vulnerability, Adaptation and Climate Resilience

- Analysis of climate impact requires a multifaceted approach through examining the effects of just transitions on social justice and equity.
- To make sustainable decarbonization more people-centric, a focus on individuals involved in these efforts is essential.
- Recognizing the potential consequences of an economy-wide transition, there is a need for a comprehensive action plan to mitigate and adapt to various challenges.
- Skilling and reskilling of workers become imperative for a smooth industry transition. Building resilience to disasters and adaptation is crucial to enhance our capacity to respond to climate change.
- Recognizing and implementing local-level climate resilience initiatives is vital, with the development of a rural-level index of indicators to understand risks and adapt at the village level.
- Efficient tracking of emission reduction due to village-level climate change programs is emphasized.
- Given the people-intensive nature of MSMEs, they should be a primary focus for the just transition of industries.
- Enhancing the measurement and assessment of adaptation schemes is crucial, with a shift from short-term to long-term impact studies.
- All mitigation finance is urged to incorporate a resilience framework, as projects are deemed unviable without resilience. Additionally, sector-specific disclosure on projects is deemed necessary.
- Studying the regional and population segment impacts of existing transitions, such as EVs and solar, is recommended to understand how adaptation and developmental schemes can complement each other.
- To avoid maladaptation resulting from developmental policies, the impact of the environment on projects, not just the project's impact on the environment, should be considered.
- Some climate resilience activities in India already yield dual benefits, such as the agro-forestry policy benefiting the environment and supplementing farmer income, highlighting the need for more holistic policies through a careful analysis of development policies in association with climate change.
- Develop Bioenergy Roadmap for India, with specific focus on Gujarat, through consultation of various ministries and relevant businesses.
- Comprehensive state-wise policy for water foot printing for various crops.
- Recognizing relevant ministries and departments as key stakeholders for the successful implementation of policies.
- Restructuring the policies/programs to incentivize the successful business models in each sector.

Press Release for the Workshop

Press Note

November 01, 2023: The Indian Institute of Management Ahmedabad (IIMA) and the IDDRI organised a day-long stakeholder engagement workshop on 'Sustainable Decarbonisation Pathways for Gujarat', with the support of the Industries & Mines Department, Climate Change Department and Forests & Environment Department, Government of Gujarat, here today.

The workshop brought together a diverse group of stakeholders including international climate experts from G20 member countries such as France, Australia, Mexico and Indonesia, top officials from the state government, industry, academia, to share their perspectives and insights on the way forward for Gujarat in meeting Nationally Determined Contributions (NDC) targets.

Ms Marta Torres Gunfaus from IDDRI Paris; Ms Meg Argyriou who is an independent strategic advisor, Dr. Daniel Buira from Tempus Analitica, and Prof. Rizali Boer from Bogor Agriculture University participated in the event as representatives of G20 member countries France, Australia, Mexico, and Indonesia, respectively.

These international experts are actively involved in the upcoming COP28 that will be held in UAE later this year and work very closely with their governments and have networks that predominantly cover countries from the global South. They work together in an international network, predominantly in countries from the global South. Their participation is an amalgamation of global North with global South.

The workshop was organised with the objective of facilitating discussions on current trends and elicit feedback from key stakeholders to enhance the understanding of the implications and opportunities emerging from Government of India's Net Zero and NDC commitments for Gujarat. The event also aimed to promote an open and meaningful deliberations between policymakers, industry leaders and researchers on the following:

- Gujarat's status and progress towards meeting NDC targets
- The implications and opportunities for Gujarat emerging from Government of India's Net Zero commitments
- The key policy interventions and actions required to accelerate Gujarat's transition to a low-carbon and resilient economy
- The role of stakeholders in supporting Gujarat's Net Zero and NDC journey

The inaugural session was led by IIMA faculty member, Professor Amit Garg and Ms Marta Torres Gunfaus, IDDRI Paris who set the Gujarat and global context for the discussions that were to follow during the day.

Setting the tone for the event, **Professor Amit Garg said,** "Gujarat is at the forefront in initiating and implementing policies for renewable energy, electric vehicles, sustainable building space, enhancing energy efficiency, and green hydrogen. However, the state's transition towards deep decarbonisation and Net Zero 2070 requires low-cost financing and international investments."

Highlighting the importance of achieving climate goals, **Ms Marta Torres Gunfaus**, Senior Researcher, IDDRI, said, "Achieving the climate goals of the Paris Agreement can boost our economies and create net new jobs. However, to capitalize these opportunities, countries, States, cities and companies must consider climate goals at the design and planning stages - investors, banks and insurers are demanding credible and coherent plans for the transition to a low-carbon, climate-resilient future. I believe Gujarat has a competitive advantage if it crystallizes a first-of-its-kind State-level net zero long-term strategy."

Gujarat has been experiencing significant climate change impacts such as rise in temperature, rise in sea level, change in precipitation patterns, etc. Increase in temperatures gives rise to heatwaves and affects agriculture yields, while altered monsoon patterns can disrupt water availability and significantly impact crop yields. Gujarat has a 1600 km long coastal region which is vulnerable to risk of flooding and coastal erosion due to rise in sea level. These climate change related impacts necessitate to work towards various sustainable measures such as, accelerating clean energy transitions, enabling sustainable decarbonisation pathways for hard to abate sector, shift towards LiFE mission and circular economy, taking appropriate adaptation measures for reducing climate change impacts, and need for climate finance for low-carbon energy transitions.

Being a leading industrialized state of India, Gujarat must contribute appreciably to meet the NDC as well as Net Zero targets set up by India and can turn these commitments into concrete economic opportunities. This would require aligning and dovetailing various policies such as policies leading to climate change mitigations, adaptation, and resilience, promoting clean energy policies, policies that lead to the transformation of the energy system, the decarbonisation of hard to abate sectors, developing policies that lead to circular economy, policies for ensuring that these transformations result in socially-robust transitions, creating awareness to shift towards LiFE mission, etc. in short term (till 2030), medium term (2031-2047) and the long-term (2048-2070).

The inaugural event was followed by a series of sessions where the international experts chaired sessions on Accelerating clean energy transition, Technical and financial challenges involved in decarbonisation, Assessing opportunities for Impact, Vulnerability, Adaptation and Climate Resilience.

Newspaper Articles

Eyeing net zero carbon emission: Experts, officials discuss policies

Ahmedabad: With a focus on net zero carbon emissions, experts and government representatives on Wednesday discussed policies and related measures at 'Sustainable Decarbonisation Pathways for Gujarat'.

The workshop was orgnised by the Indian Institute of Management Ahmedabad (IIMA) and the Institute for Sustainable Development and International Relations (IDDRI). "Gujarat is at the forefront of implementing policies for renewable energy, electric vehicles, sustainable building space, enhancing energy efficiency, and green hydrogen. However, the state's transition towards deep decarbonisation and Net Zero 2070 requires low-cost financing and international investments," Amit Garg, National Investment and Infrastructure Fund Chair in Environmental, Social, and Governance at IIMA

Ajay Prakash, Director, of Gujarat Energy Development Agency (GEDA), while elaborating on measures taken by the state to reduce the emissions, said, "The state is targeting only the large industries and not the MSMEs." ENS

INDIAN EXPRESS 02/11/2023 P. 04 AHMEDABAD

ટકાઉ ડીકાર્બનાઇઝેશન પર IIMA ખાતે વર્કશોપ યોજાયો

અમદાવાદ : IIMA અને IDDRI દ્વારા આજે સરકારી ઉદ્યોગ, ખાણ વિભાગ, આબોહવા પરિવર્તન વિભાગ અને વન-પર્યાવરણ વિભાગના સહયોગથી 'ગુજરાત માટેના ટકાઉ ડીકાર્બનાઇઝેશન પાથ વે' વિષય પર વર્કશોપનું યોજાયો હતો. જેમાં ફ્રાન્સ, ઓસ્ટ્રેલિયા, મેક્સિકો અને ઇન્ડોનેશિયા જેવા G20 સભ્ય દેશોના ઇન્ટરનેશનલ ક્લાઇમેટ એક્સપર્ટ્સ સહિત વિવિધ સ્ટેક હોલ્ડર્સે પાર્ટિસિપેટ કર્યું હતું. આ ઇવેન્ટ વિશે વાત કરતા પ્રો.અમિત ગર્ગે જણાવ્યું હતું કે, 'ગુજરાત રિન્યુએબલ એનર્જી, ઇલેક્ટ્રિક વાહનો, સસ્ટેનેબલ બિલ્ડીંગ સ્પેસ, એનર્જી એફિશિયન્સી વધારવામાં અને ગ્રીન હાઇડ્રોજન માટેની પોલિસીની શરૂઆત અને અમલીકરણમાં મોખરે છે. જો કે, રાજ્યમાં ડિપ ડીકાર્બનાઇઝેશન અને નેટ ઝીરો 2070 તરફનો ગોલ અચિવ કરવા ઓછા ખર્ચે લો કોસ્ટ ફાઇનાન્સ અને ઇન્ટરનેશનલ ઇન્વેસ્ટમેન્ટ્સની જરૂર છે.'

DIVYA BHASKAR 02/11/2023 P. 9 AHMEDABAD

'250 more EV charging stations soon'

Offshore Wind Farm In Gulf Of Khambhat Also On GEDA's Agenda

TIMES NEWS NETWORK

Ahmedabad: Identifying the need to promote electric vehicles, Gujarat will see over 250 charging stations installed at prominent tourist locations and public spots. Gujarat currently has about 300 charging stations. Ajay Prakash, director, Gujarat Energy Development Agency (GEDA), said there also plans afoot for its offshore wind farm in Gulf of Khambhat.

He was speaking at the stakeholder engagement workshop on the theme 'Sustainable Decarbonisation Pathways for Gujarat' at IIM Ahmedabad (IIMA). The event was jointly organised by IIMA and IDDRI.

IIMA's Prof Amit Garg said Gujarat is at the forefront of initiating and implementing policies for renewable energy, electric vehicles, sustainable building spaces, enhanced energy efficiency and green hydrogen. "Some of the challenges for the state's transition towards deep decarbonisation and Net Zero 2070 require low-cost financing and international investments," he said.

Marta Torres Gunfaus, senior researcher at IDDRI, said climate goal achievement can boost economies and create new jobs. "To capitalize these opportunities, countries, states, cities and companies must consider climate goals at the design and planning stages," she said. "I believe Gujarat has a competitive advantage if it crystallizes a first-of-its-kind state-level net zero long-term strategy."

International experts participated in the stakeholder engagement workshop themed 'Sustainable Decarbonisation Pathways for Gujarat' held at IIM Ahmedabad on Wednesday

Dr Daniel Buira from Tempus Analitica said that main challenge in addressing climate change is finding the simultaneous political will and investment capital to move quickly enough. Meg Argyriou, independent strategic advisor, said that by clearly linking economic opportunities to its net zero plans, Gujarat could create the enabling conditions for 'green' and sustainable long-term growth.

"Economic opportunity for cities on the path to net zero is not just a responsibility; it's a revolution. By embracing sustainability and clean technologies, cities can drive innovation, create jobs, and build a resilient, equitable future for all," said Prof Rizali Boer from the Bogor Agriculture University.

The workshop brought together a diverse group of stakeholders including international climate experts from G20 member countries such as France, Australia, Mexico, and Indonesia.

Several of the international experts are involved in COP28 to be held in the UAE later this year and are working very closely with their governments and have networks that predominantly cover countries from the global South.

TIMES OF INDIA 02/11/2023 P. 04 AHMEDABAD

Affordable finance must for net zero emission by 2070

Experts and policy makers strategise at IIMA workshop for state's green pivot

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Experts and policy makers convened at the Indian Institute of Management, Ahmedabad (IIM-A), stressing the need for low-cost financing and international investments for Gujarat's ambitious transition to net zero emission by 2070. They noted that Gujarat stands to gain if it pioneers a state-level net zero strategy.

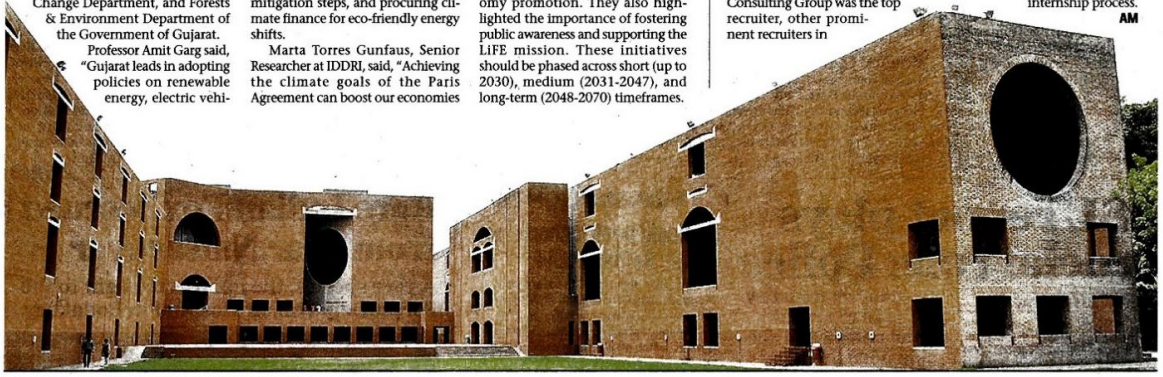
The workshop, titled 'Sustainable Decarbonisation Pathways for Gujarat', was jointly hosted by IIMA and IDDRI on Wednesday. It received backing from the Industries & Mines Department, Climate Change Department, and Forests & Environment Department of the Government of Gujarat.

Professor Amit Garg said, "Gujarat leads in adopting policies on renewable energy, electric vehicles, sustainable buildings, energy efficiency, and green hydrogen. But the push for deep decarbonisation and reaching Net Zero 2070 hinges on affordable financing and international investments."

With its 1,600 km coastline, Gujarat has already felt the impacts of climate change, from temperature increases and shifting rainfall patterns to sea-level rise. This coastal expanse also heightens the risk of flooding and erosion. Addressing these challenges demands multiple sustainable solutions: ramping up clean energy transitions, devising sustainable decarbonisation routes for challenging sectors, endorsing the LiFE mission and circular economy, implementing climate change mitigation steps, and procuring climate finance for eco-friendly energy shifts.

Marta Torres Gunfaus, Senior Researcher at IDDRI, said, "Achieving the climate goals of the Paris Agreement can boost our economies and create net new jobs. However, to capitalize these opportunities, countries, States, cities and companies must consider climate goals at the design and planning stages - investors, banks and insurers are demanding credible and coherent plans for the transition to a low-carbon, climate-resilient future. I believe Gujarat has a competitive advantage if it crystallizes a first-of-its-kind State-level net zero long-term strategy."

The experts pinpointed the state's need to synchronize policies addressing climate change mitigation, adaptation, resilience, clean energy promotion, energy system transformation, carbon reduction in stubborn sectors, and circular economy promotion. They also highlighted the importance of fostering public awareness and supporting the LiFE mission. These initiatives should be phased across short (up to 2030), medium (2031-2047), and long-term (2048-2070) timeframes.



IIMA summer placement

BCG top recruiter with 22 offers, Goldman offers 9

Investment bankers emerge largest recruiters

Boston Consulting Group (BCG) was the top recruiter with 22 offers and Goldman Sachs, with 9 offers, was the largest recruiter in the investment banking and markets cohort, at Cluster 1 of summer placement process for the Post Graduate Program in Management (PGP) – at IIM Ahmedabad, on Tuesday.

Officials at IIMA said the firms that participated in Cluster 1 comprised six cohorts – investment banking & markets, management consulting, niche consulting, advisory consulting, cards and financial advisory and private equity, venture capital & asset management. "We saw a large pool of recruiters offering about 60 roles in the process. While Boston Consulting Group was the top recruiter, other prominent recruiters in the consulting domain included Bain & Company, McKinsey & Company, Accenture Strategy, Alvarez & Marsal, Arthur D Little, Auctus Advisors, Kepler Cannon, PwC, KPMG and E&Y. Prominent recruiters in investment banking space included Avendus Capital, Bank of America, Citibank, Morgan Stanley, Estee Advisors, Goldman Sachs, JPMorgan Chase and HSBC," officials said.

In the PE and VC domain, the first cluster had participation from firms like Westbridge, I-squared Capital, RTP Global, Multiples, Faering Capital and Piramal Alternatives. It also had participation of new firms like Vector Consulting Group and Transformation X in the summer internship process.

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AMHEDABAD MIRROR 02/11/2023 P. 05 AMHEDABAD

Glimpses of the Workshop


IDDRI
IIMA


NEWS


Marta Torres Gunfaus


IDDRI


Pranav Garimella
Mehul Patel

Group Photo


IDDRI
Stakeholder Engagement Workshop on
Sustainable Decarbonisation Pathways for Gujarat
November 1, 2023 | IIM Ahmedabad
under the aegis of
Industries & Mines Department
Climate Change Department
Forests & Environment Department
Government of Gujarat

List of Participants

Sr No.	Name	Affiliation	Speaker/Participant
1	Shri Sanjeev Kumar	Forest & Environment and Climate Change Department, GoG	Speaker
2	Shri Ajay Prakash	Gujarat Energy Development Agency (GEDA)	Speaker
3	Alisha Engraver	IIM Ahmedabad	Participant
4	Amit Garg	IIM Ahmedabad	Speaker
5	Anil Agrawal	Airox Nigen Equipments Pvt Ltd	Speaker
6	Ankul Prakash	IIM Ahmedabad	Participant
7	Apoorva R	WRI	Speaker
8	Daniel Buira	Tempus Analitica, Mexico	Speaker
9	Debanjana Mukherjee	IIM Ahmedabad	Participant
10	Debashish Bose	IIM Ahmedabad	Participant
11	Devdatt P. Purohit	Torrent Power Limited	Participant
12	Dhara Thakkar	IIM Ahmedabad	Participant
13	Dhara Trivedi	IIM Ahmedabad	Participant
14	Divya Arora	IIM Ahmedabad	Participant
15	Divyesh Desai	IIM Ahmedabad	Speaker
16	Gopi Ethamukkalam	IIM Ahmedabad	Participant
17	Ishan Katariya	IIM Ahmedabad	Participant
18	Jaimin Shah	IIM Ahmedabad	Participant
19	Jaipalsinh Chauhan	IIM Ahmedabad	Participant
20	Jigar Shah	IIM Ahmedabad	Participant
21	Jyoti Maheshwari	IIM Ahmedabad	Participant
22	Kandarp Mehta	IIM Ahmedabad	Participant
23	Manmohit Singh	IIM Ahmedabad	Participant
24	Marta Torres Gunfaus	IDDRI, Paris, France	Speaker
25	Meg Argyriou	Australia	Speaker
26	Mehul Patel	WRI	Participant
27	Namrata Bhuptani	Gujarat Energy Development Agency, GoG	Participant
28	Pranav Garimella	WRI	Participant
29	Prashant Kumar	CSIR-CSMCRI, Bhavnagar,Gujarat	Participant

Sr No.	Name	Affiliation	Speaker/Participant
30	Prateek Barapatre	WRI	Participant
31	Priyankesh Dixit	IIM Ahmedabad	Participant
32	Priyanshu Agrawal	IIM Ahmedabad	Participant
33	Qumer Ahmed Khan	IIM Ahmedabad	Participant
34	Raizaldi Boer	IPB University, Bogor Agriculture University, Indonesia	Speaker
35	Ritwika Verma	IIM Ahmedabad	Participant
36	Sagar Verma	IIM Ahmedabad	Participant
37	Sakshi Srivastava	IIM Ahmedabad	Participant
38	Sanjay Jain	IIM Ahmedabad	Participant
39	Saritha S. Vishwanathan	Kyoto University, Japan	Participant
40	Shakti Naik	IIM Ahmedabad	Participant
41	Shivani Bhatt	C40 Cities	Participant
42	Shwetal Shah	Recap 4 NDC	Participant
43	Sudip Nag	NTPC Ltd and Mission Director (National Biomass Mission)	Speaker
44	Suneetha Reddy	IIM Ahmedabad	Participant
45	Sunil Kopparapu	IIM Ahmedabad	Participant
46	Sunitha Aravind	IIM Ahmedabad	Participant
47	Sweety	CSIR-CSMCRI, Bhavnagar,Gujarat	Participant
48	Tanya Ahuja	IIM Ahmedabad	Participant
49	Vicente Guazzini	IDDRI, Paris, France	Participant
50	Vidhee Avashia	IIM Ahmedabad	Speaker
51	Vinod Kumar Shahi	CSMCRI, Gujarat	Speaker

Industries & Mines Department
Government of Gujarat

Annexure 2

Seminar on
Transitioning towards a Green Hydrogen Economy for Net Zero 2070

Draft Report

Co-organized by: IIMA, ITF and NDC Aspects

Under the aegis of Industries and Mines Department, Government of Gujarat

Date: 13th July 2023

Venue: JSW-SPP, New Campus, IIM Ahmedabad

Context and Objective

At COP26, Hon'ble Prime Minister of India, Shri Narendra Modi announced the need to follow the mantra of LiFE, i.e., Lifestyle For Environment – A global movement to affect paradigm shift from mindless and destructive consumption to deliberate utilization. LiFE mission should be seen as a guideline by India as well as the world, towards achieving its objective of Net Zero emissions.

India's Nationally Determined Contributions to the UNFCCC give impetus to energy transition towards renewable sources for achieving India's targets of becoming energy independent by 2047 and Net Zero by 2070. The role of green hydrogen is indispensable for enabling this transition. As a rapidly growing economy and a global leader in renewable energy, India, has the opportunity to spearhead the adoption and integration of hydrogen technologies into its energy sector.

Recognizing this potential, the Government of India has expressed its commitment to transitioning towards a clean hydrogen economy through the National Green Hydrogen Mission on 4th January 2023. The mission aims to develop a green hydrogen production capacity of at least 5 MMT (Million Metric Tonne) per annum, alongside adding renewable energy capacity of about 125 GW[1] in India by 2030. The overarching objective of the Mission is to make India the Global Hub for production, usage and export of Green Hydrogen and its derivatives.

One of the key tenets of the mission is the allocation of Rs 17,490 crore under Strategic Interventions for Green Hydrogen Transition (SIGHT) programme, which will be distributed through a Production-Linked Incentive (PLI) scheme for manufacturing of electrolysers and production of green hydrogen.

The state of Gujarat is the hub of industrial units of various sectors. It is estimated that Gujarat will utilize 30%, i.e., 1.5 MMT of Government of India's target of 5 MMT of green hydrogen production by 2030[2]. Hence, there is a need to develop the production capacity of green hydrogen in the state through a robust policy framework. The Energy and Petroleum Department, GoG is in the process of formulating a draft green hydrogen policy to promote and facilitate development of green hydrogen projects.

Moreover, to incentivize green hydrogen investments and consequent production, the Gujarat government has announced a land allotment policy that offers several benefits to companies investing in the state's green hydrogen projects. The Policy 2023[3] for leasing out government fallow land for green hydrogen production using non-conventional energy sources such as solar, wind, wind-solar hybrid energy targets that companies must meet 50% of their green hydrogen production capacity within five years of plant commissioning and achieve 100% capacity within eight years.

Further, Government of Gujarat had already announced "The Aatmanirbhar Gujarat Schemes 2022 for Assistance to Industries" wherein large industries, thrust sectors & mega industries

[1] https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/jan/doc2023110150801.pdf
[2] *Strategy for Government of Gujarat to enable India to become a USD 5 trillion economy*, *GIDB*. Available at: https://gidb.org/Document/2022-5-14_439.pdf.
[3] https://www.eqmagpro.com/wp-content/uploads/2023/05/New-GR-for-Green-Hydrogen-08-05-2023-English_compressed.pdf

under Green Energy Eco system including Green Hydrogen / Ammonia, Electrolysers, RE equipment, BESS, Fuel cells etc will be getting financial assistance such as Interest subsidy, Net SGST reimbursement, EPF reimbursement, Reimbursement of Stamp duty & Registration fees etc.

India's Green Hydrogen Roadmap presents a clear vision for transitioning towards a hydrogen-powered economy through a combination of policy movement and business interests to accelerate the deployment of green hydrogen projects and drive innovation in the sector. However, several challenges such as costs, infrastructure, skilled workforce, etc., need to be addressed for successfully implementing and scaling up the use of green hydrogen in the country. Thus, transitioning to a green hydrogen economy requires a collaborative effort involving stakeholders from industry, academia, research institutions, and both state and central governments. It demands a comprehensive understanding of the challenges and opportunities associated with hydrogen production, storage, transportation, and utilization. It also calls for the identification of viable business models, financing mechanisms, and regulatory frameworks to support the scaling up of hydrogen technologies.

The seminar's agenda sets the stage for meaningful discussions and deliberations on the various aspects of transitioning towards a green hydrogen economy in India as follows:

- **How can the current technologies in green hydrogen be further improved to enhance efficiency and reduce costs?**

  - Indian private companies and government enterprises should acknowledge and promote indigenous/domestic hydrogen production units as the current cost of green hydrogen is in the range of USD 5-6 per kg, however, this cost can be reduced through localization of production resources. Moreover, we can utilize article 6.2 of the Paris Agreement which states that there should be assistance given to developing countries for setting up projects which can reduce carbon emissions. This provision could support significant reduction in costs of green hydrogen and green ammonia as they are highly capital intensive.

- **What are the key challenges in integrating RE sources for green hydrogen production process, and how can these challenges be overcome?**

  - The key challenges associated with integration of RE for green hydrogen production are intermittency and variability, grid integration and balancing and energy storage. Hybridization of storage technology is the need of the hour. The combination of all types of renewable energy sources is necessary to bring down the cost of hybrid RE with ESS. We should take advantage of GoI's initiatives such as "Make in India" for manufacturing Solar PV panels/cells in India to increase GH2 production. Moreover, pumped hydro should be promoted as it might be low-cost solution for energy storage and utilization. The abundance of agricultural waste present in India can be converted to several million tons of green hydrogen through gasification process. We can also utilize the existing facilities of 1200 MW pump storage of Sardar Sarovar Project can be put to operations at the earliest to serve the grid with a huge battery of 1200 MW.

- **How can the production of electrolysers be increased to make India self-reliant in green/blue hydrogen production?**

  - We should promote electrolyser manufacturing in mission mode. The Government of India (GoI) should focus on giving more business opportunities to electrolyser manufacturers in India, rather than relying on electrolyser imports. The Government has already announced PLI scheme for both green Hydrogen Production and Electrolyser manufacturing which will make the nation self-reliant in electrolyser production. We should also focus on electrolyser units with small capacity (1-3 MW) can be helpful to promote decentralized mode of green hydrogen production. CECRI and CSMCRI have developed new and highly efficient electrolyser technologies that should be scaled up for mass production. Lastly, there is a need and opportunity for collaboration between academic institutions and industry for more research & development in green hydrogen and electrolyser manufacturing space.

- **What are some of the opportunities provided by green hydrogen from a demand side perspective?**

  - Green hydrogen offers an opportunity to decarbonize the industrial sector rapidly. It is also a renewable energy storage for utilizing excess energy and to help stabilize grids and meet peak demand. Moreover, there should be a lot of focus on its usage as a transportation fuel for fuel cell vehicles, providing a zero-emission alternative for the transportation sector and reducing reliance on fossil fuels.

- **What are some global models of green hydrogen ecosystem in place? How well can these systems fit into the Indian scenario?**

  - The United States and European Union (EU) lead in policy/regulatory actions for green hydrogen, whereas China leads in the production or deployment of green hydrogen. Germany wants to create an international market for green hydrogen usage to maintain their industrial competitiveness by getting imports for their industries. The EU wants to import green and clean energy instead of fossil fuels. However, as of now it lacks the development of supply chain needed for a low carbon world/ economy. Green hydrogen can help abate Carbon Border Adjustment Mechanism (CBAM) imposed carbon taxation on green products from India.

- **How can policy frameworks and financial mechanisms be designed to incentivize investment in green/blue hydrogen infrastructure and promote the widespread adoption of hydrogen?**

  - Green hydrogen needs to be made monetarily competitive to ensure its growth as it is gaining prominence from both businesses as well as industries. India needs to stop being only trader (importing and exporting) of green hydrogen. We should leverage the digital prowess of our country to further increase demand for green hydrogen. Realtime matching of demand and supply could be possible through digital platforms. Further, 20-25% of green hydrogen production cost is because of electrolysers, which can be brought down to less than $1 per kg with more indigenous R&D activities.

- **What are the regional or state level challenges that inhibit the promotion green hydrogen?**

  - Production of green hydrogen at state or regional level in India is faced by various challenges such lack of specialized infrastructure for hydrogen production, transportation, and distribution which hinders the adoption and widespread use of green hydrogen technologies. High upfront costs for setting up electrolyser facilities and related infrastructure can deter potential investors and limit the growth of green hydrogen projects at the state or regional level in India. Land and water availability is another challenge that needs to be tackled for proper decentralized green hydrogen production in India. Special support and incentives should be provided to SMEs involved in the green hydrogen ecosystem such as earmarking a portion of the PLI Scheme benefits at every stage of the hydrogen chain.

- **What are the critical success factors such as Land, Water, RE generation and Demand centers for H2 economy and how can global partnerships be fostered to accelerate progress?**

  - We should scrutinize on leveraging our diplomatic stature to promote a green hydrogen ecosystem globally. It is important for developing countries like India to be included in green hydrogen discussions as the decisions linked to green hydrogen should not by developed countries only. We should also focus on creating an attractive investment environment for foreign companies and investors interested in green hydrogen projects in India, thus, promoting cross-border capital flows and technology infusion.

This seminar aimed to stimulate discussions to foster a deeper understanding of the challenges, opportunities, and future directions in this rapidly evolving field through the following sessions.

1. **Green Hydrogen from Supply Side Perspective**

   This session explores the current status of green hydrogen and barriers to creating a large supply. At present the supply chain for green hydrogen is minimal and the use of green hydrogen is limited. Thus, rapid growth is necessary, through R&D and policy support for the industry to scale up to the size needed to make a significant contribution towards energy transition.

2. **Green Hydrogen from Demand Side Perspective**

   This session will look into the demand-side potential of green hydrogen in India. It is essential to create supportive policies, provide incentives, and foster collaboration between industry, academia, and government to drive the adoption and integration of green hydrogen across various sectors.

3. **Green Hydrogen from International Perspectives**

   Several countries have a robust hydrogen strategy to support the sector. In this session, India can draw early lessons from the trailblazing countries in the green hydrogen sector and learn to implement the best practices through these insights.

4. Economics of Green Hydrogen and Way Forward

This session will explore the ways to accelerate the adoption of green hydrogen through a focus on providing long-term market incentives, supporting R&D efforts, establishing favourable regulatory frameworks, and promoting international collaboration to drive scale, reduce costs, and unlock the full potential of green hydrogen as a key pillar of a low-carbon economy.

Detailed Schedule

9:30 -10:00	**Registration**
10:00 - 10:15	**Inaugural Session** ● S.B. Dangayach- Founder Trustee, Innovative Thought Forum ● Amit Garg- Professor, IIM Ahmedabad
10:15 -11:00	**Session One:** *Green Hydrogen from supply side perspective* **Session Coordinator:** Mr. Chintan Shah- Former Director, IREDA **Speakers:** ● Rashi Gupta- Managing Director, Vision Mechatronics ● Sudhanshu Sharma- Associate Professor, IIT Gandhinagar ● Jitendra Trivedi- Director, Aztech Composites Pvt Ltd ● Anil Agrawal- Founder, Airox Nigen Equipment Pvt Ltd ● Chintan Shah- Former Director, IREDA ● Pawan Mehndiratta- Strategic Business Unit Head, Thermax Ltd *(Online)*
11:00 - 11:45	**Session Two:** *Green Hydrogen from demand side perspective* **Session Coordinator:** Partha Banerjee- Chief General Manager (CC&EE), SAIL **Speakers:** ● Prodyut Maji- Associate VP, Adani Enterprises Ltd ● Ashok Chaudhari- Sr. VP, Ankur Scientific Energy Technologies Pvt Ltd ● Biswajit Roy- Director General, GERMI ● Partha Banerjee- Chief General Manager (Coal & Energy), SAIL ● Sujit Gulati- Reliance New Energy Ltd *(TBC)*
11:45 - 12:00	**Tea Break**
12:00 - 12:45	**Session Three:** *Green Hydrogen from international perspectives* **Session Coordinator:** Dr. Saritha Sudharmma Vishwanathan- Post Doctoral Fellow, NIES (Japan) **Speakers:** ● Chris Bataille- Visiting Faculty, Columbia University, USA ● Hilton Trollip- Visiting Faculty, University of Cape Town, South Africa ● Ines Bouacida- Research Fellow, IDDRI, France

12:45– 13:30	**Session Four:** *Economics of Green Hydrogen and way forward* **Session Coordinator:** Mr. Rahul Walawalker- President & MD, IESA **Speakers:** ● Prasad Thakur- Strategy, Reliance Industries Ltd. ● Rahul Walawalker- President & MD, India Energy Storage Alliance ● Santosh Gurunath- CEO & Co-Founder, Umagine ● Shashi Shekhar- Director, ACME *(Online)*
13:30– 13:40	**Concluding Remarks** ● S.B. Dangayach- Founder Trustee, Innovative Thought Forum ● Amit Garg- Professor, IIM Ahmedabad
13:40 onwards	**Group Photo followed by lunch at IMDC Dining Hall**

Speakers and Attendees

The seminar was attended by a total of 45 participants. This consisted of 20 Speakers and 25 participants. The detailed list of speakers & participants is mentioned in Annexure-2.

Key Takeaways from all the Sessions

- Green hydrogen is gaining prominence from both businesses as well as industries.
- Green hydrogen needs to be made monetarily competitive to ensure its growth.
- One of the best solutions is to convert hydrogen into ammonia or methanol as their supply chains already exist in the market.
- India needs to stop being only trader (importing and exporting) of green hydrogen. We need to invest more in research & development for the development of green hydrogen technology. Government of India has already announced PLI scheme for both green Hydrogen Production and Electrolyser manufacturing on July 7, 2023.
- The price of Renewable energy at green hydrogen production site should be focus first. However, Renewable energy integration is intermittent; hence we can't focus on a single energy source in short to medium terms. Hybridization of storage technology is the need of the hour. The combination of all types of renewable energy sources is necessary to bring down the cost of hybrid RE with ESS.
- The long-term goal should be centralized storage, and short term is decentralized storage; both need to be in the right combination for an ideal energy mix.
- It is important to explore other metal based instead of Li based EV for example Aluminium Based (IOCL is already working on it) to make renewable energy sources dispatchable, we need storage technology.

- Adding appropriate additives to electrolyte will increase efficiency of hydrogen production of the same system whilst using less voltage.

- Indian private companies and government enterprises should acknowledge and promote indigenous/domestic hydrogen production units.

- Government of India (GoI) should focus on giving more business opportunities to electrolyser manufacturers in India, rather than imports.

- Advantage of GoI's initiatives such as "Make in India" should be emphasized more for manufacturing Solar PV panels/cells in India.

- Current cost of green hydrogen is in the range of USD 5-6 per kg. However, this cost can be reduced through localization of production resources.

- There is a need and opportunity for collaboration between academic institutions and industry for more research & development in green hydrogen space. There is certain patented research, which is available with various institutions on renewable energy, Hydrogen production etc. Both Institution and Industries should come forward for commercialization. This is practiced followed in European countries like Germany and Netherlands. will both motivate the students and indigenization of technology.

- 20-25% of green hydrogen production cost is because of electrolysers, which can be brought down to less than $1 per kg with more indigenous R&D activities.

    - Provision of Electricity Banking Facility for Green Hydrogen projects owing to it large, unified Grid size with consumption of more than 210 GW and supply for more than 400 GW, will make it feasible to utilize Electrolyser capacity at close to 100% levels, thus enabling the world to produce more Green Hydrogen with the limited capacity of Electrolysers.

    - Moreover, the Production-Linked Incentive (PLI) scheme for manufacturing of electrolysers will help reduce electrolyser costs and increase production of green hydrogen.

- Pumped Hydro should be promoted as it might be low-cost solution for energy storage and utilization. It is possible to promote the same in a decentralised manner like KUSUM yojana.

- India produces an average of 500 million tons of agricultural residue every year; more than 200 million tons remains unutilized. This can be converted to several million tons of green hydrogen through gasification process.

- Apart from green hydrogen, gasification of biomass can also produce biochar or carbon dioxide which can be sequestered for high quality agricultural soil.

- A decentralized mode of green hydrogen is needed which also ensures 2nd / 3rd generation biomass utilization. Electrolyser units with small capacity (1-3 MW) can be helpful to promote decentralized mode of green hydrogen production.

- Key strategies for creating green hydrogen demand:
  - Domestic consumption should be focused on rather than solely relying on exports.
  - Export capabilities should however be set up simultaneously efficiently.
  - Government could mandate for mandatory usage and production of green hydrogen in industries.
- We need to identify other industries apart from Iron & Steel under the hard to abate sectors such as chemicals and refineries.
- For the steel industry, hydrogen is not a fuel but an energy carrier.
- The United States and European Union (EU) lead in policy/regulatory actions for green hydrogen, whereas China leads in the production or deployment of green hydrogen.
- The ideal course of action for India could be an increased focus on solar as primary source of energy and shifting a little bit to coal or nuclear as and when needed. This would ensure less dependence on imports of oil and gas in India.
- India could leapfrog from coal to green hydrogen as a complement to the already existing solar sources.
- We should preplan the integration of all stakeholders to make the green hydrogen plus solar set up and gradually move away from coal over the next couple of decades.
- It is extremely cheaper to decarbonize the EU steel sector by importing steel from other countries like South Africa, India and China.
- Focus on use of hydrogen for decarbonizing or reducing emissions in existing refineries and chemicals industries while substantial usage in iron & steel industries.
- Germany wants to create an international market for green hydrogen usage to maintain their industrial competitiveness by getting imports for their industries.
- The EU wants to import green and clean energy instead of fossil fuels. However, as of now it lacks the development of supply chain needed for a low carbon world/ economy.
- To facilitate demand side growth in EU countries, its green hydrogen strategy has established partnerships between EU countries and the industry to provide a level-playing field.
- Green hydrogen can help abate Carbon Border Adjustment Mechanism (CBAM) imposed carbon taxation on green products from India.
- It is important for developing countries to be included in green hydrogen discussions as the decisions linked to green hydrogen should not by developed countries only.
- Green hydrogen offers an opportunity to decarbonize the industrial sector rapidly.
- Policy paths don’t necessarily always lead to market creation but fundamental improvements in technology will lead to better market creation.

- To achieve futuristic cost (USD 1 per kg) of green hydrogen from the current high cost, there should be increased focus on combination of different sectors wherever possible.

- We should leverage the digital prowess of our country to further increase demand of green hydrogen. Realtime matching of demand and supply could be possible through digital platforms.

- We should scrutinize on leveraging our diplomatic stature to promote green hydrogen ecosystem globally.

- Article 6.2 of the Paris Agreement states that there should be assistance given to developing countries for setting up projects which can reduce carbon emissions. This provision could support significant reduction in costs of green hydrogen and green ammonia as they are highly capital intensive.

- R&D support by the GoI is needed to compete with international players in the market; specially for domestic manufacturing of electrolysers and fuel cells.

- The existing facilities of 1200 MW pump storage of Sardar Sarovar Project can be put to operations at the earliest to serve the grid with a huge battery of 1200 MW. Besides this, possibilities to create new pump storage in the existing medium / large dams in the State should be investigated.

- The Bilateral trade agreement with the European union or other countries who have CBAM for the import of hydrogen should discuss the technology transfer under the same. Such countries are getting huge profit when they transfer the technology to India.

Industries should explore the existing Bilateral agreement with countries like Singapore, Japan etc. instead focusing only on Western Countries.

Detailed Minutes of the Meeting

Inaugural Session

Speakers:

1. Amit Garg- Professor, IIM Ahmedabad
2. S.B. Dangayach- Founder Trustee, Innovative Thought Forum

Introductory address by Mr. S.B. Dangayach

- Green hydrogen is the key factor needed for achieving net zero goals for India.
- India is a pioneer of green hydrogen however there is still a lot to learn from around the world and to grow as a country.

Introductory address by Prof. Amit Garg

- Government of India has declared its Green Hydrogen Mission and several states such have also come up with their own green hydrogen policy.
- For achieving Net Zero goals, it is important to work on several fronts simultaneously.
- Need of the hour is how can India build a green hydrogen economy? What are the requirements of green hydrogen?
- How can we manage water resources within green hydrogen production as 1 kg of hydrogen requires 18 kgs of water because of which states at water risk like Gujarat or Rajasthan might be at a disadvantage.
- We also need to analyse transportation of green hydrogen; whether it will follow coal's pathway in transportation or be transported through pipelines like oil.
- Role of green hydrogen in freight vehicles is another crucial area to be explored.

Session One: Green Hydrogen from Supply Side Perspective

Speakers:

- Rashi Gupta- Managing Director, Vision Mechatronics
- Sudhanshu Sharma- Associate Professor, IIT Gandhinagar
- Jitendra Trivedi- Director, Aztech Composites Pvt Ltd
- Anil Agrawal- Founder, Airox Nigen Equipment Pvt Ltd
- Chintan Shah- Former Director, IREDA
- Pawan Mehndiratta- Strategic Business Unit Head, Thermax Ltd *(Online)*

Discussion by Mr. Chintan Shah

- Currently only 16% of energy in India's total supply is coming from electricity.
- The target set by Government of India is to achieve at least 40% of total electricity from renewable energy. A major challenge till now was to replace oil & gas by shifting to electricity.
- However, there are certain industries that will always require fossil fuels, because of dual purpose of fuel (i.e., fuel & raw material)
- The advantage of green hydrogen is that it can cross the electricity spectrum and directly replace oil & gas through hydrogen or its derivatives as an energy Swiss knife.
- Converting hydrogen into meaningful radicals for energy or derivates for industry or commodity purposes can be very useful and the future, such as:
    - manufacturing methanol can help make petrochemicals from hydrogen.
    - When hydrogen is produced ammonia is also produced, hence green hydrogen can help replace production of ammonia through fossil fuels.
- Ammonia is the largest industrial agent and green hydrogen can help cater to its market demand. Ammonia prices are between $500- $550.
- Green hydrogen needs to be made competitive to ensure its growth.
- There needs to be proper planning of green hydrogen transmission; ideally the plant should be close to its usage point.
- Transporting electrons of hydrogen instead of whole molecules of hydrogen.
- Government of India has made transmission free for green hydrogen till 2035.
- The biggest challenge for green hydrogen currently is electrolysers. The right technology for mass scale production of electrolysers needs to be evolved.
- There are several large questions that need to be answered to ensure green hydrogen growth, viz., where should hydrogen be stored? Should hydrogen be converted into ammonia or liquefication or regassification of hydrogen should take place?
- Hydrogen is voluminous but it is not dense, hence large amounts of storage space is required.
- The best solution is to convert the hydrogen into ammonia or methanol because the supply chain for them has already been established and is in place. For supplying hydrogen directly, a new supply chain would need to be made.
- A tolling model for ammonia and electrolyser can be set up.
- A growth in domestic demand can push more supply chain.
- Scaling up green hydrogen is key and there is a need to develop a robust supply chain.
- There is a need for university and industry linkages for research & development requirement understanding.
- Research & development will also result in a reduction in costs.
- 2070 is just a number but we can surely reach our targets even sooner.

Discussion by Dr. Rashi Gupta

- The current climate crisis is 1.5 degrees, by 2030 a 2.5 degree of difference is anticipated.
- We need to stop being traders and shift our focus from simply importing and exporting to more investment in research & development for manufacturing of green technology.
- Investment in skill development is needed to fasten the process.
- Renewable energy integration is intermittent; hence we can't focus on a single source. Hybridization of tech and hybridization storage is the need of the hour. The combination of all renewable energy sources is necessary.
- Investment into research and development is necessary.
- We need to plan out the right and clean energy mix by 2036.
- Even if pipelines are modified for green hydrogen, the capital investment costs can be reduced by 60-70% by using same transmission lines as oil, however the final LCOE effect would only be affected by 10-20% and the operations & management will be the same.
- Hydrogen storage is expensive and capital intensive as hydrogen has to be stored at high pressure and in carbon fiber storage capsules; manufacturing of those products is a challenge for India. There should be focus on developing these resources in India.
- India needs to innovate to become a superpower.
- The long-term goal should be centralized storage, and short term is decentralized storage; both need to be in right combination for the ideal energy mix.
- Hybridization is required at 3 levels- generation, transmission/distribution and storage of green hydrogen.

Discussion by Dr. Sudhanshu Sharma

- Focus needs to be on making electrolyser technology more efficient.
- A voltage of 1.23 is needed for water breaking.
- It is important to see the output from the hydrogen being produced.
- Adding additives to electrolyte can help to get more output of hydrogen from the same system whilst using less voltage.
    - It can double the efficiency of hydrogen and can produce 4 molecules of hydrogen instead of 2.
- Oxidizing ammonia to hydrogen makes hydrazine. It has 4 molecules and is easy to break. Hydrazine formation is useful for hydrogen storage.
- Hydrazine has no carbon footprint and increases the efficiency of hydrogen without harming the environment. It does not increase the cost of electrolysers, reduces voltage, and leaves no carbon footprint.

Discussion by Mr. Anil Agrawal

- Indian private companies and government enterprises are not recognizing and appreciating indigenous production units.
- Most domestic orders are from foreign sources.
- MSMEs hold a lot of potential that should be recognized.
- A lot of time gets wasted in following policy hierarchy.
- Government should focus on giving more business opportunities to Indian electrolyser manufacturers.

Discussion by Mr. Jitendra Trivedi

- Composites in renewables have changed a lot over the last decade with new materials being used.
- Composites offer a distinct advantage in strength to weight ratio in order to get better efficiency. There is always emphasis on reduction of weight.
- Green hydrogen storage systems are being developed heavily abroad, for e.g., high pressure storage cylinders.
- Composites play an important role in type 3,4 & 5 storage cylinders.
- We need to analyze where can raw materials be made in India.
- Most companies and countries want to be self-sufficient in their carbon fiber needs.
- The production is sufficient in India, however most of it is being exported. There is a need for a bigger market in India.
- Government initiatives such as Make in India should be taken advantage of or growing RE in India.
- It is essential to find out how end users can benefit for demand creation.

Discussion by Mr. Pawan Mehndiratta

- Corporates and government should prioritize indigenous technology and manufacturers.
- Current green hydrogen cost is $5-6 per kg; however, costs will reduce through localization of production resources.
- Other costs such as battery cost, storage cost, electrolyzer cost, etc. also need to reduce.
- There is tremendous research & development opportunity for India for reducing green hydrogen costs to become self-reliant and not rely on imports.
- Components and raw material of green hydrogen segment need to be focused on as they contain lots of opportunity such as membrane production.
- Apart from hydrogen, sustainable energy sources like pumped storage, nuclear waste heat, etc., also holds a lot of scope.
- Energy Storage System to RE - RTC power needs to be developed efficiently.
- India is well positioned in its overall energy scenario, just needs some streamlining of resources and activities.
- MNRE is very active along with institutes like CII and FICCI in developing India’s energy ecosystem.

Session Two: Green Hydrogen from Demand Side Perspective

Speakers:

1. Prodyut Maji- Associate VP, Adani Enterprises Ltd
2. Ashok Chaudhari- Sr. VP, Ankur Scientific Energy Technologies Pvt Ltd
3. Biswajit Roy- Director General, GERMI
4. Partha Banerjee- Chief General Manager (Coal & Energy), SAIL

Discussion by Mr. Prodyut Maji

- Green hydrogen is made by using clean electricity from renewable energy sources.
- Blue hydrogen is produced from natural gas along with the use of carbon capture and storage (CCS) to trap and store the carbon produced in the process.
- Adequate green hydrogen production can replace oil and gas 100%.
- 98% of grey hydrogen goes into the refinery and fertilizer sector.
- Wind and solar powered hydrogen hubs should be developed.
- Instead of electron transfer, molecule transfer of hydrogen can be done for efficiency increase.
- A big pipeline of around 200 kms can be developed at green hydrogen generation sources till close to usage point like Mundra port.
- 10-12 hrs per day hydrogen can be stored in the pipeline itself.
- 20-25% of the cost in green hydrogen production is electrolysers, which can come down with more R&D to less than $1 per kg as the input costs reduce.

Discussion by Mr. Ashok Chaudhari

- We already have the technology needed to make green hydrogen.
- The green hydrogen mission will increase the demand for indigenous green hydrogen globally.
- Around 2 million Buses and 10 million Trucks are on-roads in India consuming approx. 32 million tons diesel annually – of these around 50% travel intercity. Their consumption can be displaced by 4 Mn tons of Hydrogen.
- As consumption of H2 in this case will be decentralized manner, distributed generation of Hydrogen from biomass will be the best fit.
- Biomass is a distributed resource and the best way to use it is in a distributed manner.
- India produces an average of 500 million tons of agricultural residue every year; more than 200 million tons remains unutilized. This can be converted to tons of green hydrogen.
- Potentially up to 5,000 plants of 2-2.5 TPD H2 capacity can be setup across India.
- Apart from generating H2, there are two important by-products – Biochar and CO2
- Biochar is a highly stable form of carbon derived from gasification of biomass.

- Biochar helps reduce concentration of GHG, and when returned to soil it enhances the soil properties, improves water retention property, provides benefits like increase in crop yield, nutrient, efficiency and several environmental benefits.
- Charcoal can be used for cooking in rural areas or for any thermal heat applications in industries in and round.
- Likewise, CO2 is another by-product, and its uses could also cut emissions.
- CO2 has various applications in many different industries as well.
- Thus, from a single biomass gasification-based project, we could generate electricity, hydrogen, biochar and CO2.

Discussion by Dr. Biswajit Roy

- Indian manufacturers of green technology should be incentivized and promoted.
- Private sector should monetize R&D in India.
- We need to analyse if supply capacity should be created first or demand for green hydrogen be given priority?
- USAID's SAREP estimates that by 2030 India will have demand of 2.8 million tons of hydrogen.
- The current production of grey hydrogen is 5 million metric tonnes per annum (MMTPA). Hence, the Green Hydrogen Mission was probably set at 5 MMTPA, ~125 GW of renewable energy is needed for producing that much green hydrogen.
- Will the green hydrogen production be utilized domestically or exported?
- If excess green hydrogen is produced, there has to be setup of domestic usage so we don't export all.
- We also need to tackle usage and distribution of green hydrogen in MSMEs.
- Department of Science and Technology needs participation of industries for producing more methanol and dimethyl ether.
- Sequestration of carbon and production of value-added products is needed in India.
- NITI Ayog states that by 2030 the GH2 demand can go up to 10 MMTPA, 15 MMTPA by 2040, and 30 MMTPA by 2050.
- Key strategies for creating a green hydrogen demand-
    - Domestic consumption should be focused on rather than solely relying on exports.
    - Export capabilities should be set up efficiently.
    - Govt mandated should be set up for mandatory usage and production of green hydrogen in industries.

Discussion by Mr. Partha Banerjee

- Steel sector is considered a hard-to-abate industry due to its capital intensity, long-lived assets and, most importantly, limited commercially viable alternatives to greenhouse intensive production technologies.
- Steel and cement industries are operating in a buyer's market, i.e., their price is determined by the market, thus any increase in price affects the industry's survival. We have different types of technologies fighting to help reduce carbon footprint which can be broadly classified as Carbon Direct Avoidance (CDA) and Smart Carbon Usage.
- Making steel with hydrogen is a CDA technology, but questions are being raised as to why are we generating renewable energy-based power and converting it into green hydrogen and using that hydrogen to produce steel? It might be better to go for direct electricity. Molten oxide electrolysis is one such technology that is still evolving.
- CCUS technology needs to be evolved efficiently at large scale.
- For the steel industry, hydrogen is seen not only as a fuel but also as a reductant.
- Coal is converted into coke by pyrolysis for utilization in blast furnace, thereby generating hydrogen rich by-product gas in the process called Coke Oven Gas.
- This Coke Oven Gas, containing about 60% (mole/mole) of hydrogen is currently being utilized by the steel industry as a fuel and not as a reductant.
- Hydrogen's reaction with iron oxide is endothermic whereas carbon monoxide's reaction with iron oxide is exothermic, hence more energy is needed for reduction with hydrogen.
- In the PAT Scheme of GoI, energy efficiency is the key criteria notCO2 emission intensity. Hence, endothermic reduction reaction may not be preferred over exothermic reaction.

General Discussion Points

- GERMI has suggested that it is cheaper to run buses on green hydrogen. The problem is that a complete ecosystem for hydrogen has not been established.
- Green hydrogen is the lowest hanging opportunity for India.
- Decentralized model of green hydrogen is needed which also ensures biomass utilization.

Session Three: Green Hydrogen from International Perspectives

Speakers:

1. Saritha Sudharmma Vishwanathan- Post Doctoral Fellow, NIES (Japan)
2. Chris Bataille- Visiting Faculty, Columbia University, USA
3. Hilton Trollip- Visiting Faculty, University of Cape Town, South Africa
4. Ines Bouacida- Research Fellow, IDDRI, France

Discussion by Dr. Saritha Sudharmma Vishwanathan

- The United States and European Union (EU) lead in policy action of green hydrogen. Whereas China leads in the production or deployment of green hydrogen.
- Japan has invested around $100 billion in its hydrogen economy.

Discussion by Dr. Chris Bataille

- Hydrogen can be in India's critical advantage going forward.
- Energy security is the top priority for all countries. Development is the next priority. Climate action is the third priority. However, we need to stop treating climate as a later priority.
- India might soon reach a point where a lot more energy and raw materials would be required suddenly.
- India has access to three main forms of primary energy, viz., coal, nuclear and solar.
- Coal is the easiest source due to accessibility and the next reliance is on solar.
- The ideal course of action should be an increased focus on solar as primary and shifting a a little bit on coal or nuclear as and when needed. This would ensure less dependence on oil & gas for the country.
- Most countries will first rely on blue hydrogen and then develop green hydrogen. The EU might go back and forth between the two, whereas, the US will rely mostly on blue hydrogen.
- India can leapfrog from coal directly to green hydrogen as a complement to the already existing solar sources.
- Electricity market reforms will be needed in terms of transmission along with a hydrogen push. Relying on coal should be used as a backup.
- For now, the concentration should be on building electrolysers, storage (which can be shared by refineries, chemical, fertilizer, etc., that have hydrogen needs) and then anchor around these hubs as an affirming role on electricity.
- We should preplan the integration of all stakeholders to make the green hydrogen plus solar set up and move away from coal.

Discussion by Mr. Hilton Trollip

- The green hydrogen ecosystem in South Africa was explored four years ago as part of its Net Zero emissions strategy.
- Industries like coal, freight transportation, iron and steel are the highest energy utilizers.
- There are high amounts of iron resources in South Africa, but the country is not industrialized enough to utilize it all.
- The economy has gone stagnant and hence the steel production has decreased.
- The country's economy is energy intensive with lots of mineral, coal, solar and wind resources.
- A research study on green iron and steel making in Africa claims that all things remaining constant:
  - It would be cost compatible with the EU
  - Costs would be lower than the electricity prices in EU
  - PV integrated green hydrogen powered steel plants
  - Decarbonization of steel production
- For the South African or African market, producing steel using coal would be cheaper than using PV.
- Steel doesn't need to be replaced with anything else because its recyclable by itself.
- It is financially unviable for South Africa to give steel sectors incentives like the Europe or the US does.
- It is far cheaper to decarbonize the EU steel sector by importing steel from other countries like South Africa.
- The upstream steel making industry in Europe might see it as taking away the industry to another place, however downstream vendors will definitely benefit.

Discussion by Ms. Ines Bouacida

- Europe started green hydrogen in 2020 through several strategies. Lots of member states were involved in the process. The goal is to make Europe a hydrogen champion in the world.
- The EU set its main principles for hydrogen through a framework.
- Focus is on decarbonizing the existing uses of hydrogen for emissions reductions in refineries and chemicals and greater usage in iron & steel industries.
- The EU is relatively small for green hydrogen production and does not contain enough resources or raw materials needed for clean energy.
- Hence many member states started getting imports.
- Germany wants to building an international market for green hydrogen usage to maintain their industrial competitiveness by getting imports for their industries.
- The EU wants to import green clean energy instead of fossil fuels. However, as of now it lacks the development of supply chain needed for a low carbon world.

- Europe is mainly focused on green hydrogen not blue or grey hydrogen.
- Leadership is needed on electrolyser front in Europe to avoid importing from China.
- The green hydrogen production race is ongoing and no region is entirely leading; all are playing at same level.
- Having green electricity is also necessary as industries should have priority access to cheap green electricity for manufacturing to ensure green industrialization and green hydrogen production.
- To facilitate demand side growth, the EU has incorporated a framework of green hydrogen in industries.
- Germany, Netherlands and Belgium are looking at building import routes for hydrogen and low carbon energy products made through hydrogen.
- Not all member states in the EU have the same perspective on green hydrogen and political interference is high which stands in the way of policy development.

General discussion points:

- Green hydrogen can help abate CBAM imposed carbon taxation on products from India.
- Beyond demand the EU will also build clean energy partnerships with green hydrogen producer countries.
- Steel industry needs lots of coal and electricity. We need to analyze the amount of solar or wind power needed to run large industries like steel to decide how much green hydrogen would be needed.
- The amount of green hydrogen required for heavy freight or railways is still unknown as battery technology is still evolving.
- It is important for developing countries to enter this green hydrogen discussion so that only developed countries don’t make all the decisions.

Session Four: Economics of Green Hydrogen and Way Forward

Speakers:

1. Rahul Walawalker- President & MD, India Energy Storage Alliance
2. Prasad Thakur- Strategy, Reliance Industries Ltd.
3. Santosh Gurunath- CEO & Co-Founder, Umagine
4. Shashi Shekhar- Director, ACME *(Online)*

Discussion by Dr. Rahul Walawalker

- Economics of green technology is always a prime priority to ensure its widespread utilization.
- Green hydrogen is an opportunity to quickly decarbonize the industrial sector.
- As demand for green hydrogen grows, the market will scale up and prices will go down.
- If we want to bring down hydrogen prices then we need to look into cost reduction through supply and demand instead of relying on other countries to innovate and bring down costs
- Policy directions don't always lead to market creation, fundamental improvements in technology will lead to better market creation.
- Currently the only driver of green hydrogen is reaching net zero targets
- For the market to grow, overall cost at user level should be recognized, not individual level prices.
- Renewable energy prices need to be managed along with transmission charges.
- Economic models for green hydrogen should not be based on low electricity costs which are not real or perceivably unattainable.
- The cheapest pathway for green hydrogen production is through a solar wind storage hybrid.
- Transportation of green hydrogen to its ultimate utilization location needs to be organized. The difference between transportation of hydrogen as a fuel compared to transmission of hydrogen converted as electricity needs to be studied in Indian perspective to see which option is most feasible.
- Hydrogen's battery making infrastructure needs to develop to promote industrial usage as fuel cell.
- We need to have realistic goals at the current cost structure. There should be increased focus on blending in different sectors wherever possible.
- The technology readiness levels and the manufacturing readiness levels need to match each other.
- Value chain needs to be developed for green hydrogen which looks into:
  - How to structure electricity usage
  - Demineralizing water and its cost structure
  - Transmission details

- Usage of renewable energy as a dispatchable storage is not possible without storage.
- Skill development and human resources training need to be developed.

Discussion by Mr. Prasad Thakur

- There should be development of green hydrogen hubs to match the demand and supply network.
- We should leverage the digital prowess of country to further the green hydrogen demand. Realtime matching of demand and supply can take place through digital platforms.
  - Can be rolled out at regional level followed by state and national level.
  - Will help in global market creation in digital space
- India can become technological spokesperson of developing world by assisting technological transfer across borders.
- We should analyze how to leverage our diplomatic stature to promote our green hydrogen ecosystem.

Discussion by Mr. Shashi Shekhar

- Hydrogen is a must for reaching net zero targets and decarbonizing the country.
- Costs of green hydrogen is the main question.
- Policy requirements for cost reduction of green hydrogen are:
  - land accessibility in places with the best solar GHI.
  - 60% of the green hydrogen cost is solar power equipment. If solar energy productions costs decrease then green hydrogen can also decrease to less than Rs. 2.
- Govt of India has introduced 40% duty on import of on solar panel
  - We need proper manufacturing of solar panels and cells in India itself
  - Lower duty on solar equipment
- The Article 6.2 of the Paris Convention states that there should be assistance given to developing countries for setting up projects which can reduce carbon emissions. This can help with a significant reduction in costs as green hydrogen and green ammonia are highly capital intensive.
- Costs also depend on land pricing and Gujarat already has a policy in place to get cheap land for green hydrogen production.
- If costs of green hydrogen come down the market will start demanding, as it happened with solar energy.
- The private sector knows how to innovate and bring down costs with an increase in demand.
- We need to generate volume. Sectors like steel, transport, hydrogen power storage, etc., can also significantly create demand.
- Replacing ammonia in urea entirely is not ideal but some measures should be taken.

- R&D support by the government is needed to compete with international players in the market; specially in electrolyser and fuel cell.
- Pumped storage and repowering of wind plants should be reserved entirely for green hydrogen.
- When costs will decrease, a huge market space for green hydrogen will open up this demand will handle costs.

Concluding Session

Speakers:

1. S.B. Dangayach- Founder Trustee, Innovative Thought Forum
2. Biswajit Roy- Director General, GERMI
3. Amit Garg- Professor, IIM Ahmedabad

Concluding Remarks

- Lack of land availability in India is a myth. India's total land mass is 325 million hectares out of which 55 million hectares is wasteland.
- Gujarat has come up with a policy for the allocation of fallow land, other such policies can aid land availability for green hydrogen.
- All green hydrogen policies should be made available to all stakeholders.
- R&D institutes should be perceived as business outlets and be incentivized in that regard.
- On the supply side, large corporations have supply equipment set up or being developed.
- On the demand side, the market rules, hence when the prices reduce, the demand will increase.
- We will have to focus on a basket of renewable energy resources; green hydrogen will be a part of this larger basket.
- Policies need to be crafted whilst keeping in mind the economic conditions of the people of the country. Hence, prices can't be too high or else will be less integration on the ground.
- Different sources like research institutes, government and private companies need to come together for best solutions to energy scenario of India.

Group Photograph

List of speakers and participants

Sr. No.	Name	Affiliation	Speaker/ Participant
1	Amit Garg	IIM Ahmedabad	Speaker
2	Anil Agrawal	Airox Nigen Equipment Pvt Ltd	Speaker
3	Ashok Chaudhari	Ankur Scientific Energy Technologies Pvt Ltd	Speaker
4	Bharat Jain	Gujarat Cleaner Production Centre	Participant
5	Biswajit Roy	Gujarat Energy Research and Management Institute	Speaker
6	Chintan Shah	Indian Renewable Energy Development Agency	Speaker
7	Chris Bataille	Columbia University (USA)	Speaker (Online)
8	D J Yadav	Arvind Envisol Ltd	Participant
9	Dhara Thakkar	IIM Ahmedabad	Participant
10	Divya Arora	IIM Ahmedabad	Participant
11	Hilton Trollip	University of Cape Town (South Africa)	Speaker (Online)
12	Ines Bouacida	IDDRI (France)	Speaker (Online)
13	Jigar Shah	IIM Ahmedabad	Participant
14	Jitendra Trivedi	Aztech Composites	Speaker
15	Jyoti Maheswari	IIM Ahmedabad	Participant
16	Kajal Mahabari	PDEU	Participant
17	Kandarp Mistry	GUVNL	Participant
18	Karan Kaushal	IRM Energy Pvt. Ltd	Participant
19	Kayan Kalthia	Kasol Energie Pvt. Ltd.	Participant
20	Ketan Shah	Ex CEO-GACL-NALCO Alkalies & Chemicals Pvt. Ltd	Participant
21	Neel Shukla	Umagine	Participant
22	Nirav Patel	Indian Space Research Organiation	Participant
23	Pallavi Rachel George	IIM Ahmedabad	Participant
24	Paresh M. Shah	Sardar Sarovar Narmada Nigam Ltd	Participant
25	Partha Banerjee	Steel Authority of India Ltd	Speaker
26	Pawan Mehndiratta	Thermax Ltd	Speaker (Online)
27	Prasad Thakur	Reliance Industries Ltd	Speaker
28	Priya Singh	ArcerlorMittal Nippon Steel	Participant

Sr. No.	Name	Affiliation	Speaker/ Participant
29	Prodyut Maji	Adani Enterprises Ltd	Speaker
30	Rahul Walawalker	India Energy Storage Alliance	Speaker
31	Rashi Gupta	Vision Mechatronics	Speaker
32	Ritwika Verma	IIM Ahmedabad	Participant
33	Rutva Patel	IIM Ahmedabad	Participant
34	S B Dangayach	Innovative Thought Forum	Speaker
35	Samir Shukla	Umagine	Participant
36	Sanjay Kumar Jain	IIM Ahmedabad	Participant
37	Santosh Gurunath	Umagine	Speaker
38	Saritha Sudharmma Vishwanathan	NIES (Japan)	Speaker (Online)
39	Shashi Shekhar	ACME Group	Speaker (Online)
40	Shwetal Shah	Climate Change and Sustainability Expert	Participant
41	Sneha Lavate	PDEU	Participant
42	Srinivas Cherla	Research and Innovation Circle of Hyderabad	Participant (Online)
43	Sudhanshu Sharma	IIT Gandhinagar	Speaker
44	Vidhee Avashia	IIM Ahmedabad	Participant
45	Yogesh Thakkar	Indian Society of Heating, Refrigerating and Air Conditioning Engineers	Participant

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Annexure 3

Seminar on
Climate and Renewable Energy Policies for Gujarat towards Net Zero 2070

Co-organizing Institutions: IIMA, IIT Gandhinagar, ITF

Under the aegis of Climate Change Department, Government of Gujarat

Event Date: 15th February 2023

Location: CR, 2nd floor, JSW-SPP, New Campus, IIM Ahmedabad

Context and objective

As announced by the Hon'ble Prime Minister of India, Shri Narendra Modi at COP26, the world needs to follow the mantra of LiFE, i.e., Lifestyle For Environment – A global movement to affect paradigm shift from mindless and destructive consumption to deliberate utilization.

Negative environmental externalities have to be internalized – be it GHG emissions, local air pollution, land degradation, water pollution etc. LiFE would guide major transformative actions for leading the world towards its objective of Net Zero emissions.

The journey towards net zero 2070 for India would need substantiating the indispensable role played by states like Gujarat, leading renewable energy transformations. Gujarat is blessed with abundant land, over 300 days of sunshine a year and vast shoreline fit for wind power harnessing. This has contributed to the Renewable Energy sector in Gujarat growing annually by 22% since 2011.

As renewable energy in Gujarat advances, new challenges are being faced at the policy making as well as implementation stages. These need to be deliberated through a holistic approach that leads to modern and practical solutions and alternatives. For instance, grid flexibility and management of fossil-based power would become important considerations for deploying more renewable energy necessitating managing the load curves. Energy storage including flow batteries and electric vehicles would also require closer scrutiny.

The objective of this event was to discuss the various new technical paradigms in the areas of energy policy and renewable energy, under an overarching framework of climate change using the current trends and emerging ecosystems that are implementable on ground.

The seminar was held to answer several questions such as:

- How can we enhance development indicators even with lower energy consumption in Gujarat through energy efficiency practices both on supply and demand sides?
- What is the future for Energy Efficiency obtained through Demand Side Management?
- What could be the role of non-fossil energy sources in a Net Zero emission scenario through appropriate policies in Gujarat?
- What role would Electric Vehicles play in optimizing the logistics and supply chains?
- What are up and coming practical renewable energy policy suggestions in solar, wind, bioenergy, and green hydrogen?
- What could be the role of buildings and greener built spaces towards NZ?
- What are the possible integration areas for energy, water use efficiency and agriculture?
- How can we utilize the AYUSH Ministry in achieving the Prime Minister's LiFE Mission goals?
- What are additional policies needed over and above the existing policies, and specific implementation challenges in existing policies Gujarat would need to address in renewable, climate change and Net Zero domains?

Moreover, the event promoted an open discussion between policymakers, industry leaders and researchers on the following themes:

Renewable Energy Development in Gujarat

The session concentrated on gaining insight into recent developments in solar and wind energy

and its implementation for contributing to the Net zero emissions target. It also discussed the future of fossil fuels in an era of sustainable development through technologies like smart grids, CCUS, and prospective expansion of bioenergy in Gujarat.

Emerging Technologies and Policies

The session deliberated on new technical paradigms in RE, mainly within Transportation through

Hydrogen Fuel Cell/Battery Operated Electric Vehicles and scope of EVs in logistics policy. Green Hydrogen and its role in the future of sustainable transportation.

Natural Resource Management

It broadly explored two integrated verticals of water conservancy and sustainable agricultural practices. It analyzed the scope of sewage water treatment for industrial, institutional, and agricultural uses. It also looked into water efficient grains like millets, agricultural market policy, fertilizer & urea policy, solar powered water pumps, etc.

Integrating climate change policies with Health and LiFE Mission

The session discussed the future and development of the AYUSH ministry under Govt. of India and its possible role in achieving the ideals of Hon'ble PM's LiFE Mission as integrated with climate change policies. It also analyzed national health schemes like Health Mission and its integration with AYUSH.

Detailed Schedule

10:00 – 10:30 AM	**Registration**
10:30 – 11:15 AM	**Inaugural Session** ● Mr. S.B. Dangayach ● Prof. Amit Garg ● Mr. S.J. Haider, IAS, Principal Secretary, Climate Change Department (To be Confirmed)
11:15 – 11:30 AM	**High Tea**
11:30 – 1:30 PM	**Session One:** *Renewable Energy Development in Gujarat* ● Solar Energy ● Wind Energy ● Bioenergy ● Fossil Fuels and CCUS **Speakers:** Mr. Divyesh Desai (Session Coordinator)- Asia Head, Shell Corporation Mr. Vinod Kala- Founder, Emergent Ventures India Mr. S.B. Patil- Former Deputy Director, GEDA Mr. Jami Hossain- Vice President and Technical Chair, World Wind Energy Association Mr. S.V. Jaltare- Former Director, MSEDCL
1:30 – 2:30 PM	**Lunch**
2:30 – 3:45 PM	**Session Two:** *Emerging Technologies and Policies* ● Green Hydrogen ● Energy Storage ● Buildings ● Transportation **Speakers:** Mr. Kirit Naik (Session Coordinator)- Energy Expert and Former Director, Centre for Fuel Studies and Research Mr. Rajan Rawal- Senior Advisor and CRDF Professor, CARBSE, CEPT Mr. Pankaj Patel- CEO, Abellon Mr. Anupam Jalote- Former CEO, iCreate Mr Pankaj Pujara- Executive Director, GACL
3:45 – 5:00 PM	**Session Three:** *Natural Resource Management* ● Water Conservation ● Sustainable Agriculture

	Speakers: Prof. Tushaar Shah (Session Coordinator)- Emeritus Professor, IRMA Mr. D.J. Yadav- Director & CEO, Arvind Envisol Ltd Mr. Shawahiq Siddiqui- Founder, IELO
5:00 – 5:30 PM	**Session Four:** *Integrating climate change policies with Health and LiFE Mission* **Speakers:** Mr. S.B. Dangayach (Session Coordinator)- Founder Trustee, Innovative Thought Forum Dr. Narendra S. Bhatt- Ex-President, IASTM. Ex-CEO, Zandu Pharmaceuticals
5:30 – 6:00 PM	**Concluding Session** **Speakers:** Prof. Amit Garg (Session Coordinator) Mr. S.B. Dangayach Mr. Divyesh Desai Prof. Vimal Mishra- IIT Gandhinagar Representative from Climate Change Department

Key Takeaways from all the Sessions

Session 1: Renewable Energy Development in Gujarat

- Looking at new and improved business practices and technical innovations in all sectors along with demand side policies to facilitate business.
- Installation of Battery Energy Storage System (BESS) to reduce penalties during peak power demand.
- Measurement of power consumption at feeder level of agricultural consumer
- Develop Bioenergy Roadmap for India, with specific focus on Gujarat, through consultation of various ministries and relevant businesses.

Session 2: Emerging Technologies and Policies

- Identifying various sources of hydrogen production and promoting its usage through increased investment opportunities.
- Ensuring proper implementation of green building practices through appropriate Monitoring, Reporting and Verification (MRV) measures.
- Prioritizing usage of green building materials and grid interactive efficient building technologies.

Session 3: Natural Resource Management

- Grid integration of unmetered tube wells and agriculture pump-sets under SKY scheme.
- Use greywater which is generated from wastewater treatment by supplying it to industries at certain cost.
- Strengthen the implementation of wastewater policies at state level and "Zero Liquid Discharge" policy at city level.
- Package sewage treatment plants (PSTP) for wastewater treatment in rural or remote areas.
- Comprehensive state-wise policy for water foot printing for various crops.

Session 4: Integrating Climate Change Policies with Health and LiFE Mission

- Promoting research and awareness program to achieve LiFE Mission
- Promote Ayurveda and Homeopathy based medicines and healthcare systems through Ministry of Ayush as they offer sustainable, eco-friendly and climate resilient solutions.

Common Takeaways

- Increased thrust on actual economics amongst energy, water, agriculture, and health nexus.
- Demand side policies/programs should be prioritized in each sector.
- Recognizing relevant ministries and departments as key stakeholders for the successful implementation of policies.
- Restructuring the policies/programs to incentivize the successful business models in each sector.
- Periodical review/revision of relevant policy/program to ensure efficient implementation.
- Gradually reducing or eliminating subsidies or incentives from policies/programs which achieve set target through market push.

Detailed Minutes of the Meeting

Inaugural Session

- Opening and welcome address by Mr. S.B Dangayach.
- Lighting of the lamp by Mr. Kirit Naik, Dr. Narendra Bhatt, Mr. Bharat Jain

Speakers:

1. Prof. Amit Garg- IIM Ahmedabad
2. Mr. S.B. Dangayach- Founder Trustee, Innovative Thought Forum Introductory address by Mr. S.B. Dangayach

- We need to develop a positive nexus between development and environmental betterment.
- The 19th and 20th century were led by development that neglected the environment. However, now with environmental regulations and laws in place, there lies a big scope of environmentally positive growth.
- There is no dearth of policies in India, the main challenge is the proper implementation of policies.
- Focus should be on the development of a holistic approach towards the nexus between energy, environment, development, health, etc.

Introductory address by Prof. Amit Garg

- Our key objective to is to deepen the existing policies whilst identifying policy gaps for achieving Net Zero emissions for Gujarat.
- This can be achieved with the help of Kaya Identity for Gujarat.
- The mapping of key energy policies at the state and national level is being done to help achieve the targets.
- Nuclear energy is a part of the solution towards NZ 2070. It has to be appropriately included.

Session One: Renewable Energy Development in Gujarat

Speakers:

1. Mr. Divyesh Desai (Session Coordinator)- Visiting Faculty, IIM-Ahmedabad
2. Mr. Vinod Kala- Founder, Emergent Ventures India
3. Mr. Jami Hossain- Vice President and Technical Chair, World Wind Energy Association
4. Mr. S.V. Jaltare- Former Director, MSEDCL

Introductory address by Mr. Divyesh Desai (Session Coordinator)

- There has been consistent focus and effort by the government to make India a low carbon economy.
- This move from fossil fuels to clean energy is a huge and demanding challenge for the government as well as for industries.
- Hence, the need of the hour is to improve dialogue between these two stakeholders to become a cleaner economy as soon as possible.
- We need to keep innovating and creating new solutions to achieve cost effective RE growth.

Suggested Policy Recommendation(s):

- Enhance dialogue between government and industries for achieving net zero targets.

Discussion by Mr. Vinod Kala

- The economic viability of energy transition to renewable sources has always been in question.
- Recently, the cost of renewable energy generation has been getting lower and will continue to do so in the future.
- Energy storage costs have been rising recently but are projected to go down as well with increased usage.
- Upcoming Sodium-ion batteries will be even cheaper and bring costs further down.
- Industries should look positively towards obtaining renewable energy and feel confident that the cost curve will decline.
- There is a need to look at businesses more creatively and view RE as an additional service provided by businesses to the consumers.
- Industrial consumers are charged more to subsidize retail consumers. Industries are already paying taxes, but they also end up paying cross subsidy surcharge or open access charge which immensely cuts into their profits.
- Subsidies given by the government to installation companies and not to consumers. Here, on several instances the subsidy companies' money from the government remains pending, hence, they get demotivated to install any more units.
- Gujarat's renewable energy portfolio is very ideal to meet its needs.
- The utility charges may seem high at first, but they are easy to recover in the long run through cross subsidizing.
- Lithium ion has become the cheapest storage source for batteries lately. These batteries can last for 7000-10000 cycles for whole life. The depth of discharge is up to 90% in them.
- There needs to be increased focus on usage of renewable energy for creating green hydrogen, running electric vehicles and energy storage.
- A reasonable open access charge (Rs. 1KWh) to utilities can lower down the scale and additional services.

Suggested Policy Recommendation(s):

Financial hurdles to production and access to RE are plentiful at all levels; subsidy challenges, high battery costs, cross subsidy and open access charge and storage costs. There needs to be streamlining and coordination between these different charges to reduce the burden on industries.

Discussion by Mr. S.V. Jaltare

- The installed capacity of RE generation is 25 % of total installed capacity of generation in the State of Maharashtra. However, during peak load period, the contribution of RE sources is only 3-6 % in catering towards the demand. On the contrary, during lean load period, RE contribution is around 21-26 %. Hence the electricity grid has stability issues and technical challenges of absorbing RE power of uncertain nature.
- Gujarat is taking power to the tune of 7000 MW from the Central Grid. The deviation from schedule attracts heavy penalties. For controlling and reducing deviation, installation of Battery Energy Storage System (BESS) can be a pragmatic option.
- It would also be beneficial for giant manufacturing hubs to have energy storage supply solutions.
- Agricultural consumption of energy is difficult to measure. But anything that cannot be measured cannot be controlled. Hence centralized measurement on AG separated feeders or Distribution Transformer level is an optimal solution.
- Survival of micro grids is a big question as without a common grid we can't have common cost & price. Hence the need for a centralized grid can't be ruled out to ensure centralized pricing.
- It is estimated that a 100 MW plant will need Rs. 1000 crore investment for Battery and Energy Storage system.
- The costs of Battery and Energy Storage systems are projected to come down from $151 per KW/hr. to $50 by 2030, however, it needs to be much quicker for positive industry results.

Suggested Policy Recommendation(s):

A balance needs to be maintained between decentralized and centralized grid usage in the country by deepening and integrating both wherever possible; Decentralized grids can ensure energy efficiency, however they are difficult to measure for cost estimation, whereas centralized grid ensures proper costing but leads to energy leakages.

Discussion by Mr. Jami Hossain

- Wind power potential of India was earlier estimated at 45 GW for the whole country but now new estimates by National Institute of Wind Energy (NIWE) peg it at 600 GW and in Gujarat at around 1500 GW. However, other assessments (LBNL/ Hossain 2011) have come up with higher estimates.
- Moreover, offshore Wind energy potential is estimated at 35 GW for Gujarat.
- The most recent development in the field is solar-wind hybridization. This is a great model for Gujarat as there is high potential for solar based generation in the daytime and abundant

coastal winds at nighttime. Hence, it helps in increasing the plant load factor when a Wind-Solar hybrid model is used. Hybrid models are also possible with other sources of energy such as biomass.

- Currently projects are set up under reverse auction regime, while earlier a system of Feed-in Tariffs was followed. Feed-in tariffs differed across the states, making it
- possible for a balanced RE development across India. However, under reverse auctions, a balanced development is challenging.
- Hybridization concepts such as Round the clock power, Peak power, Wind solar- battery storage and energy storage need to be studied deeply to create new policies for future development.
- It is clear that renewable energy can meet almost 80% of power requirements. If the operation of thermal power plants is flexible, much higher renewable energy components can be integrated into the power system.
- Size of the wind turbines has been increasing in recent times. However, Small wind turbines, i.e., less than 1MW are also needed to come up for micro grid level projects with appropriate policy measures. These can be used for rural electrification, or a relatively smaller captive C&I segment.
- Smaller vertical rooftop wind turbines (like rooftop solar) should be explored for further development.
- Individuals are only allowed to have one wind turbine as the government does not want thermal power plants to become defunct NPAs. Hence, TPPs have been given 10-15 years to recover its costs so that the move to renewable energy can be smoother.
- Cooking energy needs can be met by hydrogen.
- Stand-alone wind turbines that only generate hydrogen are under development in Europe.

Suggested Policy Recommendation(s):

The RE market is constantly developing new technologies such as wind-solar hybridization, small wind turbines for micro grid integration, clean cooking energy by using hydrogen, etc. Policymakers need to work alongside these technical advancements to create appropriate policy measures to guide the growth of new technologies.

General Discussion Points from the Session

- Bioenergy is not treated equal to other renewable energy resources. There needs to be a stronger market for bioenergy sources like liquid slurry.
- Fertilizer usage of bioenergy can provide great results.
- Bioenergy missions should be structured with different ministries coming together like Agri, power, etc. A road map needs to be developed for this utilization of bioenergy.
- There needs to be a better collection of biomass feedstock to generate more bioenergy, ethanol, and green chemicals. However, the biogas programme is not properly recognized by the Agriculture Ministry and hence, it faces immense challenges.
- There needs to be increased focus on the demand side as 24x7 power is not demanded by industries, most are 12x7.

Suggested Policy Recommendation(s):

- There exists a space to create a policy that can provide decentralized power access for businesses at lower costs since most of them can run with 12x7 power supply.
- There should be an appointed nodal agency that gives training for the implementation of new technical RE factors along with domain experts.

Session Two: Emerging Technologies and Policies

Speakers:

1. Mr. Kirit Naik (Session Coordinator)- Energy Expert and Former Director, Centre for Fuel Studies and Research
2. Mr. Rajan Rawal- Professor, CEPT Uni. and Senior Advisor CARBSE at CEPT Research and Development Foundation.
1. Mr. Pankaj Patel- CEO, Abellon
2. Mr. Anupam Jalote- Former CEO, iCreate
3. Mr Pankaj Pujara- Executive Director, GACL

Discussion by Mr. Kirit Naik

- For years humankind has been using much more energy in the form of fossil fuels than it is capable of regenerating. Hence, alternative green-regenerative resources need to be produced at a reasonable cost.
- GOI's goal is to make India a Green Hydrogen hub by producing 5 million metric tonnes per annum by 2030.
- Key elements of the hydrogen infrastructure are: points of production of Power-Hydrogen, Storage of Power-Hydrogen, transmission & distribution systems, end use options and refueling station networks.
- The biggest challenge is deciding who will bear the costs of Green Hydrogen?
- Several upcoming technologies can help solve these challenges such as one being done by SunHydrogen Inc., where they produce renewable hydrogen using sunlight and water using panels that house multiple hydrogen generators using nanoparticle-based green hydrogen technology. If this technology achieves commercial success, it will do the work of two elements of the Green Hydrogen value chain (Power Generation and hydrogen production via electrolysis) and hence bring down the total capital cost requirement across the whole value chain.
- Looking at the total investment required across the value chain, if 5 MMMTA green hydrogen production were to be achieved by 2030, it would necessitate average capital expenditure of roughly Rs. 31250-Rs. 36458 Crores month after month for the next ninety-six months.
- H2One Station Unit made by Toshiba as a one container model for Hydrogen Filling Stations for FCEV (Fuel Cell Electric Vehicle).

- There needs to be increased investment in GH2 and electrolyser manufacturing in India to help reduce the value chain costs through domestic production.
- Focus is needed towards reducing transmission and conversion losses between AC and DC power for Green Hydrogen.
- US Department of Energy, Las Vegas Valley Water District, and Proton Energy Systems, the Center for Energy Research developed a refueling station for renewable hydrogen that was powered by solar energy.
- H2One Station Unit made by Toshiba is a great one container model for boosting green hydrogen production.
- When electricity is produced using methane (natural gas or biogas) as a feedstock in the high-temperature fuel cell, additional hydrogen is produced within the fuel cell stack leading to a hydrogen-rich stream of gas leaving the fuel cell unit. Thus, 125 kilograms per day of hydrogen can be produced along with an electrical output of 250 kW, based on over 8,500 hours of system testing and a "pressure swing adsorption" (PSA) process for hydrogen separation.
- We can also use recycled mixed paper waste to produce "greener than green" hydrogen.

Suggested Policy Recommendation(s):

- Current costs of Green Hydrogen production in India are very high. Government needs to focus on attracting investments in GH2 and electrolyser manufacturing. This can be done in integration with several new technical advancements (such as H2One Station, PSA process, etc.) for producing GH2 economically.

Discussion by Mr. Pankaj Pujara

- The current challenges with Green Hydrogen lie with its production, distribution, consumption pattern, distribution network, regulatory framework, and costs.
- Generating Green Hydrogen by electrolysis of water requires about 55 kwh/kg, which is about Rs. 440/kg @ Rs 8/kwh (Rs 110/kg @ Rs 2/kwh) at generation end. The affordable price for Green Hydrogen is Rs.100 – 150/kg. at users' end.
- The market price of Compressed Hydrogen from Chlor-alkali plants is 200-250/kg plus transportation cost of about Rs.80 – 100 / kg within 50 – 100 km. The generation is decentralized.
- This Hydrogen can be used for Kick-starting Green Hydrogen Economy. By incentivizing chlor-alkali sector for use of green power to maximum extent will turn this Hydrogen into Green Hydrogen, hence, saving investment on new Green Hydrogen installations.
- This hydrogen can be used in the mobility sector and at construction/mining sites.
- Since hydrogen produced in chlor-alkali plants is generated through electrolysis of water (mixed with some common salt), this hydrogen can be considered green to the extent the power used for the electrolysis is renewable.
- This will reduce (a) the cost of green hydrogen drastically (b) save on huge capital costs being incurred on installing new electrolysers for generating Green Hydrogen (c) save a lot of time, since electrolysers in chlor-alkali plants are already operative all over India (65% in Gujarat), many of which are already operating partially on renewable energy and

- (d) make Green Hydrogen readily available for various applications in mobility (cars, buses, trucks and rail), at construction sites & at mining sites replacing diesel powered equipment.

Discussion by Mr. Rajan Rawal

- The key solution towards reaching Net Zero emissions is to analyze how to reduce our consumption rather than how to generate more power and energy.
- We need to focus on producing technology that utilizes less resources.
- Energy should be studied from both operational and embedded energy perspectives.
- The Amended Energy Conservation Act 2001 gave birth to the Bureau of Energy Efficiency (BEE).
- BEE produced a code on Energy Efficient buildings, called ECBC and ENS. But the market driven green building rating programs that are voluntary in nature led to further greenwashing in the sector as these ratings are usually limited on paper for a market push to sell them at a premium. ECBC and ENS should be implemented at the state level.
- The building sector has several custodians such as MoHUA at the national level and ULBs at the local level, this leads to a lot of confusion regarding whose responsibility the building is.
- There is no real accountability or check on the actual construction of the building with green practices in place.
- Green building and urban energy efficiency needs to be managed at mission mode for at least 5 years before being given to any ministry. There is also a lack of a Department of Energy at the National level, there is only a ministry that deals with the topic.
- Should be increased focus on creating an agency or a department that tackles the demand side of energy in India.
- The ECBC Code exists but its implementation is very improper as there are no checks in place to verify adherence to the Code. Hence, there exists an implementation gap.
- Good step forward would be to reduce the carbon intensity of steel, cement, bricks, etc., to have emission reduction at the root itself rather than attempting to make new concepts for ‘green buildings. Hence, if the govt is considering policies it should be for sourcing of green building materials.

Suggested Policy Recommendation(s):

There exists a severe lack of accountability and checks and balances within the construction sector. Lack of implementation of building code stems from authority confusion that needs to be tackled as the building sector has several custodians such as MoHUA at the national level and ULBs at the local level.

- There exists a space for the creation of a Department of Energy at the National level or a department to tackle the demand side of energy in India.

Discussion by Mr. Anupam Jalote

- There needs to be an effort to produce energy efficient Electric Vehicles, i.e., usage of renewable energy in charging and producing EVs. EVs can become 2x cleaner when recharged with RE.
- EVs are most efficient at a certain RPM, hence, the new switch electric motors used in HVACs are more stable.
- The variable frequency drive useful for energy efficiency remains the same despite low RPM.
- The usage of EV buses by states saves 8rs per/km.
- To grow energy storage solutions there should be an availability of appropriate technology at appropriate price points.
- A good area to investigate are Aluminum air batteries (produced in Israel) which are not stable yet but can definitely be improved upon for stability.
- The usage of hydrogen should not just be as an automotive fuel. It is a brilliant energy storage reserve, and its alternative uses should also be explored.

Suggested Policy Recommendation(s):

- A broader roadmap for EVs can be drawn up which suggests measures on recharging EVs with renewable energy to maximize its clean energy potential.

Discussion by Mr. Pankaj Patel

- Need of the hour is to focus on developing a circular economy model for India.
- At the current rate, almost 60% of all things produced need to be recycled in order to achieve Net Zero goals. Hence, there lie only two options with us, i.e., reduce our consumption or increase our recycling potential.
- Social infrastructure needs to be revisited to analyze and stop environmental leakages.
- Fused materials such as in phones need better understanding to ensure most efficient recycling practices with long term environmental viability.
- We need a comprehensive policy for Gujarat to harness all its renewable energy potential, even from recycled sources.
- Currently, the same REC is given for 1 MW of energy used from any renewable source. However, there should be different REC values attached to different sources of RE as some practices end up negating emission effects more than others.

- For e.g., the REC given for Solar and Bioenergy is the same, even though direct sourcing of waste by companies to produce bioenergy prevents waste from ending up in landfills and releasing methane. Hence, double benefits to the environment are seen in such scenarios.

- The land use plan in Gujarat needs improvement. It should go beyond just agriculture and buildings.
- Introduction of new clean fuel supply to street vendors such as tea shops, sweet shops, etc., through RE sources like biomass pellets will be a huge step towards less fossil fuel consumption.
- Bamboo forests should be grown and promoted as they possess a lot of potential for bioenergy. However, this development will take 2-4 more years to become popular. They can also be made highly sustainable by using greywater for irrigation as these are non-consumption plants.

Suggested Policy Recommendation(s):

- Every state should create an in-depth land use plan which includes exploration of RE positive spaces such as surface mining of bioenergy, solar parks etc.
- Need of the hour is to focus greatly on a circular economy model for India. Recycling of materials and intensive WTE plans are crucial for the Net-Zero mission.

Session Three: Natural Resource Management

Speakers:

1. Prof. Tushaar Shah (Session Coordinator)- Emeritus Professor, IRMA
2. Mr. D.J. Yadav- Director & CEO, Arvind Envisol Ltd
3. Mr. Shawahiq Siddiqui- Founder, IELO

Introductory Address by Mr. Tushaar Shah

- Opportunities for change in water, energy, food, and environment disciplines
- There exists a thick relationship between these disciplines and Gujarat is the best example for Water-Energy-Food-Environment Nexus
- Practical and implementable things that can be done to bring change in this nexus are to be looked upon.

Discussion by Prof. Tushaar Shah:

- Gujarat is by far the oldest example for a gridlock between energy and water. A bulk of irrigated land depends on Groundwater which requires pumping where water-energy nexus comes into action.
- 20 lacs tube wells 15.5 lakhs are metered tube wells having by monthly bills for which farmers are charged at 60 paisa/unit. The rest 50000 unmetered tube wells use as much energy as 1.5 million metered tube wells.

- According to the CAG report 2016, the average kWh used for the metered tube wells was 7100 units and 25515 units for unmetered tube wells. The avg subsidy for metered connection was 13600 rupees/year and for unmetered connection was 1,77,741 rupees/year.
- The average subsidy per unit for metered connection was 1.94 rupees and 6.97 rupees for unmetered connection.
- These unmetered tube-wells are a dead weight on Gujarat's economy. There is an urgent need for unmetered tube wells to be metered. However, that is a great challenge for the Water, Groundwater, and Energy sector.
- In case of flat tariff connections, the connection between groundwater scarcity and energy cost gets snapped.
- 2/3rd tube well connections in Gujarat are metered making it better than other states.
- The SKY scheme includes only 4500 solar tube wells, which are connected to the grid; the rest 35000 are still off-grid.
- Saving energy in irrigation and selling more of it has emerged as an attractive livelihood option. 90% farmers who were first buyers are now net sellers.
- The Surya Urja Rooftop Yojana-Gujarat (SURYA-Gujarat) gives Urban-rich 30% capital subsidy and freedom from paying 7 rupees/unit for 7000 units/year. If the same policy is applied for the SKY scheme it can lead to flat tariff connections will solarize and get metered and the metered tube well owners would give up subsidy and start selling energy.
- Single policy recommendation for Suryashakti Kisan Yojana (SKY) and Surya Urja Rooftop Yojana-Gujarat (SURYA-Gujarat) in Gujarat will help harness water energy nexus to max efficiency.

Suggested Policy Recommendation(s):

- An action plan is needed to achieve complete metering of all tube-wells to reduce their dead weight on Gujarat's economy.
- Increase focus on hybrid policies such as solar powered tube wells with micro irrigation facilities that can help generate more electricity whilst using less water resources.

Discussion by Mr. D.J. Yadav:

- One of the major issues faced by industries in renewable energy is the improper definition of group-captive power plants.
- Currently the industries can put only 50% of their contract demand equivalent amount of renewable power capacity, which should be removed.
- The enforcement of banking charges on a certain amount of electricity generated through renewable assets should be logical and reasonable.
- Consistency in policies and alignment of Central and State government policy essential in helping businesses become successful.
- There are three segments of water: Industry, Agriculture and Sewage. The low-lying fruit and high potential area is sewage water.
- There is a need to treat 70% of sewage water in India, which remains untreated and spoils the good water and soil.

- The High court case against Ahmedabad industries led to stoppage in discharging of industry effluents in sewage water as it makes the treatment of sewage water unfeasible.
- Several industries require greywater; thus, untreated sewage water can be directly given to them free of cost which can lead to a lesser cost burden for Urban Local Bodies (ULBs).
- By supplying sewage water to industries, treatment cost, load on sewage network and energy cost on pumping can be reduced.
- Packaged Sewage Treatment Plants: FRP tanks that can be installed underground in Gardens can save transportation and treatment cost of sewage water and save fresh water being used for the purpose.
- Packaged sewage treatment plants should be brought into use. It will help in sewage water treatment at rural or micro level usage. (This will be a big cost saver for the ULBs both and pumping and treatment cost. The sewage line capital expenses can be avoided for new areas and for old areas where a sewage line exists the capacity of lines will be released to avoid overflowing. In addition, this will save fresh water being used for gardening, washing and construction purposes.
- Proposal for industries to directly treat sewage as it will lessen the costs of ULBs and provide greywater much needed by industries. An auction system can be put into place. Untreated sewage shall be offered to Industry at no cost as ULBs will save the complete pumping and treatment cost and their lines capacities will be released. In addition, their freshwater demand will reduce. The treated sewage water shall be offered at cost to Industries to save fresh water.

Suggested Policy Recommendation(s):

- Streamlining of policies at national, state, and local levels is needed to make Renewable Energy production, financing, and access easier for industries.
- Sewage water treatment and utilization policy needs to be developed efficiently along with government and industry stakeholders and a possible suctioning system of sewage water to industries for its treatment and subsequent usage can be developed.

Discussion by Mr. Shawahiq Siddiqui:

- For Agri-Forestry, there are three verticals to be looked into for creating a good policy, viz., Motivational aspect, Enabling aspect and Implementation aspect.
- There needs to be work on developing Comprehensive Water data, this would answer: Where is the water, Quantity, and Quality of water, and what needs to be done to access and use this water.
- Policy for water in Gujarat mainly focuses on motivational and enabling aspects.
- Comprehensive evaluation of all policies across sectors on implementation of strategies is recommended.
- Preparation needs to be done to claim more water based on increasing socio-economic needs for 2024 Narmada water review.
- There is no clause in favor of Gujarat in Narmada water clause to increase the water supply based on prior use rights of river water.
- Gujarat wastewater policy (2018) has no pricing formula for wastewater, lacks information about investors and buyers, and lacks infrastructure for implementing the policy.

- There is a need for rationality in terms of Pricing and Implementability to strengthen the urban wastewater policy in Gujarat.
- The concept of Zero liquid discharge (ZLD) should be implemented in cities.
- There has been no attempt to make scientific studies of West flowing rivers of India which can ensure maximum growth through E-flow assessment. This would also make environmental clearances easier.
- The generation of green belts, strip forest and wasteland forest need to be promoted.
- The PM has pledged to restore 26 million hectares of land by 2030. Linkage of this Land restoration plan with wastewater management is to be contemplated.
- There is a need for a Comprehensive review of all the NRM policies in Gujarat to strengthen their implementable aspects (finance, monitoring, results, incentives). As of now these policies lack practical efficiency.
- Creating a concept of (cities as) wastewater catchments. 80% of all freshwaters supplied to cities must return to productive/economic uses and be incentivized. Need for revising wastewater policy of Gujarat on these lines.
- The Gujarat government should focus on preparing for negotiations for the share of water from Narmada for Gujarat.
- Need for the state's green mission, agro-forestry, and land degradation targets to be linked with wastewater reuse targets and certification system put in place.

Suggested Policy Recommendation(s):

- Carrying out a comprehensive water data drive to understand where is water present, quantity, and quality of water, and what needs to be done to access and use this water.
- Amendments are needed within Gujarat wastewater policy (2018) as it has no pricing formula for wastewater, lacks information about investors and buyers, and lacks infrastructure for implementing the policy.

General Discussion Points from the Session

- Urban local bodies can’t give away sewage for free as it is a public good. An auctioning system can be put into place for companies to purchase sewage.
- After being treated, the industrial wastewater is disposed into the ultimate disposal locations with no further use. Hence, in order to make use of the resource, further wastewater treatment can be provided to optimize the potential for recycling and reusing in the industrial cluster while lowering the need for freshwater (Gujarat has Common Effluent Treatment Plants at 35 places and created 850 MLD treatment capacity with required additional treatment, the treated wastewater can be recycled and reused).
- There should be optimal usage of irrigation practices, water, and energy in accordance with the amount of water requirement of different crops.
- Identifying multiple Groundwater recharging opportunities for maintaining groundwater reserves.
- Establishing an effective and continuous groundwater monitoring will aid in guarding quantity and quality of groundwater.
- Increasing plantation drives on the banks or shoal of rivers/rivulets/tributaries to minimize the soil erosion due to meandering paths as well as fast movement of water in the water bodies.

Suggested Policy Recommendation(s):

- Water foot printing of different crops is needed to promote sustainable agriculture and responsible water consumption.
- Water accounting should be focused on in different areas like agriculture, local body usage, industry usage, etc. across the state to have updated real figures for creating efficient policies.
- Industrial Wastewater treatment Policy needs to be redefined to provide an inevitable scope of identifying the possibilities of recycling and reusing the treated wastewater in the industrial clusters.

Session Four: Integrating Climate Change Policies with Health and LiFE Mission

Speakers:

1. Mr. S.B. Dangayach (Session Coordinator)- Founder Trustee, Innovative Thought Forum
2. Dr. Narendra S. Bhatt- Consultant Ayurveda, Research, and Industry

Discussion by Mr. S.B. Dangayach

- The term "Vasudhaiva kutumbakam" stands for One earth, One family, One future which indicates all of us being interconnected and responsible for all our actions.
- The focus on earning profit by businesses must be ethical and take into account the environment, the universe and self.
- Consumerism should be well thought out and considerate so that is not polluting and harmful to the environment.
- The health sector needs to be looked at holistically through a combination of ethics, environment, and economics.
- Resource management from the demand side holds key importance.
- The National Health Policy of 2017 is promotive, preventive, rehabilitative, palliative, and curative in nature.
- Focus needs to be emphasized on emission free health practices like Yoga and Naturopathy as it is very healthy and does not lead to any emissions.
- Homeopathy is a complete green practice as it requires very less medicinal content, is energy efficient, healthy, and eco-friendly.
- Homeopathy lacks attention and requires greater research and promotion. It is an all-rounder sustainable practice for use in human health, animal health, agriculture (as crop enrichers), horticulture, floriculture, and aquaculture.
- Autonomous system and separate set of rules for revalidation of AYUSH for greater acceptance by people should be considered.
- To keep in line with the Bhopal Declaration, we should be focusing on integrative health systems for the country i.e., Traditional practices + Allopathy.
- AYUSH has the right credentials for developing a no greenhouse gas emission system, climate friendly and climate resilient policies along with the well-being of people.

Suggested Policy Recommendation(s):

- Earnest implementation of National Health Policy 2017 to help reduce the carbon footprint of healthcare.
- Creation of an autonomous body to revalidate new and repurposed AYUSH drugs in tune with individual knowledge systems whilst ensuring its safety and efficacy.

Discussion by Dr. Narendra S. Bhatt

- Ayurveda views all life in a cyclic form. Hence, it promotes healthy consumption and a circular economy process.
- Lifestyle disorders have been on the rise due to increased work-life imbalance.
- Transportation, transformation, and formation defines the complexity of human beings which needs to be studied deeper.
- The shifting of work hour to one hour prior will help in utilizing natural sunlight and conserve energy, whilst improving people's health and lifestyle practices by waking early.
- Ayurveda practices establishing balance between the physical attributes termed as Ahar, Vihar and Ausadhi.
- Deforestation has led to decreased and degraded availability of ayurvedic medicines.
- There is a need for therapeutic relevance or application-oriented standardization model for ayurvedic plants.
- A study on the effects of air conditioners on human bodies should be performed.
- The out-of-pocket medical costs of the country are pretty high at the moment. A paper on the economics aspect of ayurveda which can lead to reducing the medical cost to 5% can be taken up.
- Environmental policies should be developed by keeping in mind the impact they have on individuals in the region.
- We need to study how carbon footprint can be reduced with the right kind of policy with cohesiveness of various departments.
- Emissions from healthcare are given minimum attention as of now. Need of the hour is for: 1) Alternatives for Disposable items and recyclable packaging, 2) Encouraging renewable energy for health infrastructure and 3) Targeting zero energy emission from health equipment.

Suggested Policy Recommendation(s):

- Enhanced policies are needed for application-oriented standardization of ayurvedic and homeopathic plants for maximizing their efficiency and growth.
- Zero emissions roadmap for the health sector can be created through interventions like recyclable packaging, utilization of renewable energy in health setups, focus on ayurvedic medicines, etc.

Concluding Session

Speakers:

1. Prof. Amit Garg- IIM Ahmedabad

2. Mr. S.B. Dangayach- Founder Trustee, Innovative

Concluding address by Prof. Vimal Mishra

Thanking everyone for a variety of new learnings spread across all the sectors discussed. We can definitely develop several policy briefs with the help of these discussions. Climate mitigation is a long process hence we need to keep developing new ideas and technologies to keep achieving our targets quickly and efficiently.

Concluding address by Prof. Amit Garg

Recapturing important and key takeaways for policy changes towards Net Zero Emissions in Gujarat.

Concluding address Mr. S.B. Dangayach

Thanks, and regards to all speakers and other participants for making the seminar successful through their fruitful discussion.

Group Photograph

Speakers and Attendees

The seminar was attended by a total of 41 participants. This consisted of 16 Speakers and 25 attendees.

List of Participants and Speakers

Sr. No.	Name	Affiliation	Speaker/ Attendee
1	Amit Garg	IIM Ahmedabad	Speaker
2	Anupam Jalote	iCreate	Speaker
3	Ariba Khan	CEPT University	Attendee
4	Bharat Jain	Gujarat Cleaner Production Centre	Attendee
5	Bhavya Pathak	CEPT University	Attendee
6	D.J. Yadav	Arvind Envisol Ltd	Speaker
7	Dhara Thakkar	IIM Ahmedabad	Attendee
8	Divya Arora	IIM Ahmedabad	Attendee
9	Divesh Desai	IIM Ahmedabad	Speaker
10	Gaurang Patel	JRK Group and IPA Gujarat	Attendee
11	Jami Hossain	World Wind Energy Association	Speaker
12	Jigar Shah	IIM Ahmedabad	Attendee
13	Jyoti Maheshwari	IIM Ahmedabad	Attendee
14	Karan Dangayach	Accura Tradelink Pvt Ltd	Attendee
15	Ketan Shah		Attendee
16	Kirit Naik	Centre for Fuel Studies and Research	Speaker
17	Kumar Shantanu Bharadwaj	Climate Change Dept, GoG	Attendee
18	Mukesh Bhandari	Firefly	Attendee
19	Namrata Ghosh	IIM Ahmedabad	Attendee
20	Narendra S. Bhatt	Ayurveda Consultant	Speaker
21	Nikhil Bhargava	GACL	Attendee
22	Pallavi Rachel George	IIM Ahmedabad	Attendee
23	Pankaj Patel	Abellon Clean Energy	Speaker
24	Pankaj Pujara	GACL	Speaker
25	Paresh M. Shah	SSNN Ltd.	Attendee
26	Rajan Rawal	CEPT University	Speaker
27	Rajesh Baldania	Climate Change Dept, GoG	Attendee

Sr. No.	Name	Affiliation	Speaker/ Attendee
28	Ritwika Verma	IIM Ahmedabad	Attendee
29	Rutva Patel	IIM Ahmedabad	Attendee
30	S.B. Dangayach	Innovative Thought Forum	Speaker
31	S.V. Jaltare	MSEDCL	Speaker
32	Sanjay Kumar Jain	IIM Ahmedabad	Attendee
33	Sailesh Patwari	NEPL	Attendee
34	Shawahiq Siddiqui	IELO	Speaker
35	Shivang Swaminarayan	Homoeopathic Medical Association of India	Attendee
36	Sushant Sahoo	DRR & Climate Change, UNICEF	Attendee
37	Tushaar Shah	IRMA	Speaker
38	Varunesh Kumar	Veeral Controls Pvt Ltd	Attendee
39	Vidhee Avashia	IIM Ahmedabad	Attendee
40	Vimal Mishra	IIT Gandhinagar	Speaker
41	Vinod Kala	Emergent Ventures India	Speaker

Climate Change Department
Government of Gujarat

IIMA
विद्याविनियोगाद्विकास:

Ministry of Environment, Forest and Climate Change

Annexure 4

Stakeholder Brainstorming Session on "Towards Climate Change Resilient and Low Carbon Gujarat"

Under the aegis of

Department of Climate Change, Government of Gujarat
Ministry of Environment, Forests and Climate Change, Government of India

Date: February 14, 2020

Venue: SR7, New Campus, IIM Ahmedabad

Agenda of the stakeholder brainstorming session

11:30 – 12:00	Registration and Tea/Coffee
12:00 – 12:05	Welcome address - Prof. Amit Garg, IIM Ahmedabad
12:05 – 12:35	Inaugural thoughts by Shri Mukesh J. Shah (Joint Secretary (E)) and Shri Shwetal Shah (Technical Advisor), Climate Change Department, Government of Gujarat
12:35 – 12:55	Presentation by Prof. Amit Garg, IIM Ahmedabad
12:55 – 13:15	Brainstorming Deliberations
13:15 – 14:15	Group Photograph & Lunch
14:15 – 16:00	Continuations of Brainstorming deliberations
16:00 – 16:10	Thoughts by Chief Guest Shri S. J. Haider (IAS), Principal Secretary, Climate Change Department, Government of Gujarat
16:10 – 16:25	Continuations of Brainstorming deliberations
16:25 – 16:30	Conclusions and The way forward
16:30 – 17:00	Group Photograph & Tea/Coffee

List of Attendees

The stakeholders from the various government departments, academic institutions and research organisations from Gujarat attended the session are as follows:

Sr. No.	Name	Institute/ Organization	Email id
1	Dr. Abha Chhabra	SAC, ISRO	abha@sac.isro.gov.in
2	Prof. Amit Garg	IIM Ahmedabad	amitgarg@iima.ac.in
3	Ms. Aradhya Agrawal	IIM Ahmedabad	aradhyaa@iima.ac.in
4	Mr. Arpit Shah	IIM Ahmedabad	arpits@iima.ac.in
5	Dr. Arun Kumar Roy Mahato	GUIDE, Bhuj	akroymahato@gmail.com
6	Dr. Chandan Kumar Jha	IIM Ahmedabad	chandan1929@gmail.com
7	Dr. Dhimant Vyas	Narmada Water Resources, Water Supply, and Kalpsar Department, GoG	dhimantbvyas@gmail.com
8	Prof. Dileep Mavalankar	IIPH, Gandhinagar	dmavalankar@iiphg.org
9	Mr. Epen Sam	M S University, Baroda	sam.joe9167@gmail.com
10	Ms. Harsha N. Shelat	AAU, Anand	hnshelat@aau.in
11	Mr. Jaypal Sinh Chauhan	IIM Ahmedabad	jaypalsinhc@iima.ac.in
12	Mr. Jigar Shah	IIM Ahmedabad	jigarshah@iima.ac.in
13	Ms. Jyoti Maheshwari	IIM Ahmedabad	jyotim@iima.ac.in
14	Dr. K. Karthikeyan	GUIDE, Bhuj	karthikmicrobio@gmail.com
15	Ms. Manju Bhati	IIM Ahmedabad	manjub@iima.ac.in
16	Dr. Minal Pathak	Ahmedabad University	minal.pathak@ahduni.edu.in
17	Shri Mukesh J. Shah (Joint Secretary (E))	Climate Change Department, GoG	ds-ccd@gujarat.gov.in
18	Mr. Omkar Patange	IIM Ahmedabad	phd16omkarp@iima.ac.in
19	Dr. Paresh Pandya	AAU, Anand	prp_anand@yahoo.co.in
20	Ms. Pavithra V	IIM Ahmedabad	pavithra@iima.ac.in
21	Dr. Priya Dutta	IIPH, Gandhinagar	priya.iiphg@gmail.com
22	Shri R D Kamboj (IFS)	GEER Foundation, Gandhinagar	dir-geer@gujarat.gov.in
23	Mr. Rajesh Shah	Vikas (NGO), GEER Foundation, Gandhinagar	vikascfd@gmail.com

Sr. No.	Name	Institute/ Organization	Email id
24	Shri S. J. Haider (IAS, Principal Secretary)	Climate Change Department, GoG	secccd@gujarat.gov.in
25	Prof. Satish Kumar	M S University, Baroda	bodla_satish@yahoo.co.in
26	Shri Shwetal Shah (Technical Advisor)	Climate Change Department, GoG	spshah987@gmail.com
27	Dr. Suresh Acharya	CC Shroff Research Institute, Mandvi	ccsri1955@gmail.com
28	Dr. Sweta R. Rajpurohit	GEER Foundation, Gandhinagar	sweta.rajpurohit@gmail.com
29	Prof. Udit Bhatia	IIT Gandhinagar	bhatia.u@iitgn.ac.in
30	Dr. V S Suthar	Kamdhenu University, Gandhinagar	vsuthar28@gmail.com
31	Dr. Vatsal Bhatt	U.S. Green Building Council & LEEDS	vatsalbhatt@gmail.com
32	Prof. Vimal Mishra	IIT Gandhinagar	vmishra@iitgn.ac.in
33	Mr. Vinay Kumar Vase	ICAR-CMFRI, Veraval	v.vinaykumarvs@gmail.com
34	Dr. Yogeshvari K. Jhala	AAU, Anand	ykjhala@aau.in

Objective

This brainstorming meeting was held to have initial discussions with sectoral and regional experts and practitioners to understand the challenges and opportunities if Gujarat has to move towards being a **climate change resilient** and **low-carbon** state.

The minutes of this stakeholder brainstorming session are as follows:

Pre-lunch session

Welcome Address by Prof. Amit Garg to all the stakeholders.

Inaugural address by Shri Mukesh Shah (Joint Secretary (E), Climate Change Department, Government of Gujarat)

- IIM Ahmedabad and IIT Gandhinagar have been given the project for revising the SAPCC for the Government of Gujarat that is to be submitted in a few months. Taken help from outside consultants (KPMG) as well for climate change decisions
- The objective of the SAPCC is to guide climate policymaking at the GoG level for the next 10 years
- Need projects and funding from GoI, Green Climate Fund, etc. for climate related activities.

Inaugural address by Shri Shwetal Shah (Technical Advisor, Climate Change Department, Government of Gujarat)

- Climate Change Department (CCD) in Gujarat started 10 years ago.
- Trying to implement climate related activities at the GoG level. IPCC AR5 now clearly defines anthropogenic emissions as the the cause of climate change. Sub-national activities also under focus. Multiple acts in place in India (Water Act, Air Act, Environmental Act) since three decades, but pollution still to be brought under control.
- CCD was first time in India that an administrative sub-national department set up for climate change with no legislative backing? But CCD's actions are speaking for themselves. They incentivized solar policy in local regions etc. Now also have wind energy policy. Progress on renewables is also good. GoG also announced no new coal-based power plants.
- GoG has done well on surface water supply, healthcare, education, emergency health services, subsidy scheme for EVs (benefits of EV include air quality, energy security by reducing oil imports - need to combine renewable generation with EVs), biofuels.
- Paris agreement commitments by India - 40% renewable energy, decoupling GDP and energy consumption (reducing energy intensity of GDP). GoG trying to do its share.
- GoG mainstreaming climate action at the budget level. 19 out of 26 government departments now budget for climate action (adaptation and mitigation). 5,000 Cr provision for climate change in 2019-20. Now making budget for 2020-21.
- Need to meet SDG targets - need to work on town planning, green buildings, circular economy, etc.
- To achieve holistic targets, need awareness creation and capacity building.

- SAPCC v2.0 - already identified nine thematic areas of work.
- Prof. Garg - matrix of policies prepared by Prof. Garg and to help prioritize actions and resources.

Presentation by Prof. Amit Garg

Objectives

- First of its kind proposal in India at a sub-national scale
- Discussion with sectoral and regional experts to understand opportunities and challenges in meeting overall objectives of become resilient and carbon neutral
- Integrated strategy (remove sectoral, regional silos)
- Keep global climate in the mind

Outcomes

- Shared understanding on steps required
- GCF proposal creation

GCF Proposal Process

- Project concept note: 12 pages
- GCF replies in a month. Provides seed money to do workshops, proposal development etc. Limit for seed money is 300 K to 1.5 M USD
- 2 years from GCF approval to submit final proposal. Funds to be channeled through SIDBI, NABARD, IDFC
- If GCF accepts proposal, it funds projects. Project funding could vary from 2 M USD to 378 M USD (Indian projects so far 34 M to 100 M). Research can be 3-4% of this funding, other funds to be used for implementation of actionable projects on the ground
- If projects succeed, they can be used as showcase to then explore alternate funding sources

Discussion Themes and Institutions

Anand Agriculture University (AAU), Anand & CC Shroff Institute, Mandvi

- Can contribute in agriculture and animal husbandry sector
- Agriculture (mainly rice cultivation interventions)
    - Reduce fertilizer requirements (25%) while increasing yield (10%) (still cannot completely replace chemical fertilizers at this point)
    - Fertilizers are less expensive than chemical fertilizer
    - Positive effects on animal and livestock industries in rural areas
    - Nitrous oxide produced during intermittent flooding and drowning
    - No additional technology required
    - Needs awareness creation for farmers to get them to use bio fertilizers and change seed treatment practices. This needs changes in traditional farming practices
    - Reduce nitrogen, potash, etc requirements in fertilizers through these interventions

- Animal husbandry – dietary interventions
  - Reduce methane emissions in ruminants. Reduce dietary energy loss
  - Focusing on ecologically friendly dietary interventions for livestock. Reduce 10%-12% of methane emissions by minor dietary emissions
  - Increases milk yield at the same time (0.5 to 1 litre per day)
  - Improved reproductive performance of animals
  - Farmer gets INR 30-40 more from the animal per day

- Question: Has AAU adopted a village and made it model village?
  - Answer: Working with local KVKs
  - Answer: Working with local entrepreneurs also

- Dr. Suresh Acharya (CC Shroff Research Institute, Mandvi)
  - Endophytes: Create secretion and layer outside cell to prevent damage to groundnut crops
  - Groundnut that are tolerate water stress and saline conditions
  - Experiments have been done to test these interventions and they have worked
  - SRT technology can improve cultivation
    - Weed management and soil erosion also stops
  - There are other interventions that can make crops temperature resistant
  - Interventions in Kutch – address issues like sodium content etc. But need farmer awareness creation

- Shri R D Kamboj (Director, GEER Foundation)
  - Need to involve all agricultural universities (SAUs) of Gujarat State as these are working in different areas and in silos
  - Bio-fertilizers are old concepts that need to be made popular

- Prof. Garg question:
  - These interventions work technically but how do we take these to market?
  - How do we convince farmers?
  - What models will work?

- Dr. Abha Chhabra (SAC, ISRO)
  - Use remote sensing to check agricultural practices in a low cost way. SAC (ISRO) can contribute to this (SAC already working with agricultural universities like AAU, Junagadh)
  - In implementation part, use remote sensing to study project progress and implementation
  - Need remote sensing to be made available to researchers, administrators, policymakers

- Prof. Dileep Mavlankar (IIPH, Gandhinagar)
  - Need to improve data systems for health
  - Local data not being compiled or being made published or usable
  - Project can include healthcare care data systems improvement
  - Policy of 10 year vehicles: need to understand differences between 10 years old commercial and personal vehicles that haven't been used much. Cannot use blanket policies at all places

- Increasing intensity of forestry in places where space was available. Can we increase tree cover in all available places? Forestry Department suggestions not in tune
- Solar projects: Streamline policies (IIPH cannot get funds for more solar since it already has funding for initial solar projects)
  - Why not fund 250% solar if an institution has space instead of restricting it?

- Shri Mukesh Shah response to Prof. Dileep Mavlankar
  - GoG will revise solar policy now (work is in progress). Please give suggestions

Lunch Break (13:20-14:30)

Post lunch session

Agriculture and livestock sector

- **4 SAUs, other research centres etc.**
  - Ms. Harsha (AAU) to coordinate agriculture relevant inputs for initial proposal note
  - Dr. Paresh Pandya (AAU) to coordinate inputs for livestock and animal husbandry projects in the proposal
    - To keep productivity and vulnerability reduction and less on methane
  - Dr. Suresh Acharya (CC Shroff Research Institute) inputs
    - Seaweed production through using coastline. Suggested other projects to increase fodder use efficiency etc. (using microbes)
  - **Shri R D Kamboj (GEER Foundation)**
    - Sea weed project did not succeed in Kutch (even though it was included in the NAPCC)
    - Need to select suitable projects
    - To increase cattle produce
  - **AAU inputs**
    - Need good genotypes for production. Need good bull to have good future generations of livestock
    - Educate farmers to use appropriate bulls for reproduction. This is a basic step that can be taken
    - Need to increase milk production of nondescript (local cross breeds) cattle as their production is currently low
- Ms Harsha and Mr. Pandya to coordinate agriculture and livestock inputs (1 page write-up expected from them after taking inputs from all agriculture focused institutes)
- Inputs by Mr Rajesh Shah (Vikas, NGO, with support from GEER Foundation)
  - Mangrove walls at the coastline project (green wall, bioshield)
    - Multiple benefits of mangroves (CO_2, soil erosion, salinity reduction)
    - Currently 35 km pilot project

- Can be scaled to a 1,000 km project (out of 1,600 km coastline) with the help of local organizations
    - Need climate research centers at all coastal areas to prepare climate change database
- Local climate information to be captured
- Needs to be led at the community level
- Need to build local institutions that can understand, address climate change
    - Urban belt industrial estates
- These cause pollutions
- Special component needed to reverse this

- Mr. Vinay Kumar Vase (College of Fisheries Science (CMFRI), Veraval)
    - Deals with marine fisheries and oceanography
    - 30,000 fishing boats in Gujarat (conflicts in coastal areas with shared coasts across states, countries)
    - Artificial fish habitats within the sea
    - This can be done as a project to incentivize sea life and reduce vulnerability of fishers
    - Can be converted to marine parks etc, in future
    - Currently pilot project with Department of Fisheries
        - Can create protected areas in the sea
        - Can maybe do technical fixes and attempt seaweed project again
- Mr. Vinay and Mr. Rajesh to take responsibility for inputs for coastal and marine components of project

Sector-wise responsible personnel

- Mr. Vinay, Mr Rajesh (Fisheries): Coastal & Marine
- Ms Harsha (AAU): Agriculture
- Ms Harsha, Dr Pandya (AAU): Livestock
- Dr. Minal Pathak (AU): Urban Development
- Dr. Minal Pathak (AU), Dr. Vatsal Bhatt (LEEDS): Performance and monitoring mechanisms
- Dr. Abha Chhabra (SAC, ISRO): Monitoring mechanism to provide real time monitoring information using indicators defined upfront for the project. Also, take enquiry to higher management at ISRO to potentially create a portal for this project specifically that combines ISRO data with data from other institutions involved in this project. Portal to rest under the control of the GoG
- Ms Priya Dutt, Prof Mavlankar (IIPH) – Addressing climate change – health externalities with wide canvas

- Mr Chandan Kumar Jha (CMA, IIMA) – Downscale national models for Gujarat, scenario analysis (to work with Prof. Sandip for this)
- Dr. Minal Pathak (Ahmedabad University)
  - Can work with demand sectors (urban development, buildings, transport) for mitigation options
  - Behavior change projects for demand reductions
  - Need to understand interactions across systems instead of projects and silos
  - Ms. Minal to take responsibility on urban development
  - What is time horizon?
  - Need representation from NGOs, industries
  - Could look at climate change education as an initiative
- Mr. Vatsal Bhatt (LEEDS)
  - Main expertise: Energy systems analysis for urban and state systems
  - Other work: Green building certification
  - Can contribute to understanding and build performance metric platforms, international best practices

Water sector

- Dr. Dhimant Vyas (Narmada Water Resources, Water Supply, and Kalpsar Department, GoG)
  - Gujarat – water scarce state. 20 of 185 basins are perennial
  - River rejuvenation programmes can be part of the project
  - Alternate water systems as part of project: Desalination, reusing treated wastewater (May 2018 policy)
  - Jal Jeevan Mission
  - On agricultural, irrigation sectors: low percentage under micro-irrigation. Improving this could be a project (saves water, improves yield, saves power, reduces vulnerability). Can coordinate with Sardar Sarovar dam into this etc.
  - Large scale groundwater recharge projects needed (Atal Gujal Yojana). Current projects have reduced dark zones from 40 to 24 talukas
  - Managed aquifer recharge programs can be part of projects
  - Addressing water runoff
  - Control of salinity
  - Inter/intra-basin water transfer projects
  - Participatory irrigation management (community management of irrigation)
  - Solar pumps used to lift water from cutting canals (PM Kusum Yojana). Could be expanded for 5 HP pumps (these can lift from canals but not from groundwater)
- Prof. Vimal Mishra, Prof. Udit Bhatia (IIT-Gandhinagar)

- Water resources, climate change projections (developing and downscaling – already doing for SAPCC)
- Climate extremes (heat waves, droughts, floods) – understanding risks and hazards
- Suggestion: Focus on 3-4 key sectors with solid proposal instead of broad-based but shallow proposal. Where are the most opportunities of making low carbon transitions at low costs? Which are the most climate vulnerable areas that need low carbon transitions?
    - Mr. Shwetal Shah agrees to focus on few areas/ districts/ sectors as vulnerability assessment is part of the exercise
    - Dr. Minal Pathak: 30% framing full landscape, 70% deep dive into specific interventions
- Prof. Udit works on resilience
    - Understanding remodeling and reusing existing infrastructures
    - Improve recovery processes with well-informed data based decision making

o Dr. Shweta Rajpurohit (Manager, GEER Foundation)

- Resource deprivation is actually a resource distribution problem
- Water, food, renewables etc resources unevenly distributed spatially
- Rural people have a huge debt problem (uncertain incomes, high interest rates)
    - Need a financial inclusion component in these projects
- Interconnecting departments, connecting with practitioners, industry people, NGOs etc. Need policies to be grounded at the local community level
- Need strong monitoring mechanism for proposal and projects
- Share data across participating institutions. Prepare database of successful case studies

o Abha Chhabra (SAC, ISRO)

- ISRO can help with mapping and monitoring mechanism
- Presented ISRO capabilities
    - Vedas (earth systems visualizations)
    - Meteorology web portal (MOSDAC)
    - Village level indicators – NDVI, vegetation condition, etc. can be tracked
    - Solar, wind site selection tools
    - Urban sprawl monitoring systems
    - Solar PV potential by location
    - Desertification atlas
    - Coastal regulation zones
    - Air quality monitoring
    - Air quality-health relationship with primary data

- Oceanography – temperature, precipitation events, ocean currents, forecasts, surface winds etc. (OceanEye)
- Heat wave amplification by urban environment
- Cyclone vulnerability – surge hikes, trajectory etc.
- Information dissemination through satellite communication
- NavIC (Indian GPS - position accuracy enhanced, advisory for fishermen, air pollution monitoring)
- NavCOM – Real time train information systems, coastal surveillance

o Dr Satish, Humanities (MSU, Baroda):

Can take responsibility for non-technical components such as

- Community engagement
- Baseline surveys
- Private sector tie-ups for CSR activities that align with these projects
- Jal Sanchar Udyan project done by MSU for small area recently
- Adopted 5 villages for another projects

o Thoughts by Shri. S J Haider (Chief Guest of Session), Principal Secretary, Climate Change Department, GoG

- Daunting task to address climate change
- Needs all of us to collaborate to tackle the problem
- INR 5,000 Cr project across 18-19 departments allocated in the previous GoG budget
- Progressive policies – solar, wind, small hydel, waste-to-energy, solar rooftops etc.
- Need these policies to be integrated to form a low-carbon roadmap
- Formulating GPDP (Gram Panchayat Development Plan) – addresses need to provide solutions for both rural and urban areas (current focus on mostly the urban areas)
- Will do vulnerability mapping as well
- Current SAPCC inadequate. Need a better plan (now that SDGs etc. Paris agreement etc. are around)

- Prof. Garg Presentation on **"**Workshop Outcomes"
  - Each institution to provide a one-page write-up
  - Main challenges for Gujarat in your sector
  - Opportunities for addressing these challenges
  - Your roles – R&D, action/implementation support
  - Deadline – February 29, 2020

- Post this, preparation of draft project concept notes (PCN) for inputs.
- PCN to be shared with CCD, GoG, then to NABARD and then MoEF&CC (GoI).
- Final Project concept note to be submitted to GCF

- Dr. Arun Kumar Roy Mahato, Gujarat Institute of Desert Ecology (GUIDE, Bhuj)
  - Working in arid parts of Gujarat
  - 25% region is arid (50% of this is Little + Great Rann of Kutch) – degraded land
  - Land restoration activities in Kutch (vegetation cover) as a pilot project (such type of vegetation as can provide livelihoods, fodder etc.)
  - Grass land development plan
  - Wetland recharge and protection plan needed
- Dr. Priya Dutt (IIPH-Gandhinagar)
  - State Heat Action Plan (on lines of Ahmedabad Heat Action Plan)
  - Database preparation for health (prepare data format and how to maintain the data)
  - Heat health threshold
  - Heat mitigation – cool roofs
  - Air pollution action plan
  - Water borne disease prevention
  - Maternal health, epidemiology
- Dr. Chandan Kumar Jha (Post Doctoral Fellow, CMA, IIMA)
  - Working in land use, sustainability, food, sustainable pathways etc.
  - Suggestion: have co-benefits or other such integrated assessment
  - Dietary systems of people – how to improve diets to minimize climate impacts?
  - Can work on assessment tools (downscale national tools to Gujarat level)

Group Photo with Stakeholders of Brainstorming Session (Pre-Lunch)

Group photo with Stakeholders of Brainstorming Session (Post-lunch)