DR KIRAN C PATEL CENTRE FOR
SUSTAINABLE
DEVELOPMENT

Annual Report

2021-22

CSD.IITGN.AC.IN

ABOUT THE CENTRE

Dr Kiran C Patel Centre for Sustainable Development (KPCSD) at the Indian Institute of Technology Gandhinagar (IITGN) was inaugurated on January 30, 2019. The Centre aims to advance local and global sustainability solutions through cutting-edge interdisciplinary research and field projects on water, pollution, waste management, climate change, energy, natural resources, wildlife and ecosystems. The Centre also promotes sustainable solutions through its strong educational, outreach and technology-transfer programs.

PROGRAMMES OF THE CENTRE

Research: research and consultancy on sustainability and promoting national and global collaborations.

Practice: lab-to-field technology transfer and implementation on campus and in its neighbourhood.

Education: curriculum development at IITGN and advancing education on sustainability nationally and globally.

Outreach: conferences, networking, training programs and workshops.

The mission of KPCSD is to:

- Identify and conduct interdisciplinary research on sustainability-related problems of high societal importance.
- Develop solutions to sustainability challenges by integrating research, traditional knowledge and field understanding, and translate them into prototypes, patents, and publications.
- Establish an effective technology transfer programme for sustainability solutions in the field.
- Implement sustainability solutions on campus and its neighbourhood.
- Develop a strong outreach programme of training, education, awareness and community engagement on sustainable livelihood and development.
- Promote networking and collaboration among scholars, policymakers, industry, non-profit organisations and other stakeholders on sustainability.
- Promote educational programmes on sustainability at IITGN.

KPCSD's current focus areas are:

Water: Water and wastewater treatment, desalination, safe drinking water production, hydraulics and water resources engineering, water resource research, water-energy systems, river science

Pollution & Waste Management: Air, water and soil pollution, air quality, laser spectroscopy, particle engineering, built environment, low-cost air quality sensors, environmental policy, surface engineering, waste to-resource techniques

Climate Change: Climate risks, extreme climatic events, climate variability, food-energy-water security, climate change impacts, critical infrastructure resilience, internal variability, hydrometeorological extremes, physics-guided machine learning for hydrological processes, hydrologic modelling

Energy: Fuel cell systems, energy systems, distributed energy, heating, ventilation and air conditioning, energy conversion and storage, optimisation, energy management, organic electronics and LEDs, solar cells, renewable energy, electricity market, smart distribution grid/ microgrids, thermodynamic optimisation, smart manufacturing

Natural Resources, Wildlife & Ecosystems: Wildlife conservation, indigenous peoples, social and environmental justice, natural resources management, environmental archaeology, sustainability modelling, earth surface processes, sustainable stream management

The Year in Review 2021 - 22

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1. Executive Summary

The Dr Kiran C Patel Centre for Sustainable Development at the Indian Institute of Technology Gandhinagar was established in January 2019 to promote interdisciplinary research and educational initiatives, undertake outreach activities and field projects, and advance sustainable development in a range of domains, including water, pollution, waste management, climate change, energy, natural resources, wildlife, and ecosystems. The Centre has a large faculty cluster, with nearly 20 faculty members associated with it.

The Climate Change Department of the Government of Gujarat and KPCSD, IITGN have established a strategic partnership to develop a Climate Change Policy and Roadmap for achieving Net Zero by 2070 in Gujarat. This collaboration sets the stage for both parties to work together towards a more sustainable future for Gujarat. IITGN's commitment to sustainability is reflected in the Times Higher Education Impact Rankings 2022, which assessed nearly 1,500 universities worldwide against the United Nations' Sustainable Development Goals (SDGs). IITGN ranked in the top 200 globally for SDG 1 (no poverty) and SDG 6 (clean water and sanitation), and in the top 300 for SDG 7 (affordable and clean energy). IITGN was also featured in the report "Universities Facing Climate Change and Sustainability", commissioned by Körber-Stiftung in preparation for the Global University Leaders Council Hamburg 2021. KPCSD contributed to collecting, compiling and submitting data on sustainability for both the rankings and the report.

KPCSD has announced an interdisciplinary "Minor in Sustainable Development" for IITGN students from the academic year 2022-23. Nearly ten graduate and undergraduate courses related to sustainability were offered at the Institute in the past year, in which around 280 students enrolled. KPCSD affiliate faculty organised various sustainability-focused workshops and short courses to foster knowledge-sharing, facilitate research networking, and identify opportunities for collaborative research projects and training initiatives.

In 2021-22, the Centre witnessed several new and ongoing sustainability-focused research projects at the Institute. Several IITGN faculty published research publications and conference presentations on sustainability. Nearly 50 research projects were sanctioned and under progress during the past year, which broadly touched upon the Centre's focus areas, including water, pollution, climate change, energy, and natural resources and ecosystems. The ongoing research projects being undertaken at the Institute address the United Nations Sustainable Development Goals and encompass a broad array of themes, including sustainable river management, sewage disposal, effluent reuse, wastewater management, drinking water production, desalination, air quality, atmospheric pollutants, greenhouse gas emissions, municipal solid waste management, climate change impacts assessment on various sectors such as water resources, agriculture, infrastructure, and energy, flood risk assessment, hydrological processes, modelling and forecasting systems, cyber-physical distribution systems, high-efficiency photovoltaics, solar cells, energy storage and technologies, electric vehicle applications, mangroves, wildlife hunting, and Indian heritage, among others. Faculty members at IITGN are engaged in consultancy and internal projects relating to sustainability in the domains of climate change, hydropower, groundwater depletion, environmental damage due to anthropogenic activities, groundwater quality monitoring, and renewable energy.

During the past year, KPCSD launched a database of organisations across India that work in the domains of sustainable development on its website. The Centre supported a pilot project to manage sewage and greywater in rural and peri-urban areas. It also hosted a 13-member delegation from Leh and Kargil districts of Union Territory Ladakh who visited IIT Gandhinagar to understand the functioning of the Institute's Sewage Treatment Plant and explore various options of sustainable systems for sewage treatment in the extreme cold climate of Ladakh.

The Centre endeavours to advance sustainable solutions in the public and private sectors by disseminating theoretical and practical knowledge, providing training resources, and raising awareness about sustainability through numerous events held throughout the year. Notable events conducted in 2021-22 include a Design Thinking Workshop in collaboration with IBM and an e-seminar on climate change mitigation and resilience organised jointly with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and PricewaterhouseCoopers (PwC). The KPCSD Sustainability Seminar Series featured eight webinars covering topics related to climate change, energy, food security, natural resources conservation, and environmental and human health, with the goal of increasing awareness and promoting networking among sustainability professionals and researchers. Due to the pandemic, most events were held online, and a diverse group of stakeholders, including industry professionals, NGO representatives, government officials, academicians, and researchers, participated.

2. People

Core Committee Members

Achal Mehra
Visiting Professor, Humanities and Social Sciences and Coordinator, KPCSD
Research interests: Online media, media management, investigative reporting, media law, media ethics, censorship, international communications, comparative media systems, mass media and society

Vimal Mishra
Professor, Civil Engineering and Co-coordinator, KPCSD
Research interests: Climate change, climate variability, hydrologic modelling, extreme climatic events, food and water security

Ambika Aiyadurai *(Core committee member until 20th September, 2021; thereafter affiliate faculty member)*
Assistant Professor, Humanities and Social Sciences
Research interests: Wildlife conservation, indigenous peoples, Northeast India, social and environmental justice, Himalayan borderlands

Sudhir Kumar Arora *(Core committee member from 20th September, 2021)*
Professor of Practice, Civil Engineering
Research interests: Infrastructure development, water supply (urban/ rural), sewer networks and STPs, reuse of treated effluent, low cost sanitation, rain water harvesting, energy efficiency

Manish Kumar *(until 30th July, 2021)*
Assistant Professor, Earth Sciences
Research interests: Freshwater contamination, micro and emerging pollutants, urban pollution and sustainability, pollution assessment tools, remediation techniques

Chhavi Nath Pandey *(Core committee member from 20th September, 2021)*
Visiting Professor, Civil Engineering
Research interests: Carbon sequestration of coral reefs of Gujarat, status of grasslands of Saurashtra and Central Gujarat, potential area mapping for mangrove restoration in South Gujarat, Kachchh and Saurashtra

Sameer Patel *(Core committee member from 20th September, 2021)*
Assistant Professor, Civil and Chemical Engineering
Research interests: Air quality, air pollution control, built environment, renewable energy, energy poverty, low-cost air quality sensors, environmental policy

Naran Pindoriya
Associate Professor, Electrical Engineering
Research interests: Electricity market, smart distribution grid/ microgrids, grid integration of distributed renewable energy resources, energy management

Jaichander Swaminathan
(Core committee member until 20th September, 2021; thereafter affiliate faculty member)
Kanchan and Harilal Doshi Chair
Assistant Professor, Mechanical Engineering
Research interests: Thermodynamic optimisation, heat and mass transfer, system-level analysis, optimisation, effluent treatment, zero liquid discharge

Affiliate Faculty Members

As on 31st March, 2022

Nipun Batra
Assistant Professor, Computer Science and Engineering
Research interests: Machine learning, air quality, energy

Atul Bhargav
Professor, Mechanical Engineering
Research interests: Fuel cell systems, energy systems, distributed energy, heating ventilation and air conditioning

Udit Bhatia
Assistant Professor, Civil Engineering
Research interests: Critical infrastructures resilience, internal variability, hydrometeorological extremes, physics guided machine learning for hydrological processes

Rajendra Bordia

Guest Professor, Material Science and Engineering

Research interests: Ceramics, energy conversion, energy storage, high temperature materials, composites

Arup Lal Chakraborty

Professor, Electrical Engineering

Research interests: Laser spectroscopy, air quality measurement, mid-infrared lasers

Sharada C V

Assistant Professor, Humanities and Social Sciences

Research interests: Environmental archaeology, archaeozoology, sciences in archaeology

Hari Ganesh

Assistant Professor, Chemical Engineering

Research interests: Smart manufacturing, model predictive control, optimisation, energy and environment, building energy management, indoor air quality

Auroop Ganguly

Guest Professor, Civil Engineering

Research interests: Climate risks, infrastructure resilience, machine learning, nonlinear dynamics

Chinmay Ghoroi

B. S. Gelot Chair Professor, Chemical Engineering

Research interests: Particle engineering, cohesive powders, surface engineering, wetting and antibacterial surfaces/ bacterial adhesion, drug formulation, nano-materials for drug delivery/ controlled release, solid-phase reactions for functional materials, water treatment

Vikrant Jain

Professor, Earth Sciences

Research interests: River science, earth surface processes, climate change impacts and rivers future, sustainable stream management, flood hazards

Anirban Mondal

Assistant Professor, Chemistry

Research interests: Organic electronics, solid electrolytes, organic LEDs, solar cells, machine learning

Sudhanshu Sharma

Assistant Professor, Chemistry

Research interests: Catalysis, CO2 conversion, hydrogen generation, syngas production, geopolymer, biofuels, emission control, flue gas absorbers

Rishi Narain Singh

Visiting Professor, Earth Sciences

Research interests: Environmental, earth system and sustainability modelling

Jimmy Thomas

Guest Professor, Civil Engineering

Research interests: Applications of geosynthetics, reinforced soil structures, geotechnical engineering

Staff

Falguni Tailor

Project Manager, KPCSD

Dr Kiran C Patel

The Dr Kiran C Patel Centre for Sustainable Development at IIT Gandhinagar has been established with a generous endowment from Dr Kiran C Patel, a distinguished cardiologist, entrepreneur and philanthropist based in Tampa, Florida, USA.

3. Glimpses of the Year 2021-22

Partnerships and Collaborations

Strategic partnership with the Climate Change Department, Government of Gujarat.

Event co-organisers

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

pwc

IBM

KPCSD hosted a 13-member delegation from Leh and Kargil districts of Union Territory Ladakh to discuss sustainable sewage treatment in extreme cold climates.

Education

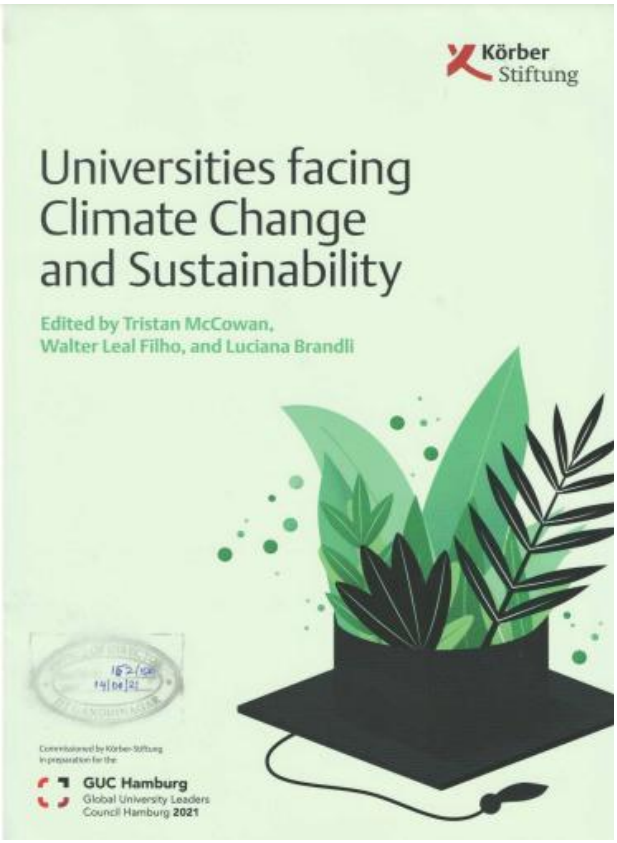
KPCSD announced an interdisciplinary 'Minor in Sustainable Development' for IIT Gandhinagar students from the academic year 2022-23.

Featured Project

KPCSD sponsored a pilot project on wastewater management, led by Prof Sudhir Kumar Arora, Professor of Practice, Civil Engineering

- New concept of 'Ring Sewer System': laying of gravity sewer in ring pattern; in-situ treatment: the sewer originates from Sewage Treatment Plant (STP) and terminates at the same STP putting the wastewater into the reactor at STP for treatment.
- The project undertakes a holistic approach, including innovations such as the use of modified traditional and locally available water-wheel (normally used in villages for lifting water for irrigation) for aeration to create aerobic conditions, ensure minimum human intervention or mechanical means for manhole cleaning, and use of plastic media balls to support growth of biomass used in reactor as well as in ring sewer.
- The pilot system demonstrated an increase in Dissolved Oxygen (DO) with modified water wheels, reduction in Bio Oxygen Demand (BOD) and Nitrogen with low media fill ratio.
- The results of the project indicate a good potential to provide sustainable and green solutions for rural sanitation issues.

KPCSD Contributions



IIT Gandhinagar was featured in the report "Universities facing Climate Change and Sustainability" commissioned by Körber-Stiftung in preparation for the Global University Leaders Council Hamburg 2021.

THE IMPACT RANKINGS 2022

Times Higher Education Impact Rankings 2022: IIT Gandhinagar ranked Top 200 globally for SDG 1 (no poverty) and SDG 6 (clean water and sanitation) and Top 300 for SDG 7 (affordable and clean energy) among nearly 1500 institutions.

Research Highlights

Projects and publications on Sustainable Development

Projects relate to following SDGs

Funding agencies for research projects initiated in 2021-22

INDICATIVE RESEARCH THEMES OF PUBLICATIONS

Sustainable river management, sewage disposal, effluent reuse and wastewater management, drinking water production, desalination, groundwater management, floodplains landforms, clay deposition and irrigation.

Air quality, atmospheric pollutants, river pollution, greenhouse gas emissions, municipal solid waste management, green alginate beads, biowaste, black and brown carbon.

Water resources, agriculture, infrastructure, and energy, flood risk assessment, tropical cyclone, flooding, hydrological processes, modelling & forecasting systems, drought monitoring index, water budget, impact of climate variability and moisture source.

Cyber-physical distribution systems, high-efficiency photovoltaics, solar cells, energy storage and technologies, power transmission systems, electric vehicle applications, energy management systems, emerging materials, batteries and supercapacitors.

Mangroves, wildlife hunting, archaeology, history of ancient India, Indian Knowledge Systems, Indian heritage, landscape evolution, traditional tank furnace, tiger and elephant conservation, phytoplanktons, river systems.

Model predicts hazard hotspots

IIT-Gn Team Proposes Resilience Plan

TIMES NEWS NETWORK

Ahmedabad: Inaccessibility of roads, primarily in hilly regions after fresh floods, can cause a major hazard for lives and infrastructure. A model proposed by a team from IIT Gandhinagar (IIT-Gn) seeks to assess the vulnerable patches by using the data available. Functionality losses can be reduced by using the information.

COPING WITH CALAMITY

The team comprised Uday Bhatia, assistant professor in the civil engineering discipline, and students including Raviraj Dave and Srikrishnan Siva Subramanian. A paper based on their research was published recently in the Environmental Research Letters journal.

"The first step in the direction of enhancing resilience is to understand the risk well for pre-disaster preparedness and post-disaster recovery," said Prof Bhatia. "The results of our modelling framework show that we could underestimate the functionality losses by 70% if we do not take into account the concurrence of extreme events, which in turn, can undermine our disaster preparedness."

Prof Bhatia added: "Our patented complex network framework in combination with our recently developed hazard model used in this study helps us identify the hotspots." These hotspots should be reinforced and protected to minimize the societal and economic disruptions, he said.

HOW THE MODEL WORKS

- The framework requires a high-resolution Digital Elevation Model (DEM) overlaid by the road network of the terrain and daily precipitation data. With this info, analysis can be done of the shallow landslides, debris flows, and inundation
- The results identify the least to most weak links (hotspot pixels) within a road network and help in deciding the locations of road segments that need strengthening. This in turn can minimize the societal and economic disruptions during heavy rainfall emergencies
- The occurrence timing (temporal), locations (spatial, hotspot pixels), and magnitude of infrastructure disruptions provided by this model are predicted using calculations based on equations of force, moment equilibrium and fundamental conservation laws (mass and momentum balance)

The research team uses satellite imagery, ingeniously developed landslide and debris flow models, and state-of-the-art flood prediction models. These tools predict the occurrence time and geographical locations that have a high susceptibility to the simultaneous occurrence of flooding, landslides, and debris flow events after heavy rainfall. The model also predicts the magnitude of infrastructure disruptions that may happen due to landslides, debris flows, and floods.

As a part of their study, the researchers reconstructed the sequence of events that unfolded in the Periyar river basin in Kerala in 2018. They quantified the exact magnitude of connectivity losses as a consequence of events triggered by a once-in-a-century rainfall.

The proposed framework can be applied to any region across the globe wherever necessary observations are available for model calibration and validation, said researchers.

RESEARCH WORKS IN MEDIA

Title: Model predicts hazard hotspots

Source: Times of India (Page No. 4)

Link: https://timesofindia.indiatimes.com/city/ahmedabad/model-predicts-hazard-hotspots/articleshow/87265559.cms

Date: 26-10-2021

ETHNOGRAPHIC STUDIES

IIT-Gn prof writes book on protection of 'our brother', the tiger

Underlines need for culturally informed, and people-centric approach to wildlife conservation

First India Bureau

Gandhinagar: The Indian Institute of Technology Gandhinagar (IIT-Gn) hosted a discussion on 'Tigers Are Our Brothers: Anthropology of Wildlife Conservation in Northeast India', a book penned by Prof. Ambika Aiyadurai, Assistant Professor, Humanities and Social Sciences, IIT-Gn.

Based on Dr Aiyadurai's long-term ethnographic fieldwork along the Sino-India borderlands of Arunachal Pradesh, the bookcritically engages in debates of wildlife conservation and its impact on the lives of the Idu Mishmi, an indigenous community of Dibang Valley.

Prof. Aiyadurai talking about her book at the session, which was held on Tuesday, ahead of World Wildlife Conservation Day commemorated on December 04 each year.

Highlighting the main contents of her book, Dr Aiyadurai discussed the conflict between natural science, social science and conservation. She underlined the need to look at the concept of conservation from the perspective of indigenous communities. Stressing the need for an inclusive, culturally informed, and people-centric approach, Dr Aiyadurai said, "Human-dimensions in wildlife conservation are largely invisible. This book provides crucial insights of the impact of wildlife research and conservation on the lives of communities who live in and around conservation sites and provides and alternate approaches to wildlife conservation."

She added: "The credit for the title must be given to the Idu Mishmi, who believe that tigers are their elder brothers. Killing tigers is, for the Idu Mishmi, a taboo. While their beliefs support wildlife conservation, they also offer a critique of the dominant mode of nature protection. This book places the Idu Mishmi experiences at the centre of a global network of cultural, economic, and political tensions to contribute to our understanding of human-non-human relationships."

Title: IITGN prof writes book on protection of 'our brother', the tiger

Source: First India (Page no. 3)

Link: https://firstindia.co.in/epapers/ahmedabad/26112021?page=3

Date: 26-11-2021

KPCSD Events

1000+ participants, including innovators, practitioners, academicians, research scholars and students, industry professionals, government officials, representatives from NGOs and think tanks, from 20+ regions across the globe participated in KPCSD events.

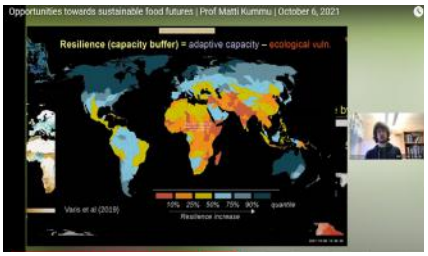
- The Centre regularly organises **Sustainability Seminar Series** on focus areas of the Centre, inviting prominent academicians, scholars and professionals to deliver lectures on sustainability.

FEATURED SUSTAINABILITY SEMINAR

Opportunities towards sustainable food futures by ***Prof Matti Kummu;***
Associate Professor, Department of Built Environment, Aalto University

The speaker sketched the opportunities to produce enough food for the ever-growing population with the sustainable use of resources.

"Those regions that are most challenged by the future, such as Africa, Middle East, South-South East Asia are observed to have lowest resilience. This is an alarming situation as where it is most needed to adapt to changes, there is the least capacity to do so."



"In some countries, food production could be increased quite a bit, for instance, up to 300-400% in Africa, and about 50% in India. There is an untapped potential for several countries across the globe to sustainably increase food supply as compared to current levels."

E-seminar on Climate Action

Scientists, scholars and practitioners discussed impact of climate change on critical infrastructure and energy-environment-economy implications of transportation.

Design Thinking Workshop

IBM conducted brainstorming sessions with students and faculty to identify potential climate change-related challenges.

4. Recent Developments

KPCSD has strived to support sustainable development projects and initiatives by IITGN faculty and students. One such project supported by the Centre was the pilot project led by Prof Sudhir Kumar Arora, Professor of Practice, Civil Engineering, to manage wastewater in rural and peri-urban areas using a spiral sewer. In October 2021, Prof Arora also hosted a delegation from Leh and Kargil who visited IITGN to explore and discuss sustainable sewage treatment alternatives.
IIT Gandhinagar has significantly contributed to innovation and sustainability through its partnerships, startup ventures, and awards. Prof Atul Bhargav, Professor, Mechanical Engineering, co-founded Cellegant Energy Systems, a startup that aims to provide fuel cell-based distributed energy systems technology for various applications. The Institute has signed a strategic partnership with the Climate Change Department (Government of Gujarat) to develop a Climate Change Policy and Roadmap for Net Zero by 2070 and also bagged the top 200 rank globally in the Times Higher Education Impact Rankings 2022 for SDG 1 (no poverty) and SDG 6 (clean water and sanitation).
KPCSD has launched a database of organisations operating in the sustainable development domain across India on its website.

KPCSD pilot project on Wastewater Management

KPCSD supported a pilot project led by Prof Sudhir Kumar Arora to manage sewage and greywater in rural and peri-urban areas. The project proposes a new concept of a spiral sewer to overcome high water requirements and steep slopes in gravity sewers.
A typical gravity sewer transports sewage from residential areas to STP, requiring about 1500 litres of water/ 100 m to run smoothly. The idea is to lay another sewer in the reverse direction from STP to residential areas to partly carry treated wastewater back into a standard sewer for flushing to save fresh water. This is feasible and viable for small pockets or villages. The project follows a holistic approach, including innovations such as the use of modified traditional and locally available water-wheel for aeration to create aerobic conditions, ensure minimum human intervention or mechanical means for manhole cleaning, and plastic waste use as fillers in HDPE balls mitigate nuisance of plastic bottles and polythene bags. Thus, the project aims to provide sustainable and green solutions for rural sanitation issues.

Visit of Leh Ladakh officials

A 13-member delegation from Leh and Kargil districts of Union Territory Ladakh visited IITGN on October 13, 2021, to understand low-cost, eco-friendly domestic wastewater management at IITGN and to explore various options of sustainable systems for the treatment of sewage for the extreme cold climate of Ladakh. The delegation included administrative officers and councillors of the Ladakh Autonomous Hill Development Council (LAHDC), elected representatives of Leh and Kargil towns, chairperson of the Block Development Council, executive officers and ward members of Leh and Kargil Municipal Committees, engineers of their Public Health Engineering Department, and urban planner of Ladakh Ecological Development Group (LEDeG). LEDeG, Urban Management Centre (UMC), Ahmedabad and KPCSD facilitated this exposure visit.
Prof Sudhir Kumar Arora hosted the delegates. The delegation was briefed about low-cost sanitation technology, the Root Zone Method (RZM) used at IITGN and also taken for site visits to the Water Treatment Plant and Sewage Treatment Plant. IITGN offered to help the delegation develop appropriate methodology and treatment schemes after field trials, pilot projects and lab studies.

Database of organisations

KPCSD has launched a database of organisations located across India that work in the domain of sustainable development. Currently, there are nearly 200 organisations in the database. Organisations will be added to the database from time to time. Please see https://csd.iitgn.ac.in/resources/ for the list.

Startup on energy systems

Prof Atul Bhargav, Professor, Mechanical Engineering, co-founded Cellegant Energy Systems, a startup company incubated by IIT Gandhinagar Innovation and Entrepreneurship Centre (IIEC). Cellegant aims to provide fuel cell-based distributed energy systems technology for various applications to reduce CO_2 emissions, decrease the total cost of ownership and augment the armed forces' capabilities. The startup has signed a licensing agreement with IIT Gandhinagar to use the design of patent-pending design on fuel reformers for strategic applications. The Department for Promotion of Industry and Internal Trade (DPIIT-recognised startup) has recognised the company as a startup. It has received the Nidhi Prayas grant from the Government of India to pursue its ideas.

Strategic partnership with Climate Change Department, Government of Gujarat

The Climate Change Department, Government of Gujarat and IITGN have entered into a strategic partnership on February 21, 2022, for the Development of a Climate Change Policy and Roadmap for Net Zero by 2070 for Gujarat. Prof S P Mehrotra, Professor-in-Charge, IITGN External Relations and Shri Rajesh Patel, Deputy Secretary, Climate Change Department were signatories of the partnership, paving the way for cooperation to create a more sustainable future for the citizens of Gujarat.

Times Higher Education Impact Rankings 2022

The Times Higher Education Impact Rankings assess universities worldwide against the United Nations Sustainable Development Goals (SDGs). It uses carefully calibrated indicators to provide comprehensive and balanced comparison across four broad areas: research, stewardship, outreach and teaching. The Institute featured in the Top 200 globally for SDG 1 (no poverty) and SDG 6 (clean water and sanitation) and Top 300 for SDG 7 (affordable and clean energy) out of nearly 1500 institutes.

IIT Gandhinagar was featured in the report "Universities Facing Climate Change and Sustainability" commissioned by Körber-Stiftung in preparation for the Global University Leaders Council Hamburg 2021

Universities play a crucial role in climate action and sustainable development through their practices and teaching, research, and innovation initiatives. The study analyses and compares the engagement of higher education institutions worldwide in these domains, presenting cross-national lessons learned and recommendations for future action. Country cases in the report covered seven countries, including Brazil, Germany, India, Japan, South Africa, the United Kingdom and the United States of America. A case study from the Indian Institute of Technology Gandhinagar was included. For more details on the study, please click here: https://csd.iitgn.ac.in/announcements/.

5. Events and Outreach

KPCSD organised several events related to sustainability during the past year. Eight webinars were conducted under the KPCSD Sustainability Seminar Series, in which academicians, scholars and professionals delivered talks on a wide range of topics related to sustainable development. The Centre conducted an e-seminar on climate action and a Design Thinking workshop in collaboration with other organisations. The events witnessed participation from various stakeholders, including industry professionals, NGO representatives, government officials, academicians and researchers.

5.1 E-seminar on 'Advancing Frontiers of Knowledge on Climate Action: Cross-sectional Approaches for Mitigation and Resilience'

The seminar, held on October 20, 2021, featured various sessions and highlights of studies on the impact of climate change on critical infrastructure and energy-environment-economy implications of transportation. The studies were jointly undertaken by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), IIT Gandhinagar and PricewaterhouseCoopers (PwC), as a part of the project "Supporting the Institutionalisation of Capacities on Climate Change Studies and Actions (ICCC)", implemented by the Ministry of Environment, Forest and Climate Change (MoEFCC) and GIZ. The project aims to develop capacities in climate protection, resilience, Nationally Determined Contributions (NDC) implementation, and transdisciplinary issues. Nearly 100 scientists, scholars and practitioners attended the seminar.

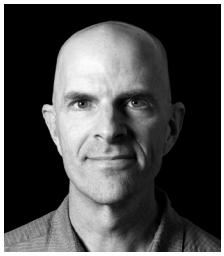
5.2 IBM Design Thinking Workshop

KPCSD, in collaboration with IIEC, organised a Design Thinking Workshop by IBM India Software Labs on December 8, 2021. The event explored potential areas of partnerships. Six teams, each of five students, faculty and IBM representatives, participated in brainstorming sessions to identify potential environmental or climate change-related challenges.

5.3 Sustainability Seminar Series

The Centre organised eight e-seminars between June 2021 through March 2022 as part of the Sustainability Seminar Series. The webinars covered topics related to climate change, energy, food security, natural resources conservation, environmental and human health by speakers from renowned organisations. Nearly 800 people attended the webinar series from India and several locations across the globe, such as Antigua and Barbuda, Australia, Bangladesh, Canada, Chile, China, Germany, Indonesia, Japan, Korea, Libya, Nepal, Pakistan, Singapore, Switzerland, Taiwan, UAE, UK, and the USA. Details of the e-seminars organised are as follows:

A. PUBLISHING IN NATURE: A CLIMATE SCIENCE PERSPECTIVE



*Facilitator: **Dr Michael White**; Senior Editor for Nature | Webinar held on 18.6.2021*

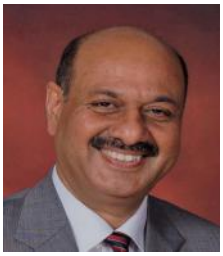
The inner workings of high-profile journals can be mysterious. How do they decide what to publish or send to review? How is the process managed? What are the odds of getting published? Do they publish papers only to be controversial and get press coverage? Furthermore, who makes the decisions? Dr White, Nature's editor for climate, discussed the overall journal processes and specific themes behind the climate science research published in Nature over the past 13 years.

B. **THROUGH A MODEL DARKLY: INSIGHTS INTO THE DYNAMICS OF WARM CLIMATES, PAST AND FUTURE**

*Facilitator: **Prof Matthew Huber**; Professor, Earth and Atmospheric Sciences, Purdue University | Webinar held on 13.8.2021*

Human-caused global warming poses a threat to human and natural systems, but large uncertainties remain. Massive warming occurred in the past as well, and insight into the dynamics of warm climates broadly may be gained by using paleoclimate model simulations and proxy data. Prof Huber summarised some of what has been learned about the climate system's sensitivity to forcing from studying past warm climates and emphasised the robust constraints on tropical temperatures, polar amplification, modes of climate variability, and monsoons that arise. With this grounding in past climate dynamics, we peer into the future to see what may be gleaned, with a particular focus on heat stress in tropical and subtropical regions and its likely impacts.

C. **DEMAND-SIDE MANAGEMENT FOR A SUSTAINABLE ENERGY FUTURE**



*Facilitator: **Mr Anand Kumar**; Professor of Practice, Electrical Engineering, IIT Gandhinagar | Webinar held on 20.9.2021*

The webinar focussed on Demand Side Management (DSM), covering the concept of DSM, the scope and significance of DSM in India, governing Indian laws, policies and regulations on DSM, the need for DSM to conserve energy and control Carbon emissions, DSM benefits to society and environmental impact, type of DSM, energy efficiency articles and its cost and benefit analysis, Demand Response and innovative tariff. Mr Kumar also discussed challenges and the way forward.

D. **OPPORTUNITIES TOWARDS SUSTAINABLE FOOD FUTURES**

*Facilitator: **Prof Matti Kummu**; Associate Professor, Department of Built Environment, Aalto University | Webinar held on 6.10.2021*

Improving the provision of sustainable and healthy nutrition to the growing and wealthier global population under environmental changes is one of humanity's most significant challenges. The talk examined global food production's challenges and how it has contributed to its crisis. This was followed by sketching the opportunities to produce enough food for the ever-growing population with the sustainable use of resources.

E. **CONSERVATION: THE ART OF POSSIBLE**

*Facilitator: **Mr Vivek Menon**; Founder and Executive Director, Wildlife Trust of India | Webinar held on 8.10.2021*

India is a country rich in biodiversity, yet facing innumerable threats to its natural heritage, whether human-induced or natural. Conservation is a constant battle to safeguard our natural heritage and push for coexistence between humans and nature. It is like a game of chess, where once we sit down and begin, we do not leave until the game is complete.

F. **LOW-COST SENSORS AND DATA ANALYTICS: THE FUTURE OF IMPROVING ENVIRONMENTAL AND HUMAN HEALTH**

*Facilitator: **Prof Michael Bergin**; Sternberg Family Professor of Civil and Environmental Engineering, Duke University | Webinar held on 19.11.2021*

Prof Bergin discussed recent innovations in developing low-cost sensors to measure air pollutants, micro-satellite imagery, and machine learning advances that are promising in characterising pollutants and improving estimates of human exposure. He also presented new methods to estimate air pollutants' health impacts by mining social media and images for human sentiment, which can serve as a proxy for health outcomes and

potentially lead to real-time interventions. A theme of Prof Bergin's talk integrated innovations in data analytics with environmental data to improve human and environmental health. Lastly, the future of engineering education that must include hands-on, project-based learning and entrepreneurship were also discussed.

G. COMMUNICATING IMPACTS OF CLIMATE CHANGE ON COMMUNITIES AROUND INDIA

*Facilitator: **Ms Disha Shetty**; Reporter, Fuller Project | Webinar held on 25.1.2022*

Ms Shetty discussed the impact of climate change on communities around India and how researchers and journalists can work together to tell this story. She emphasised the need for collaboration and interdisciplinary communication between scientists, researchers and journalists. Further, Ms Shetty shared her on-ground experience in documenting climate change stories, highlighted communication gaps and how we can better communicate climate change and climate action to the larger community.

H. GOVERNANCE OF BIODIVERSITY AND OTHER NATURAL RESOURCES IN INDIA

*Facilitator: **Dr Yogesh Gokhale**; Senior Fellow and Area Convenor, Centre for Forest Management and Governance, Land Resources Division at The Energy and Resources Institute (TERI), New Delhi | Webinar held on 25.3.2022*

The talk highlighted challenges to the sustainability of natural resources and the livelihood of forest-dependent communities. The same natural resources are also shared by other rural and urban communities directly or indirectly for developmental activities and livelihood purposes. Robust policies, comprehensive legislation and the three-tier Panchayati Raj model of governance govern the paradigm for managing natural resources in India. Global priorities such as climate change and biodiversity conservation influence natural resource management at the national level. Dr Gokahle emphasised the need for strengthening decision-making through the creation of evidence and the increasing role of education and institutions in measuring and monitoring the status of resources and developing solutions for sustainable development in India.

6. Education

The Institute offers several graduate and undergraduate courses on sustainability. Nearly 300 students registered for these courses over the past year. The Centre aims to undertake curriculum development at IITGN by implementing modules on sustainability in existing courses and advancing education on sustainability nationally and globally. The Centre also promotes student, academic and research exchanges on sustainability with institutions nationwide and abroad. The Institute conducted several workshops, lectures, short courses and training programmes relating to sustainability during the past year.

Minor in Sustainable Development: KPCSD announced an interdisciplinary 'Minor in Sustainable Development' for IITGN students from the academic year 2022-23. Students interested in the Minor are required to take a total of 20 credits. The courses encompass the domains of water, pollution and waste management, climate change, energy, and environment/ biodiversity/ earth systems, given the interdisciplinary character of sustainability.

Sustainability projects in coursework: 'CE 202: Sustainability and Environment' is a compulsory subject in the curriculum of the undergraduate students of IIT Gandhinagar's Civil Engineering discipline. Some of the KPCSD faculty provided mentoring support to students who worked on various sustainability-related projects, including those on wastewater management, electric vehicle charging stations, food waste management and waste segregation, among others. This course introduces the concept of sustainability, covering several areas such as humanity and the environment, the evolution of environmental policy, climate and global change, climate processes, biodiversity and ecosystem functions, physical resources, environmental and resource economics, modern environmental management, systems of waste management, sustainable energy systems, sustainable infrastructure, embodied energy, life cycle, sustainable materials and construction, problem-solving and tools of sustainability.

6.1 List of courses

The following graduate and undergraduate courses related to sustainability were offered in the academic year 2021-22:

CE 201: Earth Materials and Processes
Course instructor: Prof Vikrant Jain | No. of credits: 4

CE 202: Sustainability and Environment
Course instructor: Prof Vimal Mishra and Prof Udit Bhatia | No. of credits: 3

CE 308 and 308 B: Water Resource Engineering
Course instructor: Prof Udit Bhatia | No. of credits: 4+1

CE 605 : Remote Sensing of Land and Water Resources
Course instructor: Prof Vimal Mishra | No. of credits: 4

CE 611: Advanced Engineering Hydrology
Course instructor: Prof Vimal Mishra | No. of credits: 4

EH 601: Earth Surface Processes In The Anthropocene
Course instructor: Prof Vikrant Jain | No. of credits: 4

EH 602: River Morphology and Ecology
Course instructor: Prof Vikrant Jain | No. of credits: 4

EH 605: Modelling of Earth System and Sustainability
Course instructor: Prof Rishi Narain Singh | No. of credits: 4

EH 608: Biodiversity Conservation and Sustainable Development
Course instructor: Prof Chhavi Nath Pandey | No. of credits: 4

ES 635: Water Quality Engineering
Course instructor: Prof Manish Kumar | No. of credits: 4

HS 515: Politics of the Environment
Course instructor: Prof Ambika Aiyadurai | No. of credits: 4

IN 304 : Ancient Indian Technology
Course instructor: Prof Alok Kumar Kanungo | No. of credits: 4

6.2 Workshops and short courses

The following workshops, lectures, short courses and training programmes focussed on sustainability were organised by KPCSD affiliates during the past year.

WORKSHOPS AND LECTURES

- Human-animal relations at the margin: A quest for social justice on August 17, 18 and 20, 2021 sponsored by the Indian Council of Social Science Research (ICSSR) and coordinated by Prof Ambika Aiyadurai and Prashant Ingole (PhD Scholar).
- Book discussion on Tigers are Our Brothers: Anthropology of Wildlife Conservation in Northeast India by Prof Ambika Aiyadurai on November 23, 2021.

SHORT COURSES AND TRAINING PROGRAMMES

- Management of domestic wastewater - conveyance, treatment and reuse: Paradigm shift in approach by Prof Sudhir K Arora, Professor of Practice, Civil Engineering, IITGN, on Thursdays, Fridays and Saturdays, from August 20 to September 24, 2021.
- Management of domestic wastewater for external practising engineers from various state government departments by Prof Sudhir K Arora, from September 6 to 17, 2021.
- Renewable energy future and flexibility by Prof Naran Pindoriya, Associate Professor, Electrical Engineering, IITGN, from September 22 to 24, 2021.
- Organic electronics by Prof Anirban Mondal, Assistant Professor, Chemistry, IITGN, on November 09, 17, 19, 22 & 23, 2021.
- Management of domestic wastewater - conveyance, treatment and reuse by Prof Sudhir K Arora, from January 31 to February 11, 2022.
- Management of domestic wastewater: A paradigm shift in approach for the officers of Kerala Water Authority by Prof Sudhir K Arora, from March 2 to 7, 2022.

7. Focus Areas: Projects and Publications

The Institute is undertaking a significant amount of research related to various domains of sustainability. During the past year, nearly 40 projects were sanctioned. Major supporting agencies for research work on various areas of sustainability include the Ministry of Education (MoE), Ministry of Earth Sciences (MoES), Ministry of Jal Shakti (MoJS), Department of Scientific and Industrial Research (DSIR), Department of Science and Technology (DST), Science and Engineering Research Board (SERB), and Indo-German Science and Technology Centre (IGSTC). During the past year, the IITGN faculty published more than 100 research publications and conference presentations on sustainability.

7.1 Water

Several research groups at IITGN, including research scholars, students and faculty, are researching various water-related themes, including sustainable river management, sewage disposal, effluent reuse and wastewater management, drinking water production, and desalination.

RESEARCH PROJECTS

The research projects relating to water address the following SDGs:

Prof Vikrant Jain and his team conduct research on earth surface processes, including river science and geomorphic applications in stream management and develop tools and models for sustainable management of river ecosystems. Prof Chinmay Ghoroi's team has developed low-cost passive filters for water disinfection. Prof Manish Kumar and his research team have conducted wastewater surveillance for SARS-CoV-2 gene detection.

Prof Pranab Mohapatra and his team have worked on developing a fit-for-purpose water-sensitive design framework for fast-growing cities. Prof Jaichander Swaminathan's group focuses on efficient desalination, brine concentration and energy-efficient reuse of industrial effluents.

New projects:

PI	PROJECT TITLE	AGENCY NAME
Vikrant Jain	A genetic morphological classification of the peninsular rivers through clustering of river long profiles: a tool for sustainable river management	Council of Scientific and Industrial Research (CSIR)

Ongoing projects:

PI	PROJECT TITLE	AGENCY NAME
Chinmay Ghoroi	Low-cost and non-electric water filter for Point-of-Use (POU) water disinfection	WIN Foundation
Vikrant Jain	Development and application of geomorphic tool for sustainable management of a Himalayan river system, India	MoE
Vikrant Jain	Development of a predictive geomorphic model as a tool for sustainable river management	MoES
Manish Kumar	Weekly surveillance of wastewater for SARS-CoV-2 gene detection in Ahmedabad for pandemic curve monitoring	United Nations Children's Fund (UNICEF)
Pranab Mohapatra	Water for Change: Integrative and fit-for-purpose water sensitive design framework for fast growing livable cities	DST
Jaichander Swaminathan	Brine splitting for energy efficient textile dyeing effluent reuse	DST
Jaichander Swaminathan	Multi-effect membrane distillation for modular desalination and brine concentration	SERB

PUBLICATIONS

Taki, Kaling; Raval, Nirav P. and Kumar, Manish, "Utilization of sewage sludge derived magnetized geopolymeric adsorbent for geogenic arsenic removal: A sustainable groundwater in-situ treatment perspective", *Journal of Cleaner Production*, DOI: 10.1016/j.jclepro.2021.126466, vol. 295, May 2021.

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CONSULTANCY PROJECTS

Prof Udit Bhatia is working on concrete surface deterioration, salinity impacts, investigating water ingress and resulting interactions in underground infrastructure in Dholera.

PI	PROJECT TITLE	AGENCY NAME
Udit Bhatia	Investigation of concrete surface deterioration and salinity impacts on concrete surfaces in Dholera	Dholera Industrial City Development Limited (DICDL)
Udit Bhatia	Investigating water ingressing and resulting interactions in underground infrastructures in Dholera	DICDL

7.2 Pollution and waste management

Faculty and research scholars at IITGN have focussed on studies and analyses related to pollution and waste management, including air quality, atmospheric pollutants, greenhouse gas emissions, and municipal solid waste management.

RESEARCH PROJECTS

The research projects relating to pollution and waste management address the following SDGs:
Prof Arup Lal Chakraborty's research group has worked on developing innovative technologies to monitor key environmental parameters such as air quality and greenhouse gas emissions in developing regions of India. It addresses several aspects of sustainability, including livelihood, health and well-being. Prof Sameer Patel's team explores the interrelationship of air quality and built environments in urban India. Prof Nipun Batra's group is working on air quality monitoring and the impact of air pollution on Covid-19-related secondary exacerbations.

Students and researchers in the team led by Prof Chinmay Ghoroi are also working on various studies and projects to assess sources and concentrations of indoor air pollutants, including Volatile Organic Compounds (VOCs) and Particulate Matter (PM). The group focuses on developing low-cost, efficient and scalable materials for CO_2 capture. Further, they have also looked into improving the performance of solar plants, given the impact of air pollution on solar photovoltaics. A Research and Technology Development Hub for chemical processes has also been set up at the Institute, which functions under Prof Ghoroi. Prof Manish Kumar and the team have worked on developing environmentally and economically sustainable solutions for better municipal solid waste management.

New projects

PI	PROJECT TITLE	AGENCY NAME
Arup Lal Chakraborty	Novel laser-based monitoring of key environmental parameters – addressing well-being, livelihood and a healthier environment in developing regions of India	Royal Academy of Engineering (RAE)
Sameer Patel	Investigating air quality and its dynamics in built environments in urban India	SERB

Ongoing projects:

PI	PROJECT TITLE	AGENCY NAME
Nipun Batra	AI and sensor networks for air-quality monitoring	SERB
Nipun Batra	Impact of air pollution on covid-related secondary exacerbations	Google
Arup Lal Chakraborty	High sensitive detection of atmospheric pollutant gases to monitor the effects of industrial emissions on urban air quality	GUJCOST
Arup Lal Chakraborty	UAV-based laser spectroscopic monitoring of greenhouse gas emissions in urban and rural India	RAE
Chinmay Ghoroi	Assessing the concentrations and sources of indoor VOCs and PM in urban India and comparing to levels in China and the US	DUKE University
Chinmay Ghoroi	Common Research and Technology Development Hub - Chemical Processes	DSIR and IITGN
Chinmay Ghoroi	Development of low cost , efficient and scalable materials for CO_2 capture using naturally available nontoxic stable materials and industrial solid wastes	DST
Manish Kumar	Development of environmentally and economically sustainable composite solution for municipal solid waste management	Gujarat State Bio- Technology Mission (GSBTM)

PUBLICATIONS

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7.3 Climate Change

Research at IITGN in the climate change domain covers a broad spectrum, including climate change impacts assessment on various sectors such as water resources, agriculture, infrastructure, and energy, flood risk assessment, hydrological processes, modelling and forecasting systems.

RESEARCH PROJECTS

The research projects relating to climate change address the following SDGs:
Prof Vimal Mishra and his research group have worked on developing an integrated hydroclimatic framework and forecasting system for Gujarat. The team has also focussed on hydrologic modelling and forecasting systems for river basin hydrology and extremes for India and assessing impacts of climate variability and climate change on water resources in the Sabarmati river basin.

Prof Udit Bhatia's team is working on different aspects of climate change, such as understanding hydrological processes and downscaling earth system model output, with a physics-guided data science approach.

Prof Vikrant Jain is leading the project on establishing the Gujarat State Climate Change Centre. Prof Jain's group undertakes hydro geographic modelling to assess flood risk in tropical rivers and studies the impact of natural phenomena on the decline of human settlements. He is also exploring the impact of sea level fluctuations, climate change or tectonic activity on the decline of the Harappan settlement of Dholavira, Kutch, India.

New projects:

PI	PROJECT TITLE	AGENCY NAME
Vimal Mishra	Integrated real time hydroclimatic framework and forecasting system for Gujarat	UNICEF

Ongoing projects:

PI	PROJECT TITLE	AGENCY NAME
Udit Bhatia	Developing physics guided super-resolution approach and evaluation strategies for down scaling earth system model outputs	SERB
Udit Bhatia	Physics guided data science approach for predictive understanding of hydrological processes	Scheme for Transformational and Advanced Research in Sciences (STARS)
Vikrant Jain	Establishing Gujarat state climate change centre	DST
Vikrant Jain	Flood risk assessment in tropical rivers in the Anthropocene under climate change scenario using hydro geomorphic modelling	MoE
Vikrant Jain	Impact of sea level fluctuations, climate change or tectonic activity on the decline of the Harappan settlement of Dholavira, Kutch, India	DST

Vimal Mishra	An experimental operational hydrologic modelling and forecasting system for river basin hydrology and extremes for India	Indian Institute of Tropical Meteorology
Vimal Mishra	Impacts of climate variability and climate change on water resources in the Sabarmati river basin	MoJS

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CONSULTANCY PROJECTS

Prof Udit Bhatia provides expertise in preparing the State Action Plan on Climate Change (SAPCC) chapters for Sikkim. Prof Vikrant Jain aims to study the impact of different drivers for groundwater depletion in specific areas of Banaskantha district in Gujarat, India.Prof Vimal Mishra and his team have undertaken projects relating to climate change impacts on hydropower, and establishment of expertise and capacity building in climate change studies.

PI	PROJECT TITLE	AGENCY NAME
Udit Bhatia	Expertise in preparing the chapters of SAPCC for Sikkim	DST
Vikrant Jain	Special study to determine the impact of different drivers for groundwater depletion in OE/ critical talukas of Banaskantha district	Gujarat Water Resources Development Corporation (GWRDC)
Vimal Mishra	Climate change impacts on hydropower in India	United Nations Development Programme (UNDP)
Vimal Mishra	Institutionalisation of capacities on climate change studies and actions	GIZ

7.4 Energy

Ongoing energy research at the Institute includes cyber-physical distribution systems, high-efficiency photovoltaics, solar cells, energy storage and technologies, and electric vehicle applications.

RESEARCH PROJECTS

The research projects relating to energy address the following SDGs:
Prof Naran Pindoriya's research group works on various aspects of energy, including sustainable energy access, prosumer-driven grids, cyber-physical distribution systems, intelligent distribution grids, integrated distributed generations and energy technology and management.

The research team led by Prof Nipun Batra monitors the mechanism of moving non-intrusive load monitoring (NILM) to the network's edge. Students and researchers working with Prof Jaichander Swaminathan are investigating using solar energy for brine treatment to achieve near-zero carbon emissions.

New projects:

PI	PROJECT TITLE	AGENCY NAME
Naran Pindoriya	Cyber-attack analysis toolkit for cyber-physical distribution system security [CyberDiSS]	Central Power Research Institute (CPRI)

Ongoing projects:

PI	PROJECT TITLE	AGENCY NAME
Nipun Batra	Edge non-intrusive load monitoring	CISCO

Naran Pindoriya	Development of a prosumer driven integrated SMART grid	DST
Naran Pindoriya	ECO-WET - efficient coupling of water and energy technologies for smart sustainable cities	IGSTC
Jaichander Swaminathan	Harnessing solar energy to achieve near zero carbon emission for brine treatment	DST

PUBLICATIONS

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7.5 Natural resources, wildlife and ecosystems

Ongoing natural resources, wildlife and ecosystems research at the Institute includes diverse areas such as mangroves, wildlife hunting, mountains, ocean, freshwater and river ecosystems.

RESEARCH PROJECTS

The research projects relating to natural resources, wildlife and ecosystems address the following SDGs:
Prof Ambika Aiyadurai's group focuses on natural resources and wildlife conservation. Two of her projects relate to documenting mangroves in Gujarat and wildlife hunting in Arunachal Pradesh.

New projects:

PI	PROJECT TITLE	AGENCY NAME
Ambika Aiyadurai	History, science & technology of wildlife hunting and trapping in Arunachal Pradesh	Indian National Science Academy (INSA)
Ambika Aiyadurai	Mangroves stories in Gujarat	Social Science Research Council (SSRC)

PUBLICATIONS

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