Office of the Principal Scientific Adviser
to the Government of India

Science & Technology Cluster

DELHI RESEARCH IMPLEMENTATION AND INNOVATION
Initiative of the O/o the Principal Scientific Adviser to the Govt. of India
CKIC-DRIIV

DRIIV

Delhi Research Implementation & Innovation

An initiative of the Office of the Principal Scientific Adviser to the Government of India

आत्मनिर्भर भारत

अजय के. सूद
भारत सरकार के प्रमुख वैज्ञानिक सलाहकार
Ajay K. Sood
Principal Scientific Adviser to the Govt. of India

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FOREWORD

The Science and Technology (S&T) clusters were seeded on the recommendation of the Prime Minister's Science and Technology Innovation Advisory Council (PM-STIAC), an overarching body that helps develop a futuristic roadmap for India.

We have established six such S&T clusters across the country and the Delhi cluster, also known as DRIIV (Delhi Research Implementation and Innovation), is emerging as a promising cluster to create an enabling ecosystem of industry-academia-government bodies for bolstering research, innovation and entrepreneurship, essential for development at grassroot levels in India. DRIIV has been creating formal mechanisms for engaging public bodies and industry players to support S&T Innovations in addressing environmental and societal use cases.

Line ministries, local governments and public bodies can engage more deeply with the clusters and involve them in the consultation process in a bid to move towards scientific evidence driven policymaking. They can leverage the clusters as a platform to source technology solutions for their problem statements relating to administration, public health, environment and smart cities management among others. Additionally, public funding agencies are also encouraged to work with the clusters in designing R&D programmes aligned with the needs of the industry and having industry players as active participants in those programmes. Furthermore, the clusters can serve as the lynchpin for anchoring cluster-to-cluster collaboration within the country and abroad.

Finally, I hope to see more active participation from the industry to develop the S&T landscape in India. Corporates and PSUs stand to gain many competitive and economic advantages with indigenous technologies, which can be co-created with researchers and startups. The CSR spend can also be utilised more effectively in supporting environmental sustainability and community welfare projects of the clusters, where technology is used for lasting impact.

As Clusters continue to grow, I wish the entire team of DRIIV, a continued success in delivering on the cluster's objectives. I am sure that this handbook shall come in handy for stakeholders and policymakers alike as a ready reference for many more successful interventions in Science and Technology.

(Ajay K. Sood)

Foreword by Prof. Ajay K Sood, PSA to the GoI

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डॉ. (श्रीमती) परविन्दर मैनी
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Scientific Secretary

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MESSAGE

It is indeed impressive to see the Prime Minister's Science Technology & Innovation Advisory Council's (PM-STIAC's) vision of a thriving innovation ecosystem comprising of industry-academia-local body collaboration come to life in the form of S&T Clusters. Delhi Research Implementation and Innovation (DRIIV), the Delhi S&T Cluster, has been demonstrating the ability to forge collaborations across multiple stakeholders to work on scalable solutions for environmental and societal issues.

For any initiative to create impact, multi-stakeholder engagement is vital, and DRIIV has been working towards a common goal of India's global aspirations and identification of levers of growth for bridging the gaps. Their focus on attracting private capital for complementing government's R&D spend, mobilising public bodies and corporates to adopt technology solutions for sustainability initiatives and creating an innovation ecosystem for research based start-ups is palpable.

We are happy to observe DRIIV playing a major role in mainstreaming S&T narrative in the public discourse. Be it combining community engagement with project SAMEER (air pollution mitigation project with DPCC and GMDA), engaging with the Delhi Government on data driven policymaking, involving school and college students in the Collective Responsibility Drive (recycling of plastic waste to school desks and chairs) or conducting deep-tech (AI/ML) or Electric Vehicles (EV) workshops for students and young professionals, DRIIV has taken the perceived expert topics to the masses via integrating them with real-life situations.

We wish the team the very best in their efforts to achieve the cluster's objectives.

(Parvinder Maini)

Prof. Subhash Kak

*Regents Professor at Oklahoma State University,
Padmashri Awardee, PM-STIAC member*

MESSAGE

As a member of the PM-STIAC I have followed the discussions regarding setting up of S&T clusters from the beginning. The central idea behind the creation of clusters was to leverage the power of local knowledge ecosystems to accelerate India's technological growth. It is indeed a rewarding experience to see these clusters come to life and deliver on the vision with which they were created.

I'm deeply impressed with what the Delhi cluster (DRIIV) has achieved in such a short time frame. Amongst other things, DRIIV has made a tremendous contribution to public healthcare by creating AI based models using genomic sequencing, which are being used by ICMR for predicting the onset of potentially pandemic diseases such as COVID & Anti-microbial resistance (AMR) up to two months in advance, allowing enough lead time to policymakers to take necessary interventions.

From my personal involvement in stretching the technology frontier in deep-tech areas such as quantum computing, I get to see emerging use cases and apprehensions about the consequences of technology on the future of society. I feel that the Delhi S&T cluster, given its technical prowess, contextual relevance, and strong leadership, can be an ideal candidate for researching India's take on the intersection of AI and society to investigate future scenarios and tech opportunities.

Furthermore, given that India's GDP on a PPP basis is already in the top three in the world and expected to become second largest in just a dozen years, it is essential that India takes leadership in certain key areas. These include medicine and healthcare where given the inadequacies that became apparent in the response to Covid entirely new policy approaches that incorporate the mathematically superior ternary logic be investigated. With the inevitable further centralization of information, and considering that financial transactions represent exchange of information, this area is deserving of independent research to determine and develop opportunities that are consistent with India's expected role on the world stage.

Warm regards,

Subhash Kak

Prof. Rangan Banerjee
Director, IIT Delhi

MESSAGE

We are delighted to partner with the Principal Scientific Adviser's Office to host the Delhi Research Implementation and Innovation (DRIIV) Cluster. The Institute focusses on excellence in academics and research. We are keen to see that our research makes an impact in society. DRIIV provides us the platform to work together with academic and research organizations in the National Capital Region and create a visible impact in the region. We are working on problems and solutions of urban air quality, waste to energy, healthcare and electric mobility that are critical to the region as well as have national relevance.

Through DRIIV, we hope to catalyze and strengthen the research and innovation ecosystem across the nation. Our experience over the last few years makes us optimistic about the transformative power of the Science and Technology Clusters like DRIIV. We are keen to partner with stakeholders and make a difference in the region with our ideas and technologies. We hope we can use DRIIV to demonstrate the feasibility of scalable and replicable technologies, products, and solutions.

We believe that DRIIV can help provide a roadmap and implementation strategy for S&T involvement and support the growth aspirations of the industry and society. We are happy to get your ideas, suggestions, and support for the future of DRIIV.

Warm regards,

Rangan Banerjee

Shipra Misra

MD & CEO, DRIIV

EXECUTIVE SUMMARY

Dear Reader,

DRIIV is the umbrella body for the Delhi science and technology (S&T) cluster, set up by the Office of the Principal Scientific Adviser (PSA) to the Government of India (GoI), alongside five other S&T clusters nationwide. DRIIV has made rapid strides in creating a vibrant S&T cluster since its inception two years ago and I'm delighted to share its achievements till date with you.

At DRIIV, we deliver on National Missions and UNSDGs by leveraging S&T solutions, and commercialising research outcomes in the process. We are:

✓ Empowering **researchers** and **startups** by mobilising private capital to support innovations, creating use-cases based pilots with local government bodies and **corporates**, providing opportunities for cross-border collaborations with other international clusters and showcasing them on national and international forums.

✓ Enabling corporates and **PSUs** to 'co-create' with innovators and execute sustainability and community welfare projects for their CSR commitments.

✓ Providing technology solutions to **public bodies** for their mandates such as pandemic preparedness, public transport, sustainable mobility and mitigating environmental pollutants.

I. Impactful network of premiere institutions across industry-academia-government bodies

We have built a network of c. 100+ (and counting..) cluster members, working collaboratively across disciplines. In addition to having premiere academic and research institutes (e.g. IIT Delhi, AIIMS, IIIT Delhi, The Energy & Research Institute (TERI), National Institute of Solar Energy (NISE), National Physical Laboratory (NPL) etc.), we have deep engagements with corporates and business houses (e.g. TATA Power, Google Research, Baxy Group etc.), government bodies (e.g. Ministry of Housing and Urban Affairs (MOHUA), Gurugram Metropolitan Development Authority (GMDA), Delhi Pollution Control Committee (DPCC) etc.) and technology scale-ups (such as Log 9, Social Alpha, EVI Technologies etc.).

With such an enviable member base, we aim to replicate (and surpass) the success of other international S&T clusters such as Cambridge and Oxford (U. K.), Eindhoven (Netherlands/Belgium), San Jose–San Francisco (U. S.) etc. in the medium term.

II. Delivering on National Missions and UN SDGs

All of DRIIV's thematic areas are aligned with the National Missions, which also cater to the UN SDGs. These include Waste to wealth, Water Security, Air Pollution mitigation, Sustainable mobility, Renewable Energy, Healthcare (One Health Mission) and Effective Education.

We are executing sustainability projects at scale to create significant on-ground impact. **Examples include:**

⊙ **Collective Responsibility Drive** (CRD) in collaboration with Blue Planet Environmental Solutions Pvt. Ltd. (a waste management company) where we aim to mobilise **10 million** school and college students to collect **1 billion tons** of **plastic waste**, which is recycled into desks for donation to deprived government schools. So far, **1000** such benches have been delivered to **27** govt. schools, funded by Rural Electricity Corporation (**REC**);

⊙ Rejuvenating natural tanks for rainwater harvesting as part of the government's **Amrit Sarovar** project, where **50** waterbodies are planned to be revived some of which will be in the aspirational districts in Haryana, Punjab and U.P.

Several other such initiatives are planned over the next few months covering environmental and healthcare domains and we would welcome sustainability champions to engage with us.

III. Creating success stories in commercialising research outcomes and executing pilots

Some examples of DRIIV's innovations that have been successfully deployed commercially include **EV charging infrastructure** in **17+** cities, battery **swapping stations in Delhi, public transport** app Chartr (now One Delhi) being used by commuters and depot managers in Delhi and Orissa and **predictive** platform for **COVID** and other **infectious diseases** being used by ICMR.

Alongside, DRIIV has created a successful PPP model for executing pilots - e.g. **project SAMEER** (a pilot on air pollution mitigation) is currently ongoing in collaboration with local government bodies such as GMDA and DPCC. Such pilots have not only created a mechanism whereby startups and MSMEs can engage meaningfully with local government authorities to implement projects of environmental and societal relevance but also validate their technologies in real life situations through premiere institutions such as IIT D and AIIMS. These pilots have also received funding support from public institutions and corporates as part of their **CSR** spend.

Going forwards, project SAMEER will be scaled up and several other such pilots will be seeded across DRIIV's thematic areas.

IV. Attracting private capital to create 'market-ready' innovations

Whilst scientifically advanced countries spend 3%-5% of their GDP on R&D, India has seen only 0.7% R&D investment. Furthermore, the West receives a healthy mix of public-private funding, where private component far outweighs the public spend. This is in stark contrast to an almost non-existent private funding source in India. Furthermore, there is no mechanism to support mid-TRL (technology readiness level) technologies, which is why most innovations fail to reach commercialisation.

DRIIV has collaborated with **Edison Hub** (an initiative of the Baxy group which owns businesses such as Central Park, Le Meridien etc.) to create a corporate backed accelerator that provides **investment** and **market access** support to **R&D** driven startups. Similarly, we have partnered with **India Health Fund** (a **TATA** JV) to support healthcare innovations. We are also mobilising Corporate Social Responsibility (**CSR**) spend towards research. For example, **MongoDB** is supporting research on anti-microbial resistance (**AMR**) being carried on at IIIT D in collaboration with the Indian Council of Medical Research (**ICMR**).

Over time, we aim to mobilise CSR as a significant source of R&D funding and forge several other partnerships to strengthen the innovation ecosystem.

V. Building a 'co-creation' model with corporates

A **'co-creation' model** where corporates/PSUs as commercial partners collaborate with researchers/startups to make high TRL technologies market ready, is urgently wanting. DRIIV is bridging that gap by bringing together corporates/PSUs and innovators to develop and commercialise technology solutions for national and global markets. Some such examples include production of **Green Hydrogen** (under National Green Hydrogen Mission) and development of indigenous **power modules** for **EV** chargers.

We aim to establish the 'co-creation' model firmly in the ecosystem over the medium term, so that researchers are incentivised to work on 'applied research' as opposed to simply publishing papers and for corporates/PSUs to boost indigenous technologies vs. importing basic engineering solutions at exorbitant costs, in line with the vision of **Atmanirbhar Bharat**.

VI. Building international bridges for cluster-to-cluster collaborations

India's presidency of G20 upholds the ethos of **'Vasudhaiv Kutumbakam'** (One Earth. One Family. One Future). Global problems require solutions that are only possible through cross-border collaborations. COVID vaccines, renewable energy transition, food security are only some such examples. DRIIV offers an ideal platform for anchoring such international collaborations involving multiple stakeholders across countries.

We have built deep cluster-to-cluster engagements with **Sweden** and have hosted several delegations, including 20+ delegates led by the DG of Trade, Swedish Ministry of Foreign Affairs, H'ble Per-Arne Hjelmborm and Head of Science and Innovation, Swedish embassy in India, Counsellor Per-Arne Wikström at the first edition of our annual flagship conference **'RESOLVE'**. Likewise, our delegates explored partnerships in healthcare, genomics and mobility during Sweden Innovation Days at Lund University in March this year. These relationships are now translating into collaborative initiatives, jointly funded by agencies from both countries.

Similar engagements are progressing with **Germany** and **UK**, particularly in the areas of sustainable mobility and healthcare (esp. One Health) respectively. These associations will not only accelerate technological progress without re-inventing the wheel, but also enable student/researcher exchange programmes for a global exposure. We will work on widening the cluster-to-cluster engagement with other countries such as France, Israel, U.S.A. etc.

We hope that our efforts will help India leapfrog from its current ranking of 40th in the Global Innovation Index to top 10 in the coming years and I cordially invite you to join us on this journey.

Warm regards,
Shipra Misra

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Rendering Science & Technology Solutions for AtmaNirbhar Bharat

DRIIV is an ecosystem of 100+ stakeholders comprising eminent academic institutions, national & state research laboratories, industry partners, startups, MSMEs, relevant ministries, state governments and philanthropic foundations to use scientific research and innovation for India's socio-economic development. With a vision to contribute to AtmaNirbhar Bharat as envisaged by our Honourable Prime Minister, DRIIV is working relentlessly on environmental and societal problems pertinent to Delhi and neighbouring regions. Relevant thematic areas include issues related to Air Pollution Mitigation, Solid Waste Management, Water Security, application of AI/ML in Healthcare (e.g. developing early warning systems for infectious disease prediction), Sustainable Mobility (e.g. e-mobility infrastructure, digitisation of public transport), Effective Education (developing new experiential pedagogies for STEM using real life issues) and Sustainable Energy. Additionally, new focus areas such as Semiconductor Technology are being introduced and the Healthcare vertical is being augmented with additional capabilities in assistive medical devices and biotechnology.

DRIIV's technical prowess comes from the collective expertise and shared facilities of its premiere member base [eg. IITD, IIITD, IIT(ISM) Dhanbad, DU, AIIMS, JNU, NSUT, CSIR-IGIB, NPL, CRRI, THSTI, ICAR, TERI, Ashoka University, Google Research, RSPL Group, Renew Power, TATA Power etc.]. DRIIV has been serving as a platform for bringing together diverse stakeholders across industry, academia and government bodies for taking innovations from lab to market through seamless collaboration. DRIIV has also been successful in attracting private capital via Corporate Social Responsibility (CSR) for funding sustainability initiatives.

DRIIV's location in the national capital adds physical proximity to the policymakers, who are already deeply engaged with the cluster activities via the Office of the PSA. These unique advantages allow DRIIV to create a significant impact at national/international scale.

Some of the examples of DRIIV's cutting-edge research creating ground level impact include:

➤ Strainflow dashboard for COVID surge prediction, being used by ICMR

➤ One Delhi app (formerly Chartr app) - digitising public transport - adopted by the Delhi Transport Corporation

➤ Deployment of EV battery swapping stations and 380+ chargers in more than 150 locations (17+ cities).

➤ Pilots in the areas of waste management, air pollution (Project SAMEER), water security, e-mobility (Green Campus Initiative) and healthcare are being executed/initiated in collaboration with local government bodies.

DRIIV is also forging strategic partnerships to create a strong innovation ecosystem for supporting startups based on core R&D solutions. This will help create technology transfer mechanisms via startups, enhance focus on applied research and market-ready solutions and steer venture capital funds to support mid-TRL technologies.

1.1

Towards a cleaner air in Delhi NCR :
Combating the hurdles of NCAP implementation
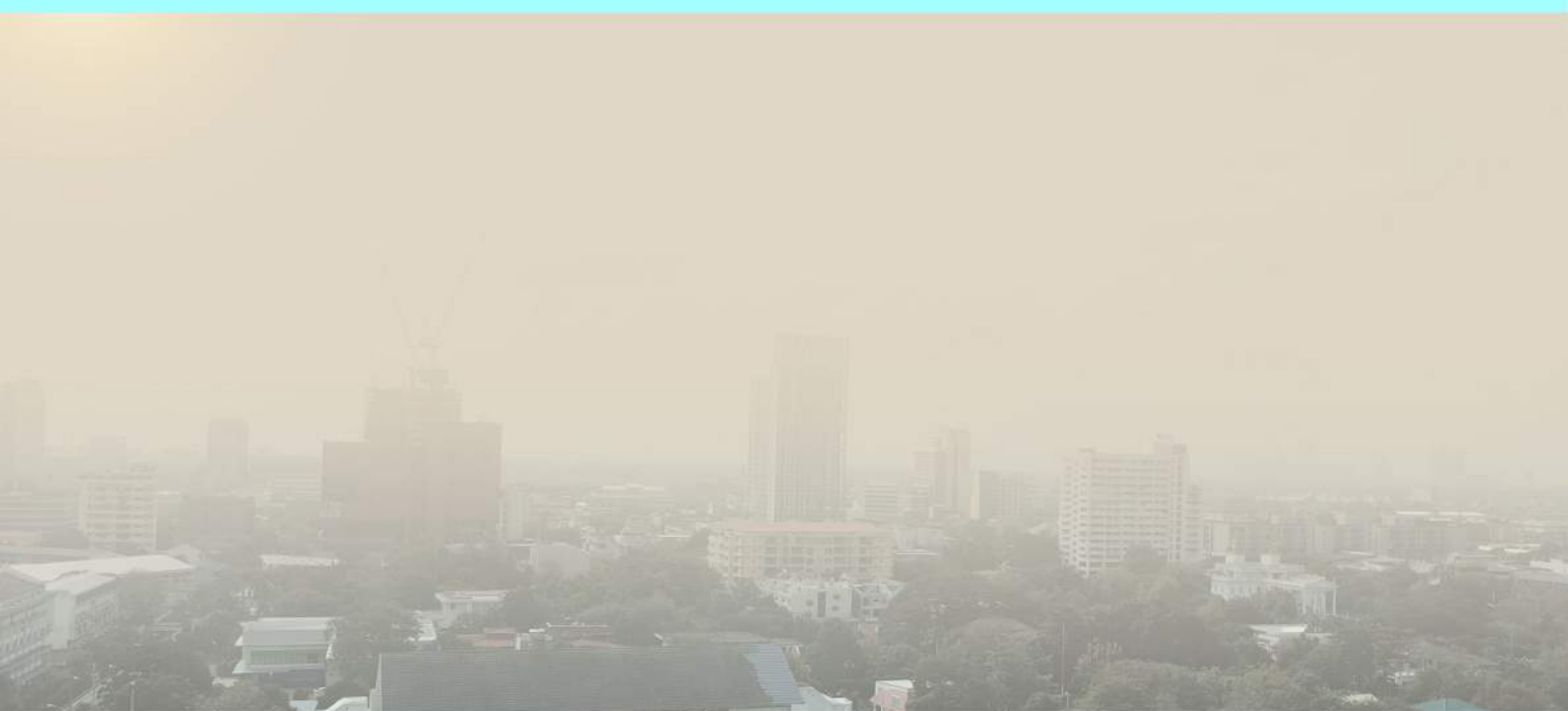
National Clean Air Program (NCAP)

India, being a vast country and an emerging economy, faces enormous challenges with its burgeoning population and widespread poverty. The associated growth in terms of industrialization and urbanization has led to manifold increase in pollution issues, specifically air pollution issues. To combat the menace of deteriorating air quality, the Government has come up with a national framework for air quality management with a time-bound reduction target. National Air Quality Monitoring Programme and regulation to curb vehicular emissions by introducing fuel quality norms have been established to tackle the challenge of unhealthy air quality in urban and regional areas.

Moving forward, a national level strategy document prescribing measure for reducing air pollution has been launched by the Ministry of Environment Forest and Climate Change (MoEFCC) in January 2019. It is the first-ever effort to lay down a framework to gradually improve the air quality at the national level by emphasizing on the need of comprehensive mitigation actions and knowledge augmentation. It seeks to cut the concentration of coarse (particulate matter of diameter 10 micrometer or less, or PM 10) and fine particles (particulate matter of diameter 2.5 micrometer or less, or PM 2.5) by at least 20% within a stipulated time, with 2017 as the base year for comparison.

The plan includes 102 non-attainment cities, across 23 states and union territories, which were identified by the Central Pollution Control Board (CPCB) on the basis of their ambient air quality (AAQ) data between 2011 and 2015.

NATIONAL CLEAN AIR PROGRAMME (NCAP)

Cities to be covered: 102

GOAL: To meet annual average ambient air quality standards

MID-TERM (5 Years): To meet annual average ambient air quality standards

HOW: Through city-specific air pollution abatement action plan

01 National emission inventory

02 Air information centre for data analysis

03 Source apportionment studies

04 Guidelines for indoor air pollution

05 Rural monitoring stations
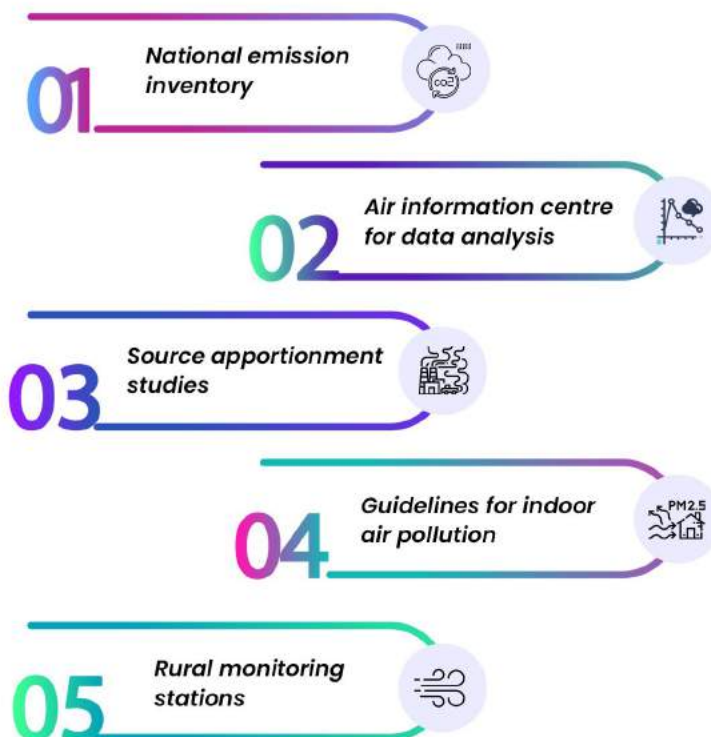
> *Through a collaborative and participatory approach between relevant ministries, State governments, local bodies and other stakeholders and by bringing in benefits of international experiences, NCAP focuses to address regional and transboundary sources of air pollution.*

Right to clean air : need of the hour

The national capital suffers 30,000 deaths because of air pollution every year. Additionally, increasingly higher rates of lung cancer, diabetes, premature births and even autism can also be directly linked to polluted air, according to the health experts. 2.2 million children in Delhi have irreversible lung damage due to the poor quality of the air. In addition, research shows that pollution can lower children's immune system and increase the risks of cancer, epilepsy, diabetes and even adult-onset diseases like multiple sclerosis.

> *Delhi, once again covered in a cascading haze of smog - witnessing very poor air quality, sticking to the trend that has existed during winter months for some years now.*
> *The last stage of the Graded Response Action Plan (GRAP) was activated and then revoked, primary schools closed, and the debate about the "main culprit" for the polluted air was rekindled.*

Delhi's vulnerability to poor air quality can be attributed to various factors:

Geographical placement: Delhi is seated in flat plain circumscribed by the mighty Himalayas; a chain of mountains and hills that blocks the movement of air. During the winter months, morning mist traps the particles at ground level and even in the absence of a breeze, smoke and dust build up, getting immediately suspended and remaining hanging in the air.

Motor vehicle emissions: The emissions that come from lakhs of poorly tuned vehicles running on low-grade fuel.

Emissions from other sources: The emissions from the coal-fired power plants, stubble burning, factories, and furnaces burning cheap pet coke and furnace oil and last but not the least the spate of illicit industrial activities in the city.

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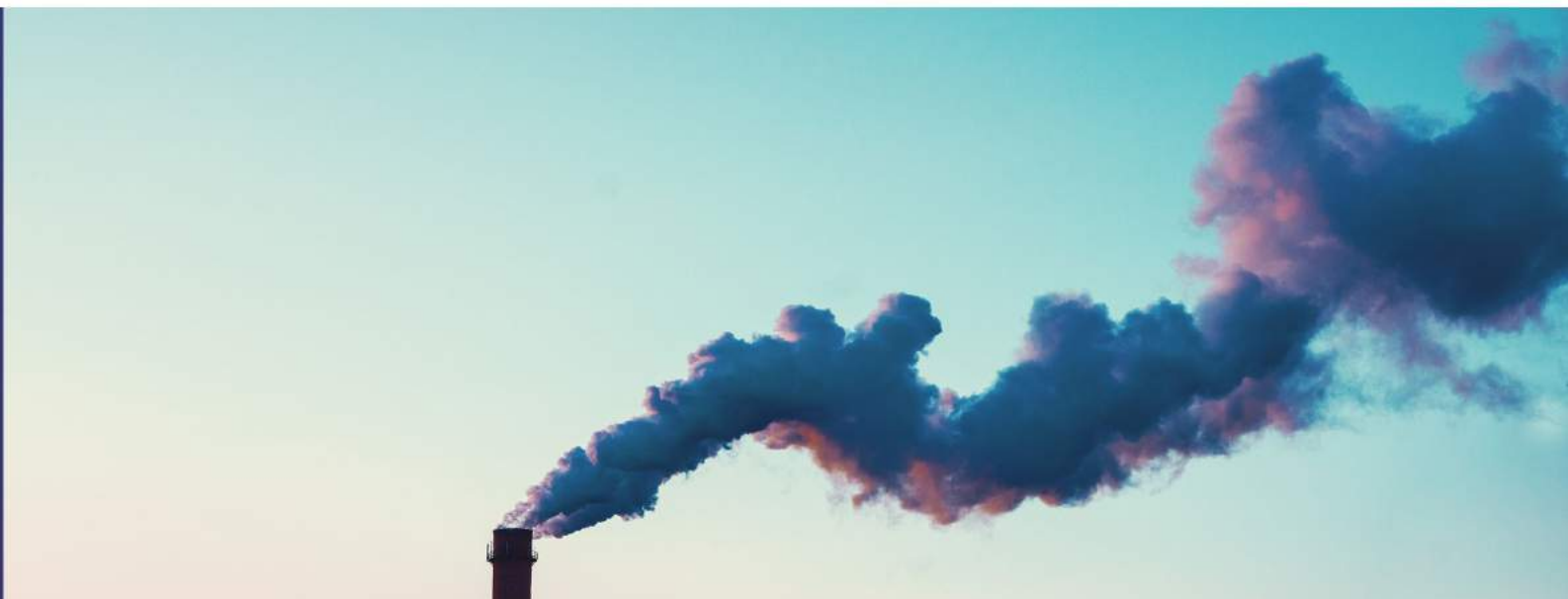
The current PM 2.5 concentration in New Delhi is 5.9 times above the recommended limit given by the WHO 24 hrs air quality guidelines value.

”

1.1.1

Delhi air pollution: the cluster DRIIV*en* solutions

DRIIV'S Air Pollution vertical was conceptualized to identify the technological, economic, societal and legal hurdles in implementing clean air action plan in Delhi NCR. This multi-stakeholder project envisages to help national capital attain the National Clean Air Program target of 20-30% reduction in PM that would eventually take the city closer to the national ambient air quality standard (NAAQS) by 2030.

Better standards

The World Health Organization (WHO) has updated its global air pollution standards from the limits set in 2005. A look at how it compares with India's National Ambient Air Quality Standards (NAAQS) last revised in 2009

Figures in g/m3

	WHO (2005)	WHO (updated)	India (NAAQS)
PM2.5 annual mean	10	5	40
PM2.5 24-hour mean	25	15	60
PM10 annual mean	20	15	60
PM10 24-hour mean	50	45	100

The broad objective of the vertical is to tackle the air pollution problem in Delhi by providing technical and academic support to the pollution control boards for efficient implementation of the clean air action plan.

The Air Pollution vertical led by **Prof. Sagnik Dey, Centre for Atmospheric Sciences, IIT Delhi** undertook multiple source apportionment studies to identify the nature and origin of pollutants. In line with the mandate of DRIIV, implementation of solutions for monitoring and mitigation of Air Pollutants were specially focussed upon.

> " *Air pollution is the largest environmental and health concern in India. It is connected with almost all SDGs, like economic growth, health burden, cognitive impairment, loss in solar power (1GW) due to aerosol, climate change etc. Without public support, mass awareness and technology interventions, the issue of air pollution cannot be resolved* "

The team addressed the following aspects of air pollution in India:

i. Management of air pollution hotspots through monitoring of air quality at local hotspot level to suggest interventions for mitigating air pollution.

ii. Awareness and capacity building programmes to orient public attention towards this issue and to highlight the impact of air pollution on health especially on pregnant women, children, elderlies and those with ailments.

iii. Open data platform for informed and data driven decision making vis-s-vis air pollution in India.

iv. Hyperlocal monitoring of air pollution and exploring the air pollution problem through a regional airshed management based approach

Implementing solutions to create impact "in the air"

The Vertical has come a long way towards identifying various bottlenecks in implementing the NCAP in Delhi. By aiding the policymakers in informed decision making by conducting feasibility studies and developing integrated, open data analytical tools, the project is helping the national capital inching slowly and surely closer to the National Clean Air Program target in the next few years. The collaborative effort over the period of time led to the development of the following insights and solutions:

(A) Dashboards tracking air quality in real-time.

Air Pollution Vertical has shown great potential in identifying the local hotspots by collecting ward-level data for the past 20 years. A real-time dashboard to track air quality at the municipal ward level in Delhi has been developed. This would be made operational with Delhi Pollution Control Committee (DPCC) for a real time analysis of air pollution at municipal ward-level (https://arcg.is/0O5zL9). Another real-time dashboard on district-level stubble burning status in Punjab and Haryana has been prepared and made operational (https://lookerstudio.google.com/u/0/report-ing/667ad61c-3944-40a4-a2bb8ef06c0b2338/page/iFt2C?s=vsPppeQE3hg).
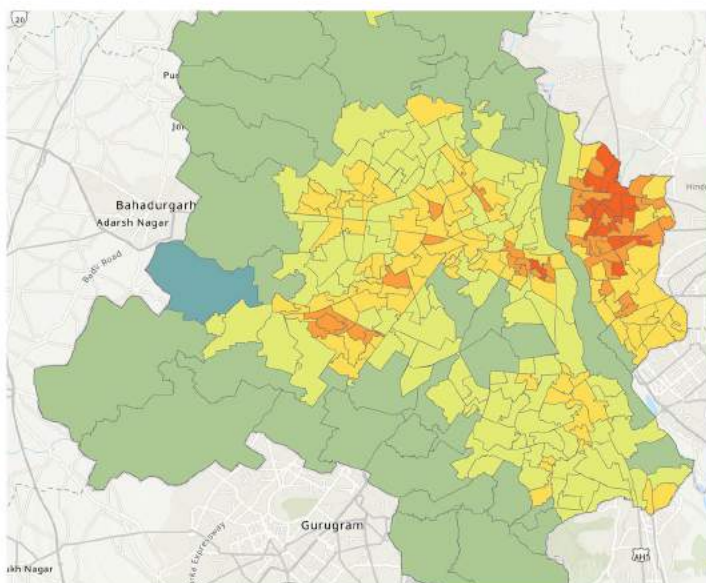
Ward-level real-time air quality monitoring dashboard

District-level stubble burning status in real-time

(B) Technological and behavioural interventions reducing pollution at source

I. Technological and behavioural interventions to reduce stubble burning in **Kapurthala**, Punjab were undertaken with **ITC** (under **Mission Sunehra Kal**) and **Manav Rachna Sansthan**. The crop residue management programme in Kapurthala and Dhilwan blocks of Punjab resulted in no stubble-burning incidents in about 1.65 lakh hectares of land i.e. about 89% of the targeted area. The climate-smart agriculture practices (adopted as part of behavioural interventions to prevent stubble burning) such as direct seeding of rice and zero tillage farming resulted in a reduction of water consumption by 25% and an increase in farmers' net income by 24%. A GPS-enabled mapping tool for accurate tracking of stubble management practices for interventions and evidence-driven policy-making & planning has been prepared in association with **Manav Rachna Sansthan** for effective on-ground interventions to stop stubble burning practices in Punjab and Haryana.

II. Multiple reports have been submitted to **Punjab Environment Ministry** suggesting interventions to tackle stubble burning in Punjab. The report examines the comparative air quality scenario with and without (in absence of) stubble-burning incidents. A study has been conducted in Ashram region especially for identifying the impact of local interventions such as road pavements on road dust pollutants. The report suggesting interventions would be presented to DPCC, Delhi.

Lead farmers training on field along with KVK Kapurthala

Training to operators on Super Stubble Management System and Happy Seeders

Awareness Campaigns at Panchyat Level

Wheat Planting in paddy stubble by Happy Seeder

Wheat Planted in Paddy Stubble

(C) Executing pilots in collaboration with local Government Bodies

Project **SAMEER** (Solutions for Air Pollution Mitigation through Engagement, Engineering, and Research) was launched in the peak air pollution period in Delhi NCR (Nov, 2022) along with Gurugram Municipal Development Authority (GMDA), Gurugram and DPCC, Delhi.

Project *SAMEER* : A journey to *"de-smog"* The National Capital Region

SAMEER is currently operational and following a 3-pronged approach to tackle air pollution in Delhi NCR (Awareness and community engagement; S&T interventions for monitoring & mitigating the hazardous PM 2.5 and PM 10 emissions; Industry roundtables mobilising sustainability champions to deploy tech solutions). Air pollution mitigation and monitoring devices have been installed in public buildings such as schools, hospitals, and on vehicle rooftops to gather relevant data and effectively address the issue of air pollution as part of project SAMEER. A host of startups have also been mobilized to deploy their technological solutions (please see below the list) across the major hotspots of Delhi NCR.

- **Umeandus :** APS (Ambient Purification System): Filterless, modular ideal for highly polluted industrial areas, marketplaces
- **Omnilon :** APC (Air Pollution control) Device: Ionization based, ideal for traffic crossroads
- **Active Buildings :** Open-Source Air Purifier & Sensors: ideal indoor solution
- **Rena :** Affordable Indoor Air Cleaner Retrofit
- **Airth :** Indoor clean air module
- **Aurassure :** AQI monitoring system (Indoor & Outdoor)
- **Indus AAQMS :** Ambient Air Quality Monitoring System
- **PrKruti :** Smart Air Quality Monitoring System
- **Oizom :** Smart Air Quality Monitoring for Sustainable Future
- **Shudhvayu :** Air Filter for vehicular roof-tops
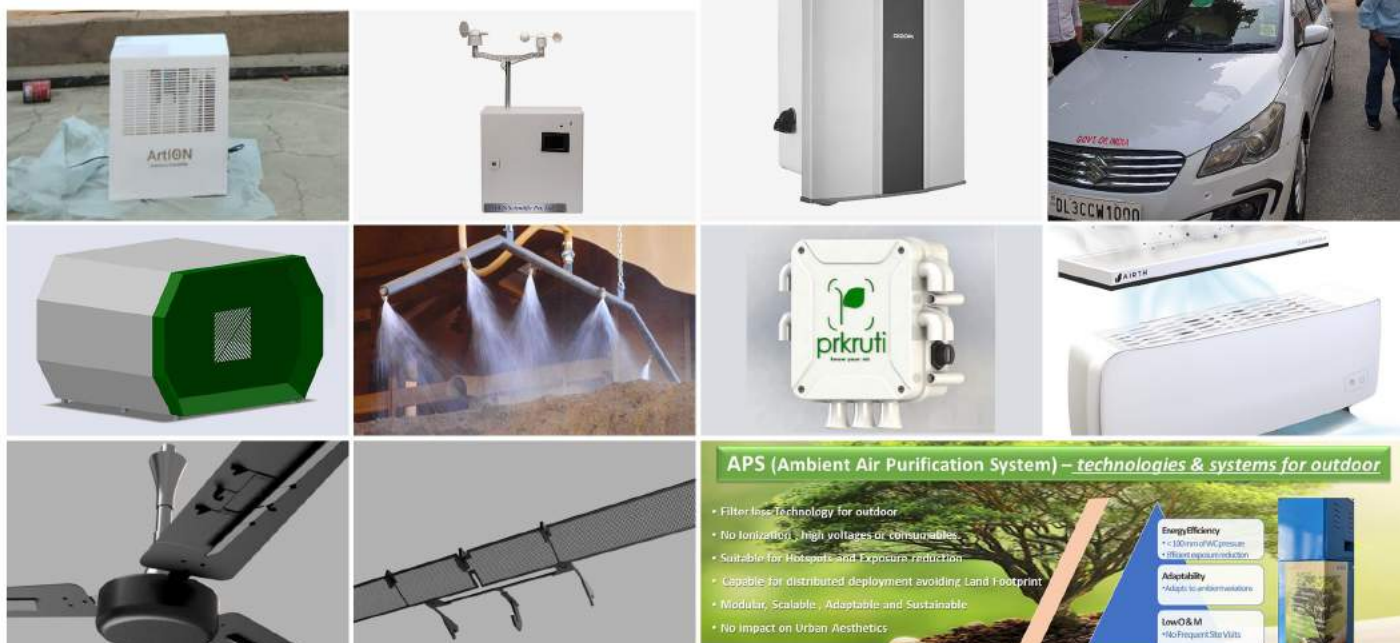
Startup technologies piloted through SAMEER

In order to truly solve the problem of air pollution, it is important to control emissions at source and DRIIV is working on renewable energy and sustainable mobility technologies to help achieve that. However, project SAMEER has successfully achieved the three objectives it was designed to deliver.

✓ Firstly, the well-structured pilot with clearly defined outcomes, brought together **startups** and **public bodies** - **DPCC** and **GMDA** - to address the problem of air pollution monitoring and mitigation in Delhi NCR. Such an engagement, without any mediating platform such as DRIIV, would not be possible.

✓ Secondly, a framework for **technology validation** has been established where startups can get their solutions validated in real life conditions from the country's premiere institutes such as **IIT Delhi** and **AIIMS**.

✓ Finally, a number of **corporations** and government bodies have come forward to adopt the technology solutions and/or financially support their adoption. Encouraged by its success, DRIIV will replicate this model in other areas of environmental concerns such as **waste management** and **water security**.

Glimpses of SAMEER: Calibration of portable sensors with regulatory unit (1st panel) at Safar site, IIT Delhi; Awareness workshop and industry roundtable event (2nd, 3rd & 4th panels)

D. Trends of PM exposure in Delhi and its acute impact on health

With the novel use of high-resolution (1 km) satellite data, the team observed the trends of PM exposure in Delhi and its acute impact on health. Over 1500 stakeholders participated across multiple workshops conducted to raise awareness on **Air Quality and Health Impacts** of air pollution.

Toxic emission of **NO_2** at high concentration contributes tremendously to polluting air by activating various noxious chemical reactions. The team has made inroads in estimating **NO_2** emission (by TROPOMI data, emissions of other trace gases like **SO_2** can be estimated using the TROPOMI product) from as many as 9 thermal plants (a major contributor of air pollution in Delhi besides brick kilns) within 300 km radius in Delhi.

i. The nine TPPs in the vicinity of the world's most polluted megacity Delhi emitted NO_2 in the range 8.00–30.56 Kt in 2019.

ii. The NO_2 emission varies seasonally and is not uniform throughout the year.

iii. The NO_2 emission reduced significantly (in a range 41%–290%) during the COVID-19 lockdown in 2020 compared to the same period in 2019 due to the reduced operating capacity of the plants.

These findings would be useful in ensuring that the thermal power plants across the country follow the emission protocols.
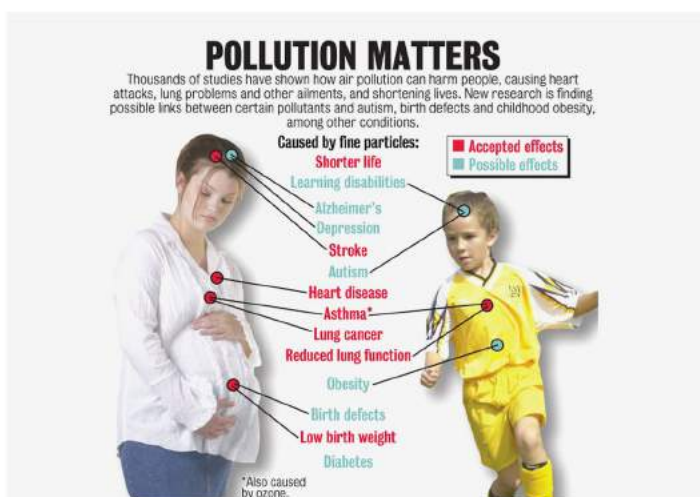
Impact of air pollution on pregnant women
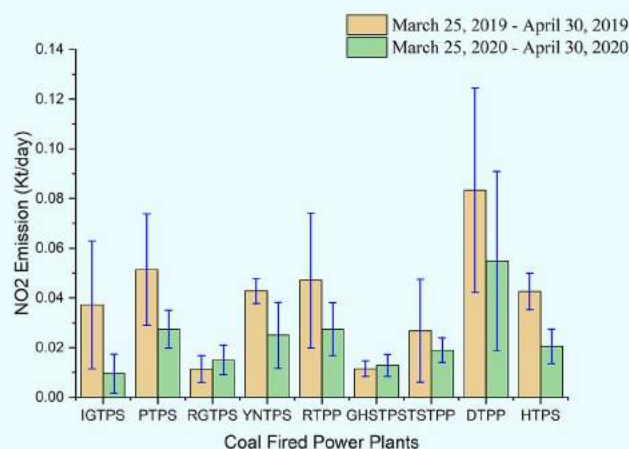
IGTPP : Indira Gandhi TPP | **TSTPP :** Talwandi Sabo TPP

RTPP : Rajpura TPP | **DTPP :** Dadri TPP | **YNTPP :** Yamuna Nagar TPP |

HTPP : Harduaganj TPP | **PTPP :** Panipat TPP |

GHTPP : Guru Hargobind TPP | **RGTPP :** Rajiv Gandhi TPP

Estimated NO$_2$ emissions from 9 TPPs in north India
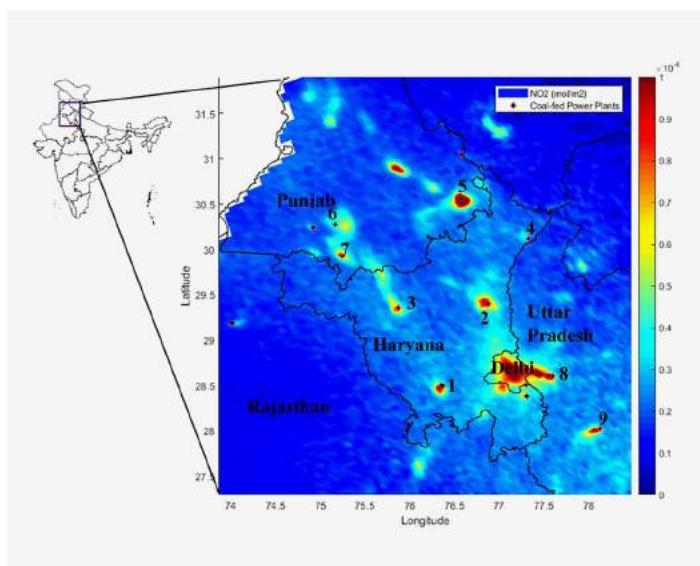
Distribution of tropospheric NO$_2$ columnar density over north India (Oct. 2019)

E. Source apportionment analysis

An analysis of the status and trends of air pollutant emissions and air quality concentrations in India, impacts, and policy response, for use in policy processes and decision-making during policy implementation has been conducted with TERI (https://www.teriin.org/sites/default/files/2018-08/Report_SA_AQM-Delhi-NCR_0.pdf). This would serve as a policy and decision-making tool for agencies such as CPCB.

All of India's 1.4 billion people (100% of the country's population) are exposed to unhealthy levels of ambient PM 2.5 – the most harmful pollutant - emanating from multiple sources

Winters

PM 2.5

Dust (Soil, Road, and Const.)
Others
Transport
17%
28%
11%
30%
10% 4%
Residential
Agri. Burning
Industry

PM 10

Dust (Soil, Road, and Const.)
Others
Transport
25%
24%
10%
27%
9% 4%
Residential
Agri. Burning
Industry
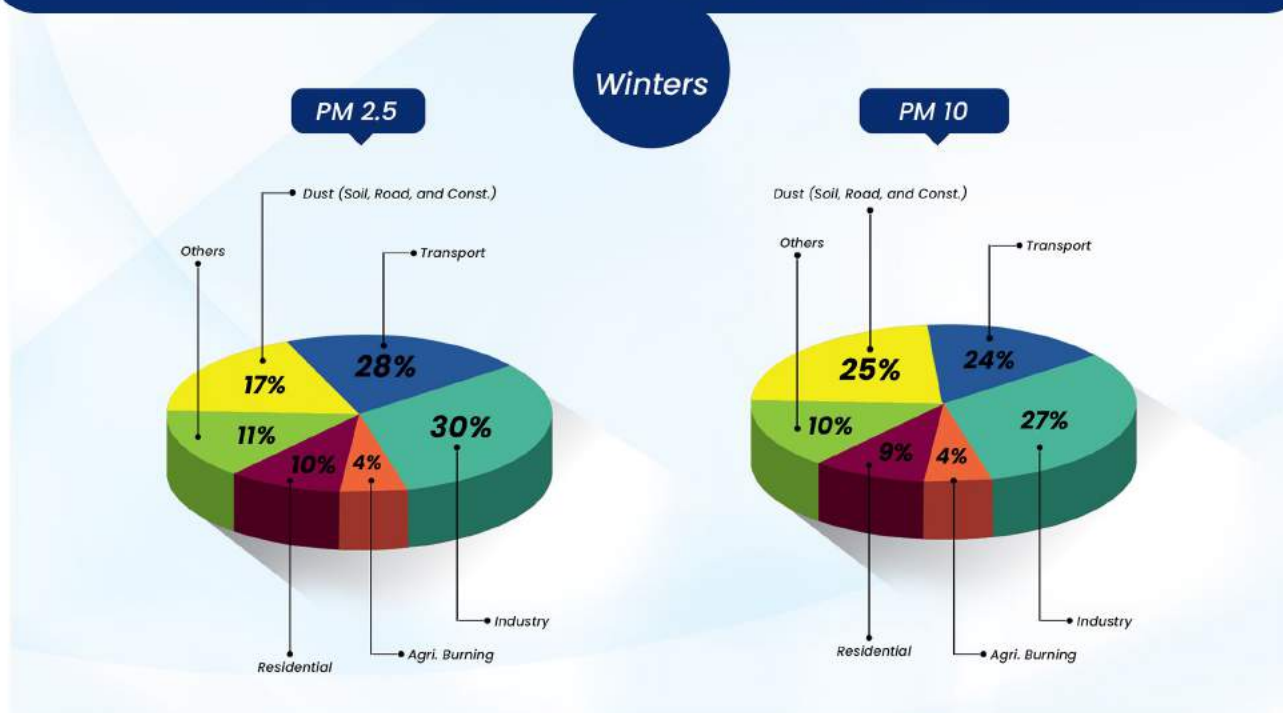
1.1.2

A snapshot of future roadmaps towards improving the ambient air quality

I.   **A matchmaking-based solution** to connect the prominent stakeholders [corporate sector, expert institutions (including NGOs, CSOs, and academia), international development agencies, international philanthropic organizations, National philanthropic organizations, and the UN system of organizations] and present a joint solution for tackling the air pollution problem is being prepared under the framework of UNEP supported Air Quality Action Forum (AQAF). The forum would enable stakeholder consultation focussing on solutions for air pollution.

> Solutions Centre as part of the AQAF has been conceptualized to provide demand-driven expert assistance and direct support to the Indian policy and decision-makers in the government on specific air quality issues through an **"Assistance Service"** that is addressing ad-hoc requests from the government for immediate support.

II. **Assessment report has been formulated on highlighting gaps in NCAP implementation** and presented to MoEFCC under the framework of the **Air Quality Action Forum**.

III. **Preparation of White Paper with World Bank Group** on Air Quality Measurement and Analysis Systems – Global Perspectives and Approach for India.

IV. **Hyperlocal monitoring of air quality in and around monuments in Kolkata** to identify dispersed sources and track air quality has been started in association with New York based Environmental Defence Fund (EDF). The project involves setting up of a dense network of static monitors in central and north Kolkata for identifying dispersed sources. The findings and recommendations would be shared with the West Bengal PCB.

V. **Hyperlocal monitoring** of air pollution in Delhi using a dense sensor network (12-13 sensors per hotspot) having at least one sensor per municipal ward (250 wards) and mobile sensors on buses.

VI. **A joint IITD – AIIMS study** to analyse the effect of air pollution in the city of Delhi on the health of pregnant mothers and their new-born children, and asthmatic adolescents is being conducted. The project involves a consortium of doctors, scientists, and technologists drawn from 9 institutions (six in India and three in the UK) to study the health impact of air pollution on vulnerable population.

VII. **A technological study with SBI Cap Ventures** is being conducted to assess the impact of diesel engines to air pollution, the health and economic burden of air pollution, success of emission control policies taken by state PCBs, and potential of introducing retrofit technologies in India.

World Bank program (Country Partnership Program) is introducing tools to support state and regional air quality managment approaches. These initiatives will help formulate India's first State Air Quality Action Plan and India's first large Airshed Action Plan for the **Indo Gangetic Plains (IGP)**, spanning seven union territories and states.

Prof. Sagnik Dey at AQAF annual conference (2023)
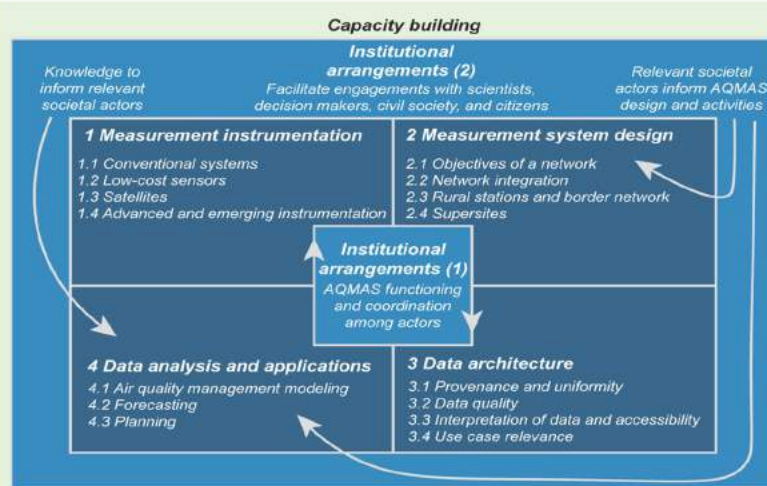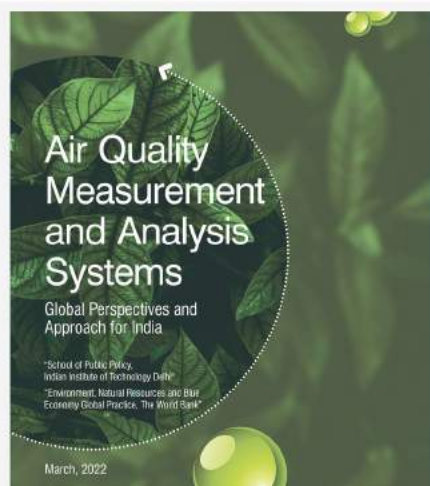
Publications

Publications & Reports

I. Shashi Tiwari, Alok Kumar, Supriya Mantri and Sagnik Dey, Modelling ambient PM2.5 exposure at an ultra-high resolution and associated health burden in megacity Delhi: exposure reduction target for 2030, Environmental Research Letters, DOI 10.1088/1748-9326/acc261

II. Gautam Kumar Saw, Sagnik Dey, Hemant Kaushal, Kanhaiya Lal, Tracking NO2 emission from thermal power plants in North India using TROPOMI data, Atmospheric Environment X, https://doi.org/10.1016/j.atmosenv.2021.118514

III. Tanushree Ganguly, Kurinji L. Selvaraj, Sarath K. Guttikunda, National Clean Air Programme (NCAP) for Indian cities: Review and outlook of clean air action plans, Atmospheric Environment X, https://doi.org/10.1016/j.aeaoa.2020.100096

IV. White Paper on Air Quality Measurement and Analysis System (AQMAS) for India

V. White Paper on cost effectiveness of interventions for control of air pollution in Delhi https://www.teriin.org/sites/default/files/2021-12/Cost-effectiveness-of%20-interventions-for-control-of%20-air-pollution-in-Delhi.pdf

1.2

Waste to Wealth Mission : for a ZERO-WASTE nation

The Waste to Wealth Mission, as the **"scientific arm"** of the **"Swachh Bharat Mission"**, aims to generate energy, recycle materials, and extract worth by managing waste through identifying, developing, and deploying novel technology solutions. It is one of the nine national missions of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC) to assist streamlining waste handling in the country by creating financially viable circular economic models.

"

Significance: The benefits of effective waste management is huge,
as it is predicted that India has the potential
to generate 3 GW of electricity from waste by 2050.

"

The mission envisages

➤ To support the development of new technologies that can help create a cleaner and greener environment.

➤ To boost and augment the Swachh Bharat Mission and Smart Cities Project by leveraging science, technology and innovation.

➤ To create circular economic models that are financially viable for waste management.

➤ To streamline waste handling in India.

"
The waste dumped openly and not collected makes for unaccounted waste
"

The enormity of solid waste generation in India

Municipal solid wastes (MSW) are highly heterogeneous mixture of residential, commercial (clothing, disposable tableware, yard trimmings, cans, office disposable tables, paper, & boxes), and industrial sectors (restaurant trash, paper, classroom wastes, wood pellets, plastics, corrugated box, and office papers). The composition of MSW could be highly variable with organic materials being the largest component. The world generates 2.01 billion tonnes of MSW annually and that number is estimated to rise to 3.40 billion tonnes by 2050. In India, each year, approximately 62 million tonnes of waste, including plastic waste, e-waste and medical waste, is generated, making an enormous impact on the environment by contributing towards ever-increasing landfills and throwing a daunting challenge for the public authorities. The gloomy story continues with a generation of over 1.60 lakh (1,60,038.9) tonnes of solid waste per day in the municipal areas in India [as per the annual report (2020-21) by CPCB].

> *If the present scenario of waste management is considered, where most of the waste is dumped without treatment, we are actually looking at an estimated 88 square km (equivalent to the size of the New Delhi Municipal Council area) of precious land being brought under waste disposal through landfilling.*

The challenge of ever-growing mountains of waste in Delhi NCR

Disposal of MSW is a major concern in India. On average, about 15-20 acres of land by ULBs are dedicated to waste disposal in about 7,000 metropolitan regions, accounting for more than 1 lakh acres of land. That is, nearly half the size of the city of Delhi is considered waste disposal sites. A mountain (65 metres) of garbage in the Ghazipur area standing high around 13 km away from the India Gate in the Delhi. The landfill site, commissioned in 1984 and overflowing since 2002, exceeded its capacity two decades ago but garbage continues to get dumped here. This is just one of the several stories about legacy waste in Delhi and in other cities.

> *The term 'legacy waste' has received close attention in the wake of Swachh Bharat Mission (SBM) 2.0 and it mandates that cities in India should clear legacy waste sites, reclaim the land and prevent more waste from reaching dumpsites.*

1.2.1

'Waste to Wealth' – DRIIV's 'circular economy' approach to waste management

Recognizing the centrality of effective and sustainable waste management in the nation's developmental agenda, the **Waste to Wealth vertical** of **DRIIV** led by **Prof. K K Pant**, IIT Delhi designed, developed, and deployed multiple smart, secure and sustainable solutions for the management of municipal solid waste, electronic waste, plastic waste, kitchen, horticultural and agricultural waste, and others.

> *The varied nature of waste generated from our daily or industrial activities demands a multi-stakeholder approach for its management. A multi-institutional approach under the aegis of DRIIV, comprising of researchers from various leading institutes of Delhi-NCR is working on the management of different types of waste with an objective of creating value added products from the discarded waste material and hence ushering into a truly circular economy.*

Market-ready 'Waste to Wealth' technologies developed by DRIIV

(A) Management of MSW/organic waste/bio-degradable waste/plastic waste through decentralised solution, converting kitchen/horticultural waste into fuel, and agricultural waste into biochar/biofuel

I. Plant converting waste plastic into fuel and carbonaceous material

Pilot plant for management of plastic waste at IIT Delhi

2 kg/hr pilot plant for waste plastic [varied types of plastic waste (PP, HDPE, LDPE), received from SDMC, New Delhi] to fuel conversion has been designed and developed in IIT Delhi by **Prof. K K Pant and team**. The novelty of the plant lies in utilizing an in-house synthesized catalyst for the conversion of waste plastic into liquid fuel. The reactor is uniquely designed and consists of batch reactor, fixed bed reactor, condenser (shell, and tube type), liquid collector, and outlets for flue gas. The thermo-catalytic cracking has been employed for the conversion of plastic waste into liquid fuel with an efficiency of 75%.

Plastic Waste → Liquid Product Yield 70-75%

II. Pyrolysis reactor converting agriwaste to biochar

A Pyrolysis reactor, under the leadership of **Prof. Dinesh Mohan**, for biochar production from agricultural residues has successfully been developed and patented by JNU, New Delhi. One such reactor is operational and producing biochar in JNU Campus. Patented Kaccha reactor for in-farm production of biochar has also been developed which can produce 30-40% of biochar/ unit mass of biomass fed. The produced biochar has been shown to efficiently improve soil quality (impacting water retention, C and N_2 components along with quality of the harvest) and have the potential for water purification. Patented Biochar Nanocomposites has been developed for removal of arsenic from water.

Bio cartridge made of biochar for water filtration purpose

Kaccha reactor for in-farm biochar production (2nd pic) Testing the efficiency of biochar in improving harvest quality (3rd and 4th pics)

III. Sound blocking materials from biochar

Prof. Fatima, **IIT Delhi** has developed novel composites of sound insulating materials utilizing solid waste through compression molding technique. Biomass and biochar were used for this purpose and natural rubber-bamboo biochar composites were developed for applications such as manufacturing automotive cabins. The proof of concept trials or implementation of composites for noise control applications in automotive cabins (dashboard, door panels, engine cover, battery insulation and EV motor cover), generator insulation, office partitions and highway barriers are underway.
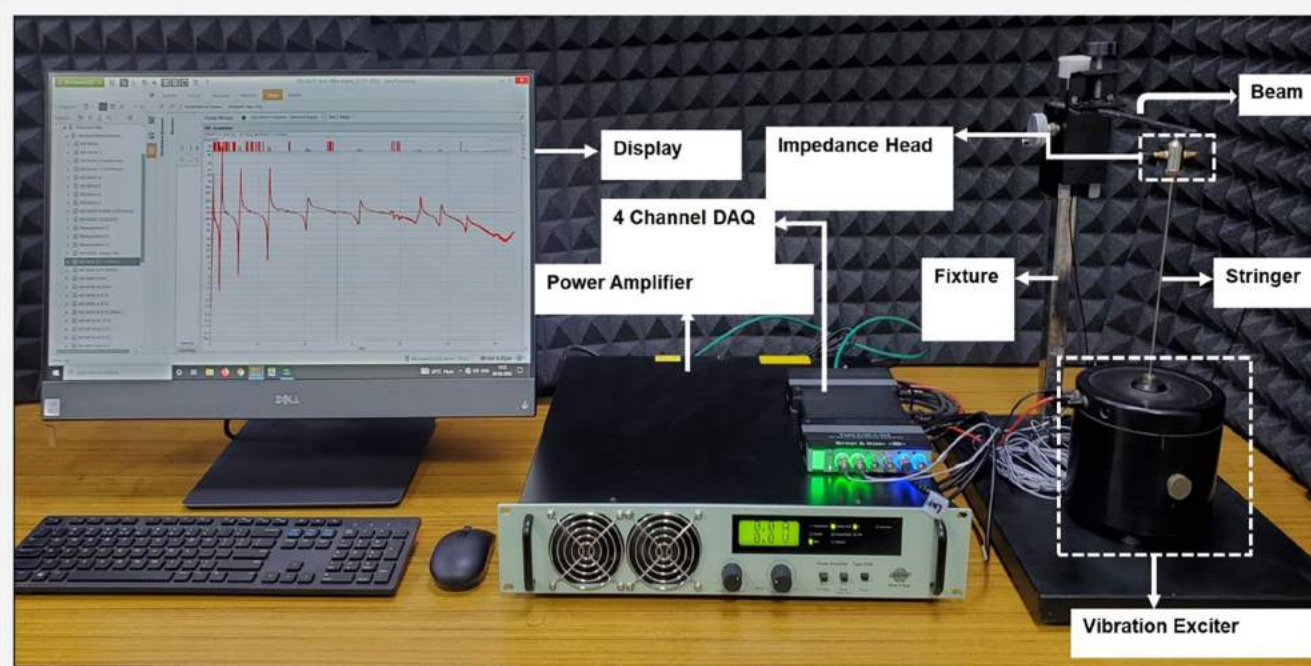
Process flow for testing of biochar-derived sound blocking composites

IV. Biogas plant to manage kitchen/horticulture waste and production of CBG

A fully automated biogas purification and bottling plant with improved design parameters has been designed, fabricated and implemented at IIT Delhi under the leadership of **Prof. V K Vijay**. Waste from domestic households, hostels and horticultural sources are collected from campus and biodegradable waste and recyclable waste are segregated. This plant (having a capacity of 25 m³/day) uses 250 kg of waste per day to produce biogas and compressed biogas (CBG). The biogas produced is being upgraded to a quality of natural gas using a biogas purification and bottling plant situated in Biogas Production and Upgradation Laboratory. The biogas is being also upgraded to natural gas quality fuel by a water scrubbing-based system (20 Nm³ /h of biogas). Further, the upgraded CBG is being used as vehicular fuel to substitute CNG.

Biogas plant at Gramodya Parisar, IIT Delhi

(B) Management of inorganic waste through conversion of e-waste into fuel, extraction of precious metals from e-waste and battery waste & managing construction & demolition waste

Recycling of e-waste can be effectively streamlined and a 'circular economy' can be created via extraction of metals and commercially useful compounds

As per CPCB 2021 data, c. 32.3 lakh tonnes per annum of e-waste is generated in India. Most of it (c. 90%) is being handled by the informal sector. The unregulated and unstructured e-waste recycling activities can pose a high risk to the environment and human health. These activities can affect people who are exposed to such hazardous substances, including acute lung damage stemming from the inhalation of fumes of heavy metals such as Pb (lead) & Cd (cadmium). Furthermore, e-waste dumped in landfills causes leaching of toxic heavy metals such as Pb, Cr (chromium), Ni (nickel), Cd, Hg (mercury) etc. into soil and surrounding waterbodies, thus putting human and animal life at risk via contamination of vegetation and water.

I. Plant converting e-waste to fuel and metals

A Pilot plant having capacity **10 kg/hr** for conversion of e-waste and battery waste into fuel has been developed by **Prof. K K Pant** and **Prof. Ejaz Ahmad** from IIT (ISM) Dhanbad and is operational in IIT Delhi. The individual recovery of precious and semi-precious metals [Cu (93%), Ni (100%), Zn (100%), Pb (100%), Ag (86%), and Au (76%)] has also been successfully undertaken. This Patented technology converts e-Waste to fuel with an efficiency of over 90% and has the potential to convert all types of e-waste to combustible gases of 28 MJ/kg (Megajoule per Kilogram) calorific value, liquid fuel of 30 MJ/kg calorific value, and a metal-rich solid residue.

Pilot plant for converting e-waste to value-added products

II. Ecofriendly conversion of battery waste to metals

An eco-friendly method has been developed within DRIIV, employing solid state chlorination that uses low operating temperature range (200-400 °C) as opposed to the conventional pyrometallurgical process (>1000 °C) for the recovery of metals from rechargeable batteries. Furthermore, compared to hydrometallurgical processes, where highly corrosive solvents are used, here green solvents are used for leaching of metal chloride, leading to toxin-free effluent.

> "
> *An organized value chain, comprising of collection,*
> *transportation, dismantling and recycling should be*
> *set up to form a closed loop (circular economy), integrating*
> *E Waste generators, aggregators and final processors.*
> *This can be done via formation of a hub and spoke model*
> *that channelizes the waste to the end processors, involving formal (companies)*
> *and informal sector (recyclers, kabadiwallas) as stakeholders.*
> "

III. Managing construction and demolition waste

Under the leadership of **Prof. V Havanagi**, experiments carried out in **CSIR-CRRI**, revealed that nearly 60% of conventional aggregates can be replaced with C&D wastes in Dry Lean Concrete layer of road. Economic feasibility lies in 1% cost reduction in road construction using C&D waste and incinerated residues in the mixture.

Case Study :
Collective Responsibility Drive (CRD), an educational initiative

DRIIV along with **Blue Planet Environmental Solutions** (BPES) **India Pvt Ltd**, has initiated behavioural nudging of school children for plastic waste collection and segregation through organizing Collective Responsibility Drive (CRD)-Recycling. This drive aims at nudging **10 million youth and collecting 1 billion tonnes of plastic waste** thereby preventing them from going to landfills and impacting the environment and climate change. The drive in true sense depicts a perfect example of **circular economy** wherein the accumulated waste will be upcycled, transformed into school benches & donated to the government schools of Delhi and Haryana. CSR support from **REC FOUNDATION** has kick-started CRD in Gurugram, Haryana, which includes donating **1000 school benches** (impacting a total of **3000 students**) made from **recyclable plastic** waste in 27 government schools and conducting awareness programme in **50 schools** towards climate change & sustainability.

1.2.2

Demonstration of self-sustainable integrated waste management technologies: Ready solutions to be adopted by public bodies to manage legacy waste

I. Plasma pyrolysis plant installed at Jaffrabad Technology Park, as part of Su-Dhara, to manage MSW : an initiative of the Office of the Principal Scientific Adviser under the Waste to Wealth Mission

Through **Su-Dhara** (https://www.driiv.co.in/waste-to-wealth/index.html), a sentinel project of the PSA, a plasma pyrolysis plant has been installed at Jaffrabad as part of an integrated waste management technology. It is operating at 40-50 kg/hr, and the energy consumed per kg of waste is 0.5 kWh which is 20-30% less in comparison to previously reported technologies. The ash generated as a by-product is approximately 6-8%, and after testing, it was found to be non-hazardous and carbonless. Zero carbon content in bottom ash makes it more considerable for ash brick manufacturing than the ash of incinerators and others. Approximately 100 tonnes of MSW have already been treated in the last ten months, and the exhaust gas was found to be nontoxic and harmless to the environment. These combustible gases are a good source of heat and can also be used to generate power. Toxic compounds such as dioxins, furans, poly-aromatic hydrocarbons, and others are destroyed in the plasma pyrolysis chamber due to high temperature, unlike conventional incinerators. The plasma pyrolysis plant was developed as part of Centre of Excellence on solid waste management at IIT Delhi with **Prof. Satyananda Kar** as the team lead.

Plasma pyrolysis plant at Jaffrabad Technology park

II. Waste biomass to biocoal through Torrefaction at CSIR-NPL

Being an agro-based country, India generates nearly 750 MMT of biomass per year with a surplus of 230 MMT biomass from different types of agricultural residues. Biomass is an eco-friendly energy source having several advantages such as carbon neutrality, renewability, less sulfur content, and huge availability. CSIR-NPL, under the leadership of **Prof. S R Dhakate**, has developed a decentralized torrefaction technology to convert the waste biomass to biocoal having equivalent properties of that of coal and can partially replace it in existing thermal power plants and blast furnace in steel industry, boilers in small scale industry etc. The torrefaction pilot plant of capacity 10 kg/hr currently runs on LPG, however, can be made fully energy efficient by utilizing released volatile matter as a fuel source.

Plant converting agriwaste to biocoal   *Biocoal brickets*   *Rice straw*

III. Utilization of waste plastic for societal applications

(A) Waste plastic to smart tiles

India generates 3.5 MT/y plastic waste (CPCB) nationwide with the national capital contributing towards a staggering high 690 TPD. Waste plastic bags and waste plastic scraps are utilized for designing of tiles which can be used in building structures, paver tiles, interlock tiles, roof tiles, rooms, smart toilets thereby contributing towards societal benefits. WP RM composites developed upon blending of red mud and LD/PP were subjected to further compression molding to give rise to wall/floor/paver tiles. Smart tiles have superior mechanical strength, flame retardancy, water permeability, UV-protection & antistatic response than conventional structures. **Prof. R Singh**, CSIR-NPL is leading this project.

Waste plastic Bags + bottles Shredded into small pieces

Shredded plastic mixed with fillers and molded into tiles

Tiles used in fabricating structures.

Process flow diagram

Waste plastic bags + bottles shredded into small pieces

Plastic Waste

LDPE 4   HDPE 2   PP 5

Shredded plastic mixed with fillers & molded into tiles

Paver Tiles

Waste plastic composite tiles used to build toilet structures

Smart toilet structure with solar panel

Floor/Wall Tiles

Stretches of pavements constructed with plastic tiles

(B) Development of prefabricated plastic panels for road construction

In collaboration with CSIR-CRRI, CSIR-NPL is designing and developing prefabricated panels from engineered polymers from waste plastic as base material for roads. Further properties will be improved through R&D by adding some additives etc. and finally engineered plastic will be used for production of slab/panel for road construction applications and other value-added products useful for building roads.

> "
>
> *Garbage disposal capacity of the country has increased by 4 times since 2014. More than 1600 bodies are getting material recovery facilities to get rid of single use plastic.*
>
> "

IV. Waste to Wealth Mission in collaboration with East Delhi Municipal Corporation (EDMC)

The Waste to Wealth Mission, operational under the leadership of Dr. Monoranjan Mohanty, O/o PSA, in collaboration with the Invest India Team (https://www.investindia.gov.in/waste-to-wealth) envisages to identify, develop, and deploy technologies for waste management, generating energy, recycling materials, and extracting resources of value.

A Decentralized Waste Management Technology Park at New Jaffrabad has been set up by the O/o PSA (www.wastetowealth.gov.in) and EDMC, as part of the sentinel project Su-Dhara, towards showcasing a suite of technologies providing end-to-end solutions for waste management. It demonstrates conversion of open dumpsites (dhalaos) to decentralized waste processing sites covering around 1000 sqm of area (area previously been utilized for open dumping or secondary collection site) with 10 TPD capacity.

From semi-automated segregation of municipal solid waste to on-site compaction and treatment of the waste, the park has piloted five technologies with an integrated approach including 'Xaper' (by M/s E3 Waste Solutions, Punjab), 'Plasma pyrolysis Unit' (by IIT Delhi), 'Enviro-RISE R-A1100' (by M/s DESMI India LLP), 'Gasifier' (by M/s GD Environmental Pvt. Ltd., Maharashtra) and Johkasou STP (by M/s Daiki Axis India Pvt. Ltd., Delhi).

Xaper

Gasifier

Gasifier : internal mechanistics

Johkasou

Enviro-Rise-R-A1100
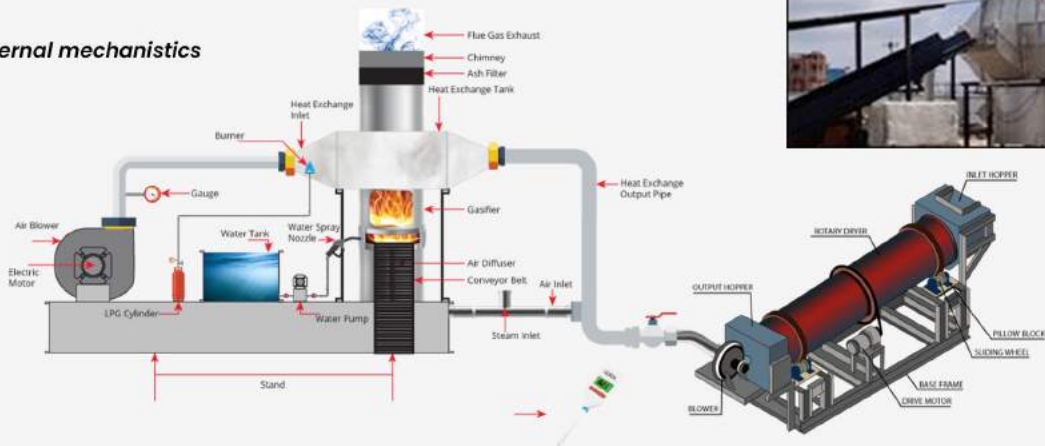
Plasma pyrolysis plant

Publications

Publications & Reports

I. S Kushwah, S Gokarn, E Ahmad, K. K. Pant , An empirical investigation of household's waste separation intention : A dual-factor theory perspective, J. Environ. Manage, DOI: 10.1016/j.jenvman.2022.117109

II. P. R. Jadhao, E. Ahmad, K. K. Pant, K. D. P. Nigam, Advancement in the Field of Electronic Waste Recycling: Critical Assessment of Chemical Route for Generation of Energy and Valuable Products Coupled with Metal Recovery, Sep. Pur. Techol. https://doi.org/10.1016/j.seppur.2022.120773

III. P. R. Jadhao, A. Pandey, K. K. Pant, K. D. P. Nigam, Efficient Recovery of Cu and Ni from WPCB via Alkali Leaching Approach, Journal of Environmental Management, DOI: 10.1016/j.jenvman.2021.113154

IV. Tech Rep. No. NGRI-2007-Assessment of Groundwater Pollution due to Tannery Effluents in Unnao District, Uttar Pradesh, VVS Gurunadha Rao, BA Prakash, M Ramesh, K Mahesh Kumar, K Krishna Kumar and N Pavan Kumar (NGRI) and KP Singh, Amrita Malik and Dinesh Mohan (Environmental Chemistry Section, ITRC, Lucknow CSIR Network Project on Groundwater Research)

Patents

I. A process and two-step catalytic reactor system for the production of liquid hydrocarbons from plastic waste (Indian patent)

II. Pyrolysis Reactor for Biochar Production from Agricultural Residues (Indian patent)

III. A Device and a Process for Conversion of Biogas to a Fuel Gas with enhanced Thermal Efficiency (Indian patent)

1.3

Water Security with National Water Missions :
Save water now to secure future

Water security constitutes the sustainable availability of adequate quantity and quality of water for resilient societies and ecosystems in the face of uncertain global change. India is experiencing a very significant water challenge. Average per capita water availability, which is already low enough for India to be categorized as water-stressed, is expected to reduce further to 1341 m³ by 2025 and 1140 m³ by 2050. Sustainable agricultural production, ensuring water security and maintaining environmental integrity are becoming increasingly important issues in view of burgeoning population and its increasing pressure on land. Population density together with changing climatic conditions are creating increasing scarcity of water due to erratic rain distribution (unexpected events), fast depleting water resources (both ground and surface), runoff rainwater along with soil erosion/sediments, non or less functional water bodies, wetlands and/or reservoirs, low water productivity, fast depleting water quality and widely differing agro-climatic regions. Delhi NCT and NCR are no exception in facing all these problems.

The National Missions to ensure water security in an equitable & sustainable manner

As an overall part of the National Action Plan on Climate Change (**NAPCC**), the National Water Mission (NWM) envisages developing a framework to optimize water usage by increasing efficiency by 20% through regulatory mechanisms with differential entitlements and pricing. Through the adoption of new and appropriate technologies, the mission will ensure enhanced water storage both above and below ground, rainwater harvesting and that requirements of water needs of urban areas and coastal cities with inadequate alternative sources are met.

Five goals of National Water Mission :

01 Comprehensive water database in the public domain & assessment of the impact of climate change on water resources

02 Promotion of citizen and state actions for water conservation, augmentation and preservation

03 Focused attention to vulnerable areas including over-exploited areas

04 Increasing water use efficiency by 20%

05 Promotion of basin-level integrated water resources management

Additionally, with an objective of harvesting and conserving water for the future generation, the **Mission Amrit Sarovar** was launched in 2022 to rejuvenate water bodies in each district of the country as a part to the celebration of Azadi ka Amrit Mahotsav. Ministry of Jal Shakti has further launched **"Catch the rain where it falls when it falls"** campaign through the **Jal Jeevan Mission**.

> *Under the Jal Shakti Abhiyan programme, emphasis has been given to water conservation and rainwater harvesting, renovation of water bodies/tanks/wetlands, recharge of, bore well and other recharge structures, watershed development and intensive afforestation.*

> *The groundwater table in Delhi has depleted to 20-30 metres in various areas across the city. The optimum use of surface water by large scale water harvesting structures and its conjunctive use with groundwater is the only viable solution to boost and maintain current level of food grain production especially in the water scarce regions.*

1.3.1

How DRIIV is working towards ensuring water security

A host of problems threaten water security in Delhi NCR region such as, a water supply system suffering from both quality and availability issues, inadequate handling of sewage in drains, frequent flooding even with a very low intensity of rain, pesticide and metal in the aquatic ecosystem, pharmaceutical and personal care products polluting both surface and ground water etc.

With a mission to ensure availability and sustainable management of water and sanitation in DelhiNCR, aligning to multiple United Nation Sustainable Development Goals (UN SDGs) in clean water, sanitation, sustainable cities, and climate action, a congregation of eminent scientists from IARI and IIT Delhi has taken up the following objectives :

Objectives

Water resource assessment and conservation	Technology-driven enhancement of water productivity	Remediation and management of poor-quality water	Groundwater management strategies	Enhancing resilience to water risk

This vertical aims to deliver a comprehensive array of technologies, best practices, and training materials that will be of use to both government machinery as well as public.

(A) Creating a repository of water bodies of Delhi NCT in terms of the quantity and quality of water and conservation of water security

I. Creating a repository of water bodies

Along with the **Wetland Authority** of NCT Delhi, a repository of around 800 water bodies of the Delhi-NCR region is in the process of being mapped with high accuracy. Quantity and quality estimates are being done through modelling and ground truthing followed by ensuring functionality of waterbodies. These activities will provide relevant information crucial for **water resource assessment** and **flood monitoring**.

Recharging of water bodies for rainwater harvesting (Sanjay Lake, Smriti Van)

II. Optimizing rainwater harvesting

Government of India's **Jal Shakti Abhiyan programme** has given emphasis to rainwater harvesting. In IARI, a tank has been developed to optimally harvest rainwater and arrest its run-off to the nearby Najafgarh drain. The tank (1 Ha in area) has a capacity of about 50,000 cubic metres and will be capable of irrigating an area of about 120 Ha.

Revival of pond under Amrit Sarovar Mission

Pusa Amrit Sarovar

A rain water harvesting pond spread over 2.5 acres has been built in the city-based Pusa-IARI campus having a capacity to meet 60% of total water requirement of the research farm land. It is also going to help arrest depletion of water table and reduce the use of borewell.

III. Designing protocols for optimal utilization of harvested rainwater

The team is actively involved in formulating guidelines for optimal utilization of harvested rainwater in different built up/agricultural land use systems through watershed planning and hydrological modeling. Development of web/mobile based application of design and revival of **water bodies/wetlands/water harvesting structures** is also underway.

> Water Security team is engaged in developing appropriate guidelines for optimal utilization of harvested rainwater through MCDM techniques and enhancing water quality, and its upscaling to NCR.

(B) Enhancing water use efficiency in the irrigation of fields

I. Soil moisture sensor based automatic basin irrigation system

This was developed and evaluated at Water Technology Centre (WTC), IARI, New Delhi. The system comprised of capacitance soil moisture sensor, solar panel, aluminium check gate, control unit box and web/mobile based app. A wireless communication was established between the soil moisture sensor and check gate through LoRa and GSM communication protocol. The system enables saving 24.3% water in wheat crop compared to manual control irrigation. The system performed very well at research farm and is ready to be upscaled at farmer's field.

Groundnut and mustard cultivation with trickle Irrigation

The total cost of the system including soil moisture sensor, automatic check gate and one year service of web/mobile app is Rs 17,800/-.

II. Improvement of conveyance efficiency using pipeline network

HDPE and PVC pipeline networks with hydrants at desired intervals for water conveyance and irrigation were installed and demonstrated in farmer fields, **Bheema Gaon, Nuh Block, Haryana**. The pipe network system saves about 25-30% of water by reducing conveyance losses. A lay flat pipe network was also installed in PFDC farm, WTC, for performance evaluation.

Demonstration of different types of water conveyance systems

(C) End-to-end technology suite for purification of water for agricultural and drinking purposes

I. Water Security with Jalopchar™, an eco-friendly wastewater treatment technology

ICAR-IARI developed & successfully operationalized an innovative, decentralized and highly cost-effective wastewater treatment technology, Jalopchar™, having a distinctive edge over other resource intensive conventional technologies under the leadership of **Dr. Ravinder Kaur**. This **"cash from trash"** technology is characterized by pollutant reduction efficiency, positive environmental impacts, ecological efficiency, sustainability, scalability and more importantly the revenue generation potential. Altogether a success story, the effectiveness of Jalopchar™ has been validated through its wide scale operationalization as large community scale sewage treatment facility (capacity 2.2 million litres/day). It harnesses the pollutant sequestering potential of the hyper-accumulative emergent wetland plants instead of chemicals. The technology has demonstrated exceptional efficiencies with respect to BOD (Biological Oxygen Demand 78 to 88%), turbidity and pathogen load (90 to 99%) as well as nitrate and phosphate reduction (30 to 57%) and is associated with about 80-85% lower capital expenditure demand. A report on Jalopchar™ has been widely disseminated in the country across policymakers. The technology has been recommended for national level adoption and implementation by the Parliamentary Committee on Agriculture and for extension to 400+ Indian cities by the Ministry of Urban Development, Government of India.

https://icar.org.in/content/jalopchar-eco-friendly-wastewater-treatment-technology

Jalopchar™ - treated water

II. Permeable Reactive Barrier [PRB]

Though PRBs have been widely adopted for groundwater remediation in many developed countries, yet their application in India, having multi-pollutant contaminated groundwater sites, is still limited. **Prof. Chakma** at IIT Delhi is working towards developing novel integrated PRB and photobioreactor (PBR) systems. Once developed, via this technology, DRIIV's Water Security vertical envisages effective removal of pathogenic bacteria from drinking water supply preventing the spread of diseases and to ensure the safety of consumers which has so far been a key challenge in the small, sub-urban and the rural areas of the country.

1.3.2

Blending with existing national programmes with novel technology interventions within the ecosystem

DRIIV's vision aligns with identification and building win-win solutions for complex and challenging water problems of our nation by developing & evolving smart and wise water management practices and implementing them in the field, by leveraging innovative technologies/solutions, while balancing conflicting objectives of stakeholders and working with the society and government to formulate policies.

A. Treating industrial wastewater by TADOX

Reuse of treated water is becoming increasingly essential for industries as crisis of freshwater availability is looming large. However, the lack of adequate quality of treated water with existing technologies having huge land and operational costs, along with being highly energy intensive and unsustainable, leaves a lot to be desired for. Therefore, in pursuit of integrating novel approaches and advanced technologies that can reduce overall load on tertiary treatment trail in a much affordable manner, **Dr. Nupur Bahadur** and team from TERI have come up with a novel eco-friendly solution called TADOX (TERI Advanced Oxidation Technology). TADOX enables sustainable and affordable ZLD compliance with 85-90% enhanced water reusability, which is the need of the hour. Further, being modular, few hours treatment time together with resource & energy efficiency, the treatment of highly polluted wastewater streams is expected to bring down OPEX by 30-40% than current values. Notably, The National Mission for Clean Ganga (NMCG), Ministry of Jal Shakti and TERI are all set to explore possibilities of TADOX implementation in point-source pollution abatement across ETPs/STPs under the **Namami Gange Programme.**

Industrial Wastewater Treatment

TADOX® in Textile WWT

PARAMETERS	PRE-TADOX®	POST-TADOX®	% CHANGE
pH	7.62	9.1	-
Salinity, ppm	3470	130	96
Conductivity, μmho/cm	7644	294	96
TSS, mg/L	850	4	99
TDS, mg/L	3823	163.3	96
Chloride, mg/L	240	30	88
Hardness, mg/L	60	ND	100
BOD5, mg/L	255	12	95
COD, mg/L	1360 (BOD/COD=0.18)	128 (BOD/COD=0.38, indicates improved biodegradability)	91

TADOX® in Pharmaceutical / API WWT

PARAMETER	PRE-TADOX®	POST-TADOX®	% CHANGE
pH Value	6.2	8.1	-
BOD5, mg/L	255	11	96
COD, mg/L	1200	80	93
Total Nitrogen, mg/L	10.1	1.0	90
Total Ammonia, mg/L	ND	3.39	-
Reactive Phosphorus, mg/L	5.5	0.1	98
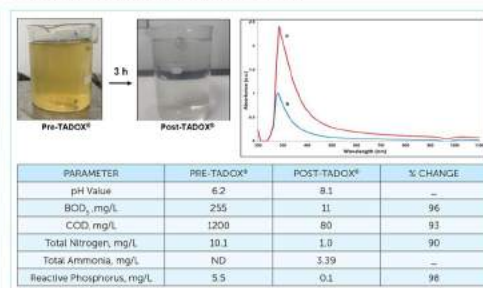
TADOX® in polishing of MEE Condensate

PARAMETERS, UNITS	PRE-TADOX®	POST-TADOX®	% CHANGE
pH	10.96	8.01	-
Color, Pt-Co Colour Units (CU)	92.21	10.5	89
Total Dissolved Solids (TDS), mg/l	228	144	37
Total Suspended Solids (TSS), mg/l	157	106	32.5
Turbidity, NTU	9.31	2.02	78
Chemical Oxygen Demand (COD), mg/l	2400	600	75
Nitrate, mg/l	65.01	45.3	30
Phosphate, mg/l	0.265	0.23	13

TADOX® in Oil & Gas WWT

PARAMETERS	PRE-TADOX®	POST-TADOX®	% CHANGE
pH	8.16	8.91	-
BOD_5, mg/L	104	42	60
COD, mg/L	336	80	76
TDS, mg/L	7041	3357	52
Oil & Grease, mg/L	588	31.20	95
Zn, mg/L	0.20	0.05	75
Pb, mg/L	0.40	Nil	99.9

TADOX® in Tannery WWT

PARAMETERS	PRE-TADOX®	POST-TADOX®	% CHANGE
pH	8.26	8.19	-
BOD_5, mg/L	7.82	24.62	Increased BOD indicates conversion of recalcitrant organics to biodegradable components
COD, mg/L	128	80	37.5
TDS, mg/L	1040	767	26
Hexavalent Chromium (Cr^{6+}), mg/L	1.2	0.06	95

TADOX® in polishing of Distillery Slop Condensate

PARAMETERS, UNITS	Pre-TADOX®	Post-TADOX®	% CHANGE
pH	9.1	7.1	-
Color, Pt-Co Units (CU)	222.7	28.8	87
Total Dissolved Solids (TDS), mg/l	3012	608	80
Total Suspended Solids (TSS), mg/l	746	122	84
Conductivity, µmho/cm	5530	1029	81
Turbidity, NTU	6.2	2.7	56
Chemical Oxygen Demand (COD), mg/l	6800	1160	83
Sulphide, mg/l	50.4	36.5	28
Ammonical Nitrogen, mg/l	728.3	163.2	77.5
Total Alkalinity, mg/l	5200	1056	80
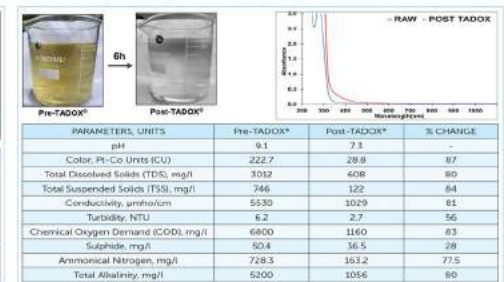
Municipal Sewage Treatment

Current Conventional Treatment

TADOX® Treatment

Cleaning
Highly Polluted Water
at a Lower Cost

STP INLET

pH	7.9
Colour, (Pt- Co) (CU)	185
COD, mg/L	650
BOD, mg/L	261
TSS, mg/L	380
Total N, mg/L	32.0
Total P, mg/L	81.2
E. coli, MPN/100 ml	1.02×10^5
Total Coliform bacteria, MPN/100 ml	6.12×10^8
Total count, CFU/100 ml	5.24×10^5

DIRECT END-TO-END TADOX®

pH	8.0
Colour, (Pt- Co) (CU)	8
COD, mg/L	64
BOD, mg/L	7
TSS, mg/L	<5
Total N, mg/L	1.9
Total P, mg/L	<1
E. coli, MPN/100 ml	16
Total Coliform bacteria, MPN/100 ml	1.16×10^2
Total count, CFU/100 ml	28

STP OUTLET

pH	8.2
Colour, (Pt- Co) (CU)	125
COD, mg/L	400
BOD, mg/L	78
TSS, mg/L	110
Total N, mg/L	30
Total P, mg/L	13
E. coli, MPN/100 ml	1.21×10^4
Total Coliform bacteria, MPN/100 ml	1.13×10^5
Total count, CFU/100 ml	1.84×10^4

TADOX® AT POLISHING STAGE

pH	8.1
Colour, (Pt- Co) (CU)	5
COD, mg/L	46
BOD, mg/L	<3
TSS, mg/L	<5
Total N, mg/L	1.7
Total P, mg/L	<1
E. coli, MPN/100 ml	<8
Total Coliform bacteria, MPN/100 ml	3.13×10^2
Total count, CFU/100 ml	11

Wastewater quality parameters analyzed at a National Accreditation Board for Testing and Calibration Laboratory (NABL), Delhi as per ISO/ IEC 17025:2005.

B. Mending the fractured relationship with nature: Restoring Promise of Water (RPOW)

Healthy ecosystems, whether they be forests, rivers and lakes, oceans and coasts, mountains, grasslands and peatlands, or farmlands and urban landscapes, are a source of wealth for society. Interconnected tanks or "waterbodies" (ranging from less than 1 acre to up to a few hundred acres at the surface) are crucial to life. Over the last century, the community connect to these ecosystems has drastically reduced, including their symbiotic maintenance via silt removal. Due to human interventions through groundwater mining with modern pumps, lowering dependency on surface water from the tanks and also by the use of fertilizers lowering perceived value of the silt, the tanks were no longer as essential as in the past. As a result, neglect over decades resulted in drastically reduced water capture due to decadal accumulation of silt and loss of inter-connectivity between waterbodies. The problem is further aggravated by changing rain patterns and precipitation levels. India accounts for ~18% of the world population and harbors ~ 4% of freshwater resources signifying the need for waterbody rejuvenation. Rejuvenation of Water Bodies (RWB) programme by **IIT.IIT** (a philanthropic network of ex-IITians), has successfully revived thousands of waterbodies across drought prone parts of Maharashtra, economically India's largest state.

Given its relevance to other water security programs, IIT.IIT is now engaged with DRIIV as implementation partner for their project for climate change through lake rejuvenation by silt excavation with the prime objectives of adequate collection and use of rainwater, increasing the lake's capacity to store more water, to augment farm production, land value and community involvement for sustainability & transparency.

Objectives of RPOW

| Reconnecting the community with the lake | → | Increase in ground water level | → | Creating an environment, conducive to restore biodiversity | → | Greater opportunities for rural livelihoods |
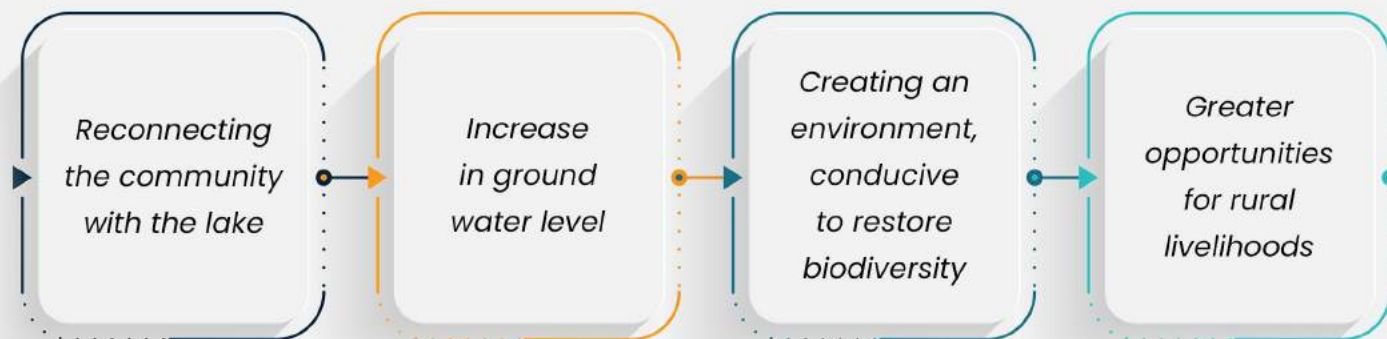
DRIIV in association with IIT.IIT envisages rejuvenation work for around 1000 dry water bodies in 50 districts, some of which are aspirational districts in the northern belt of India. The silt collected from the ponds will be put into cultivable lands reducing fertilizer costs in the long run while creating additional water storage capacity.

DRIIV, IIT.IIT and India Pariyavaran Sahayak (IPS) Foundation have joined hands towards implementing the waterbody rejuvenation project in Sangrur and Sunam districts in Punjab. Other sites initially shortlisted for this purpose are Rohtak, Nuh and Kasna in the states of Haryana and Uttar Pradesh respectively.

" With 7.5 billion people and climate change threatening, our world faces many challenges. But one of the most immediate has to be the scarcity of non-saline water - to drink, to clean, to irrigate, for life. "

BIO DIVERSITY, LIVELIHOODS OPPORTUNITY, WOMEN EMPOWERMENT AND SUSTAINABILITY CAN BE ACHIEVED BY THIS LAKE REJUVENATION PROJECT

LAKES REJUVENATION FOR CLIMATE CHANGE

Lake before the silt excavation work

Basaveshwarakere, Naganala- Kolar Tq,

Lake after filled rain water

Farmer- Virabhadragowda, Silt taken -500 ttls, Crop after silt application- Tomoto

C. Phycoremediation to the rescue : wastewater management

DRIIV's endeavours to bring innovative solutions that can revolutionize wastewater treatment is in perfect alignment with Trinity International's objectives, where a group of scientists are involved into the **restoration of wastewater (lakes, rivers, ponds, domestic and industrial effluents)** through the use of Phycoremediation. This is the use of selected strains of micro green algae, diatoms and bioculture to treat wastewater naturally without the use of chemicals. It requires 90% less electricity than the conventional methods and is carbon negative in its footprint. This CPCB approved technology has a huge positive ecological impact and the potential to uplift local economy.
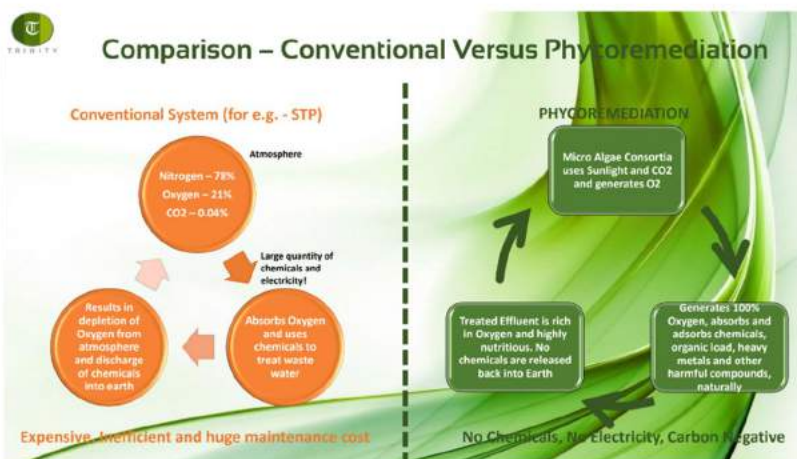
Trinity International managing polluted river/pond water and industrial effluent

i. After successful completion of a pilot and receiving a green signal from the National Green Tribunal (NGT), the team rejuvenated one of the rivers (Kyrhuhkhla River) in East Jaintia Hills, Meghalaya with highly acidic water (pH value of 2.5), by successfully raising the pH value upto 6.2+ and re-establishing the communities of aquatic flora and fauna back into the river. Mainath pond in UP, laden with duckweed, was also cleaned in just 4 weeks.

ii. Trinity International is currently cleaning highly polluted Lukha river in Meghalaya. The water of this river is extremely toxic owing to the presence of contaminants like high amounts of aluminium, ferrous, sulphur and various other non-metallic substances, imparting a blue colour to the water. The microalga consortia, through phycoremediation, could effectively lower the toxic levels of the contaminants.

iii. The technology has also been very effective in cleaning industrial effluent and recovering value-added products in UP and Tamil Nadu by installing phycoremediation plants.

(Before Treatment)

pH – 3.3

(After Treatment)

pH – 6.2+

> As per government statistics, 62.5% of wastewater in urban India remained untreated or partially treated. The meagre infrastructural capacity of wastewater treatment and poor operational maintenance add to the country's water pollution, conservation, recycling, reuse, and recharge woes.

Eco-friendly site for Lukha River - Sonapur Meghalaya

During the day time

During night time with LED lights

Project sites with algal ponds-completely eco-friendly

Day view

Night view

Publications

Publications & Reports

I. Monalisha Pramanik, Manoj Khanna, Man Singh, D.K. Singh, Susama Sudhishri, Arti Bhatia, Rajeev Ranjan (2022), Automation of soil moisture sensor-based basin irrigation system, Smart Agricultural Technology, Elsevier. doi.org/10.1016/j.atech.2021.100032

II. Monalisha Pramanik, Manoj Khanna, Man Singh, D K Singh, Susama Sudhisri, Arti Bhatia and Rajeev Ranjan (2022), Performance of sensor-based automatic basin irrigation system in wheat crop under semi-arid conditions, Journal of Agricultural Physics.

III. Monalisha Pramanik, Manoj Khanna, Man Singh, D K Singh, Susama Sudhisri, Arti Bhatia and Rajeev Ranjan (2023), Evaluation of irrigation events with WinSRFR model in basin irrigation system, Indian Journal of Soil Conservation.

1.4

The overarching goal of AI/ML in Healthcare

Modern healthcare system faces huge challenges exacerbated by pandemics, continuous rise in lifestyle-related diseases, and an exploding population. Using artificial intelligence (AI) to create intelligent processes and workflows could make healthcare cheaper, more effective, personalized, and more equitable. AI together with machine learning (ML), a subset of AI, plays a key role in many health innovations, including the development of new medical procedures, handling of patient records and the treatment of chronic diseases. The 2030 sustainable Development Goals focus on the central promise of "leaving no one behind". From an Indian perspective where prevails major health inequities, this remains a lofty challenge. Leveraging predictive analytics by AI for early detection presents a powerful tool for targeted public health interventions, especially in the Indian context, to bridge the inequities of limited healthcare capacity and delayed disease detection capabilities.

India could add $1 trillion to its economy by integrating AI in healthcare

from World Economic Forum

01 AI expenditure in India is expected to reach $11.78 billion by 2025 and is expected to add $1 trillion to India's economy by 2035.

02 AI is already being integrated into diagnostic algorithms for screening for diseases ranging from cancer, diabetic retinopathy, to cardiovascular disease.

03 A measured approach that scales up AI in healthcare, while ensuring meaningful human control and informed consent is critical to long-term success.

The growth curve of AI/ML in Healthcare in the nation

NITI Aayog envisages to apply **AI in primary care** for early detection of **diabetes** complications, validate the use of **AI as a screening tool in eye care**, and integrate AI capabilities with portable screening devices, which wil eventually expand the capacity for disease screenings and also enable access in remote places. The think tank's **National Strategy for AI** prioritizes principles of privacy, ethics, security, fairness, transparency and accountability, as well as alignment with the rights afforded by the Indian Constitution. India is a founding member of the **Global Partnership on AI Alliance** and has thus far adopted a measured approach for integration of AI, while maintaining ethical and responsible standards.

National Digital Health Mission: Ayushman Bharat

The **National Digital Health Mission (NDHM)** aims to make India Atmanirbhar in providing universal health coverage to all the citizens in the country. It aligns with the goals and objectives of the **National Health Policy (NHP) 2017** and the **National Digital Health Blueprint** to create a digital infrastructure for providing healthcare services across the country. This would consist of large amounts of health-related data and various standardized digital services while ensuring strict confidentiality and security of the personal information of the public. Under the aegis of NDHM, the Ayushman Bharat Digital Mission (ABDM) envisions to develop the backbone necessary to support the integrated digital health infrastructure of the country by filling the existing gaps among different stakeholders of the healthcare ecosystem through **digital highways.**

Goals — Then and now

2002
- Eradicate leprosy by 2005
- Eradicate kala azar by 2010
- Eradicate lymphatic filariasis by 2015
- Achieve zero level growth of HIV by 2007
- Bring down IMR to 30 and MMR to 100 by 2010

2017
- Eradicate leprosy by 2018
- Eradicate kala azar in 2017
- Eradicate lymphatic filariasis in 2017
- HIV is still a problem and the policy aims to achieve the global target of 2020
- Bring down IMR to 28 by 2019 and MMR to 100 by 2020

National Health Policy 2017

Digital interventions for the nation's health

- **Promoting tele-consultation linking tertiary care institutions** with specialist consultation
- **National Knowledge Network for** Tele-education, Tele-CME, Tele-consultations and digital library
- **National Digital Health Authority** to regulate, develop and deploy digital health
- **Introduction of Electronic Health Record (EHR)**

Components of ABDM

- **ABHA Number:** to standardize the process of identification (#37,53,10,212)
- **Healthcare Professionals Registry (HPR)** (#1,63,924)
- **ABHA Mobile App (PHR)** (#15,90,635 downloads)
- **Health Facility Registry (HFR)** (#2,02,851)
- **UHI** Unified Health Interface (UHI)

Now Health is just a click away

Ayushman Bharat Digital Mission

Salient Features

- Create a seamless online platform through a wide range of data, information & infrastructure services
- Enable exchange of longitudinal health records of citizens with their consent
- Ensure security, confidentiality & privacy of health-related personal information

> *India has just 64 doctors/100,000 people compared to a global average of 150/100,000. Primary health centres at the rural peripheries are often woefully understaffed and lack critical infrastructure to meet patient needs. This often translates to a lack of high-quality diagnostic services, especially in rural India, home to more than 70% of the population.*

1.4.1

DRIIV's endeavours towards an integrated digital health infrastructure

The COVID-19 pandemic has demonstrated the need for an effective digital backdrop that connects stakeholder organizations and ensures a rapid response toward mitigation of epidemics in a concerted manner. This motivated the formation of the Precision Health and Artificial Intelligence for Healthcare theme of DRIIV. The **AI/ML in Healthcare vertical** of DRIIV led by **Prof. Tavpritesh Sethi, IIIT Delhi** designed, developed, and deployed multiple smart and secure AI-based solutions for the protection of the health and well-being of citizens in the face of epidemics. The objectives of the vertical are laid down as follows:

i. Stakeholder mapping and building a digital platform for operationalizing the cluster towards pandemic preparedness.

ii. Development of a sustainable backbone for emerging or re-emerging epidemics.

iii. Formalizing the rapid response backbone through generic implementation for the most prevalent epidemics.

THE ABDM ECOSYSTEM

Innovations sprouting from focussed efforts

The team focussed its efforts on the development of solutions for a better response to pandemics like COVID-19 & other epidemics like AMR etc. In particular, the team addressed the following key issues in the healthcare segment in India :

i. The team has developed AI-based digital innovations to revolutionize the primary healthcare segment by addressing the concerns of primary healthcare infrastructure in India.

ii. Augmenting the solutions for secondary and tertiary healthcare through digital tools built on authentic data from a wide range of sources.

iii. Developing predictive/preventive healthcare solutions through AI/ML based predictive data modelling tools.

Development of implementable solutions creating impact in healthcare

The following technologies and products were thoroughly tested and validated at the lab scale for accuracy and reliability, before being deployed across multiple locations in India :

I. COVID AI Stack having 3 main dashboards : (https://federatedhealthplatform.tavlab.iiitd.edu.in/modelzoo)

a. Strainflow : an AI model for Genomic Surveillance and Surge Prediction by tracking the spike protein latent space features.
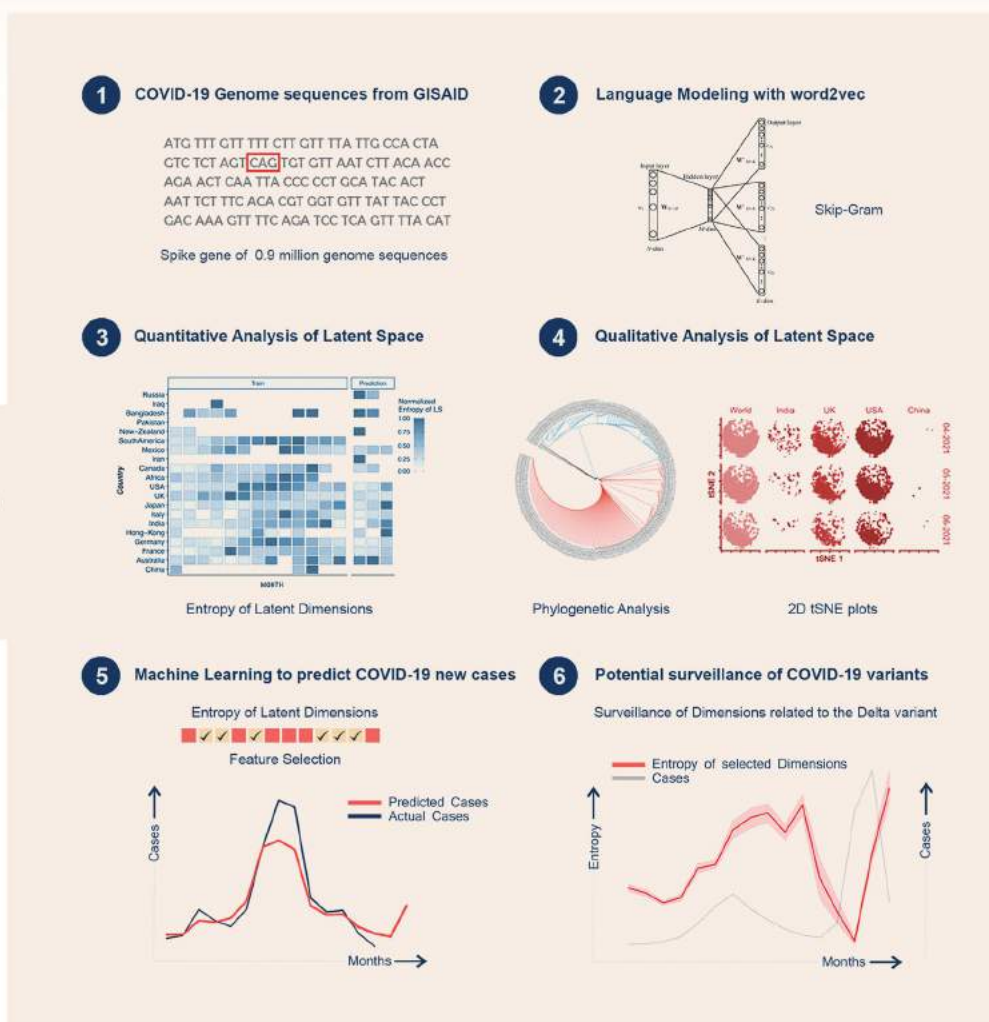
b. EvidenceFlow : Evidence mining with artificial intelligence. The EvidenceFlow web-application is publicly available and emerging trends are updated on a monthly basis. Such approaches are crucial to understand and pre-empt actionable research such as vaccine strategies in the pandemics.
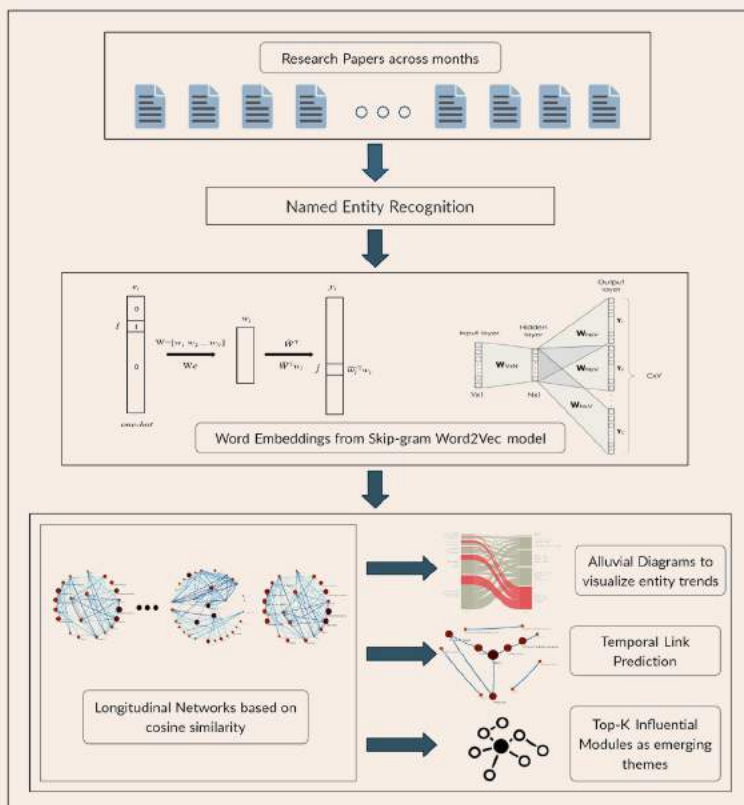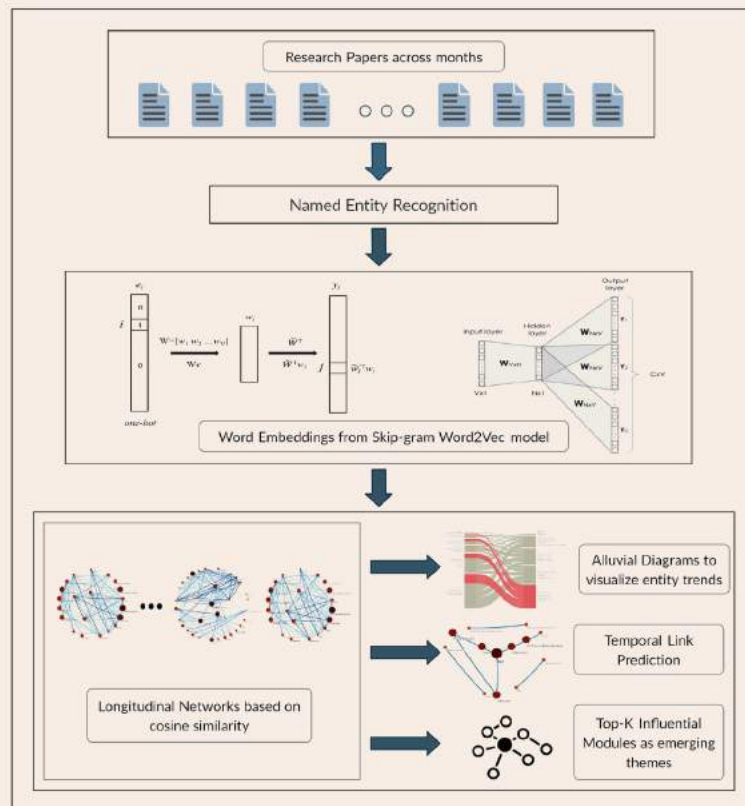
c. VacSim : AI model for vaccine resource allocation across India.

II. Digital **dashboards** to track Antimicrobial Resistance in order to identify measures that can prevent its spread.

III. **Pandemic preparedness suite** for future outbreaks by collating data and information from a variety of sources (https://federatedhealthplatform.tavlab.iiitd.edu.in/communitydata).

IV. **AI-enabled decision support system** for primary health care : This would lead to the digitization of primary health care by designing and implementing digital health interventions at the primary care level including clinical decision support systems, electronic health records, client-friendly and privacy-protecting data systems for low-resource contexts. The model can be replicated across all the primary health centers of the country.

V. **Health dashboards** for policymakers using AI-driven policy indicators.

1.4.2

The success stories : towards implementing scalable, NDHM compliant, and AI-enabled platforms

I. **Strainflow model** is being used in a project by Indian Council for Medical Research (ICMR) to create national dashboards for pandemic preparedness using strain data and ICMR testing data and data from other sources.

> The **strainflow suite** accurately forecasted case surges in all three waves in India two months ahead of time.
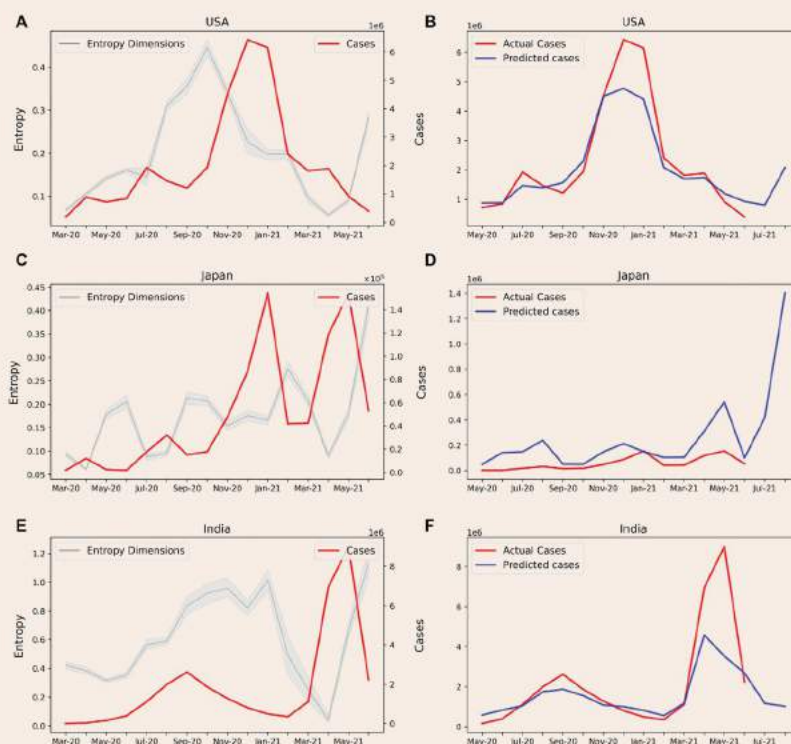
**II.** **WashKaro App :** The Delhi Corona App of the Govt. of NCT of Delhi which provided citizens with comprehensive resources to combat COVID 19, had components from the **WashKaro App** developed by the AI/ML team for spreading awareness among the masses regarding water & sanitation using AI and NLP (Neuro Linguistic Programming) techniques. The work was also showcased at WHO.
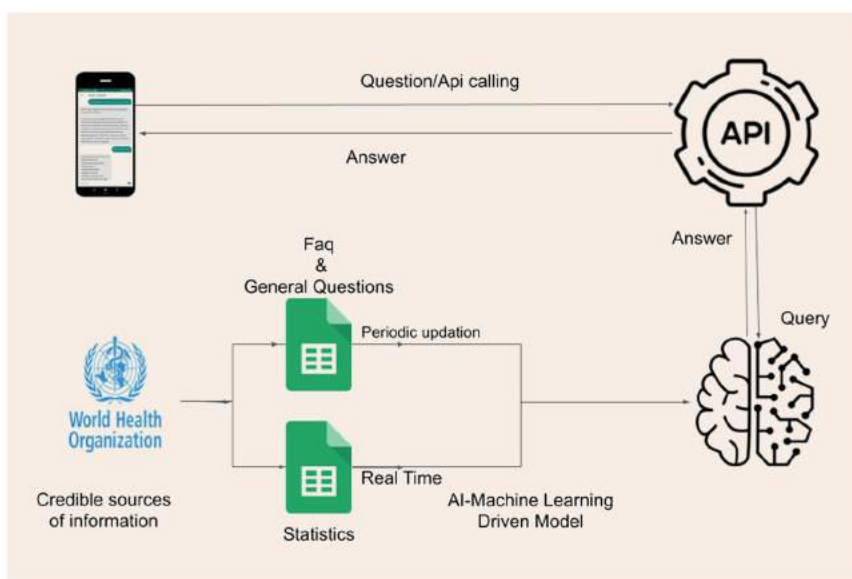
ML-based application for raising WASH awareness in the times of COVID-19 pandemic. It also helps to warn public about a coronavirus containment zone nearby and helps them check whether a news item about the pandemic is genuine or fake.

III. An AI enabled decision support system for primary health care in **Mohalla Clinics** in Delhi is being tested and developed in association with **Wish Foundation** and **WHO Alliance**.

IV. A sandbox for AI for **ICU decision-making**, built on data from AIIMS and publicly available ICU data from more than 200 ICUs of the USA has already been deployed at AIIMS, New Delhi. The machine learning tool aids doctors in **inside-ICU decision-making** through early prediction of hemodynamic shock and hypothermia etc. in intensive care units.

Pipeline for generalizing the prediction of hemodynamic shock at ICUs
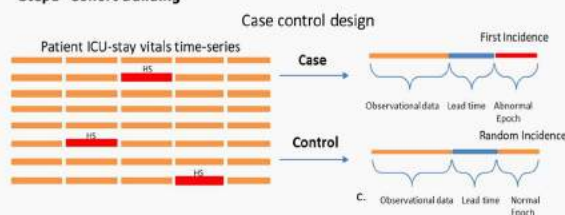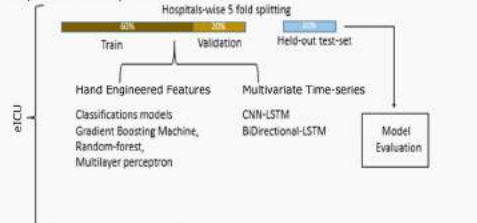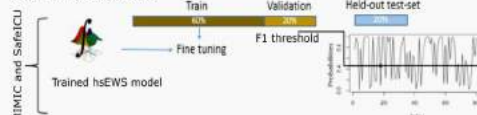
The **SAFE** (Sepsis Advanced Forecasting Engine) **ICU app** is in use in AIIMS with a prediction accuracy of over 90%.

V. AI-based mobile **screening** tool is being used to screen the vulnerable population of migrant workers in Mohammadpur, Delhi for tuberculosis in association with **Swasthi Foundation**.
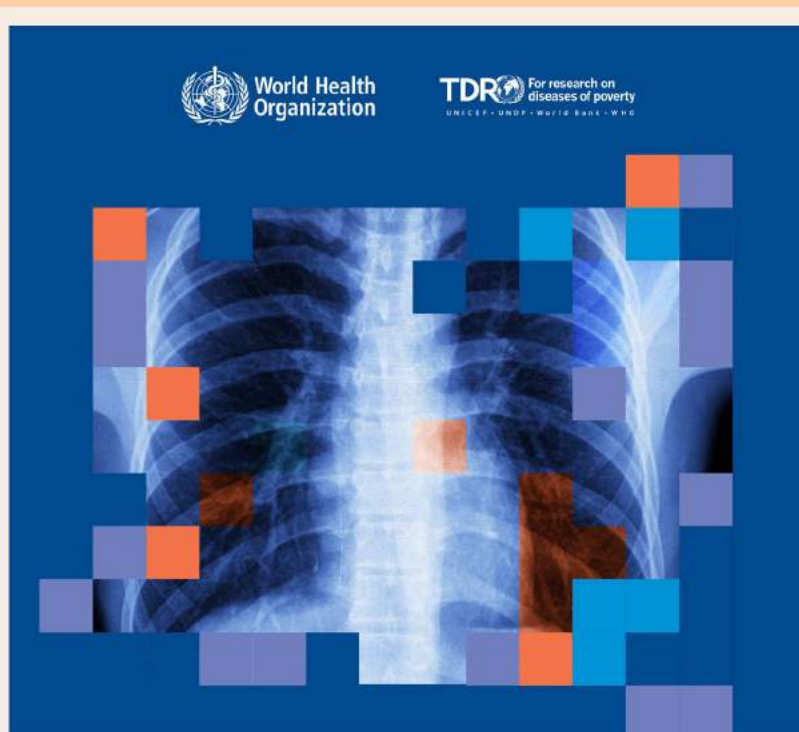
VI. AI-powered dashboard for State level COVID modelling and a dashboard to track AMR are being developed under a project supported under the CSR initiatives of **MongoDB**. This is an AI-enabled data port, an analytics platform to track AMR using a database of 0.7 million records globally, and antibiotic resistance data from AIIMS, New Delhi.

VII. Real-time Health dashboards for policymakers are being prepared by analysing strains from mobility data (obtained through **Facebook** in association with **Meta**). Additionally, health & socio-economic data from National Family and Health Survey are also being analyzed to arrive at temporal correlations of the pandemic period.
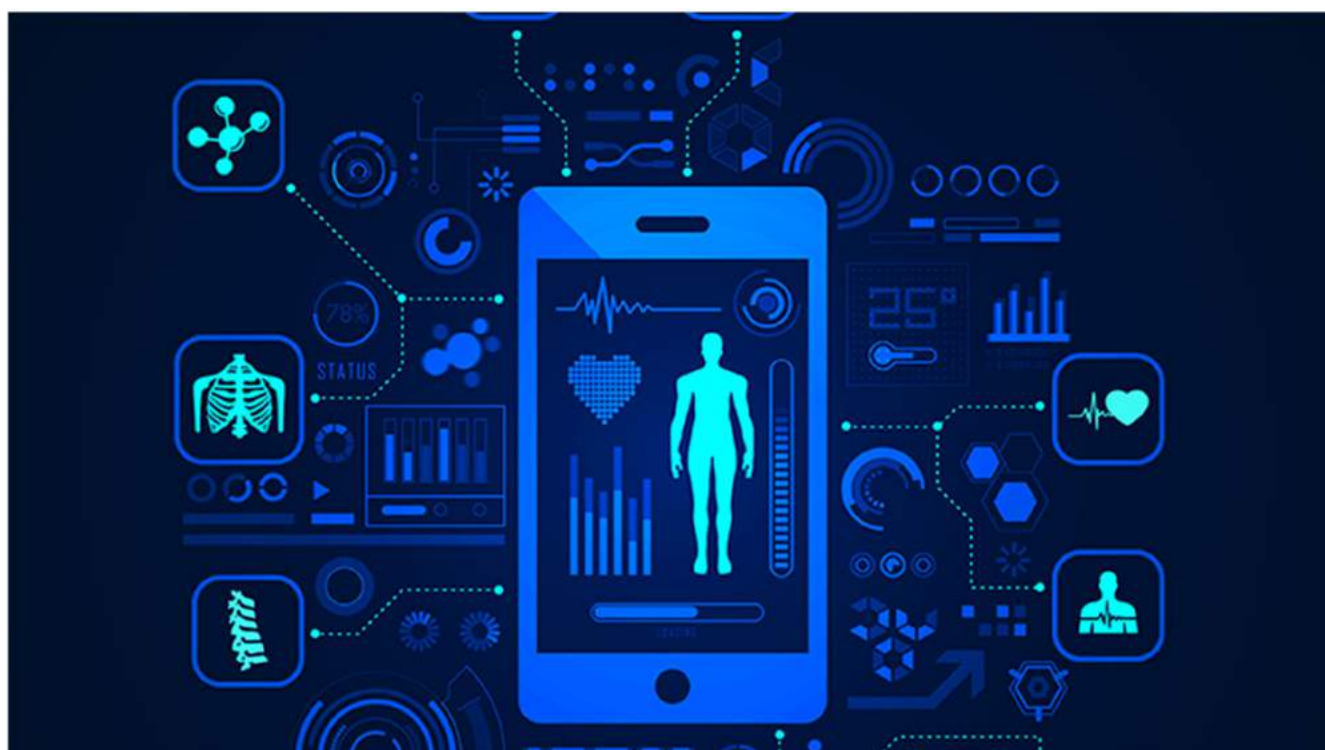
VIII. A national dashboards tracking trends in AMR across 20 sites in India with the last 5 years' ICMR data especially in UTI infections is being prepared and would be launched by ICMR.

A **pandemic preparedness suite** that integrates signals from conventional sources such as testing, strains, and vaccination and non-conventional sources such as social media is being prepared with ICMR. This would help analysing a pandemic both from a retrospective and prospective point of view.

COVID 19 AI Stack

A collection of approximately 6000 datasets related to covid-19. A pipeline is being created for all the publically available datasets for COVID 19 (can be extended to any disease).

EvidenceFlow

Alluvial diagram tracking the trends of temporal dynamics of literature across different.

StrainFlow

Dashboard for surge prediction.

VacSim

Dashboard for optimal distribution of COVID 19 vaccines in India.
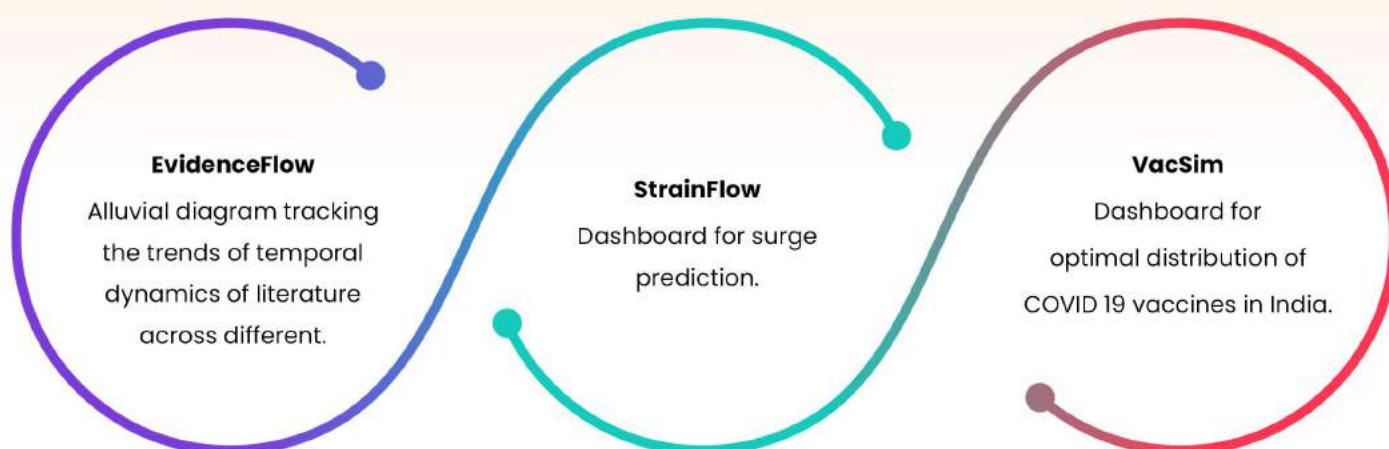
1.4.3

Way forward with AI in healthcare : India's trillion-dollar opportunity

I. Adaptation of the developed dashboards to other diseases and healthcare applications. For example, strainflow model can be adapted to model cases for diseases like cancer, etc.; the Vacsim platform can be used for devising effective strategies for the distribution and allocation of hospital beds.

II. Deployment of a comprehensive and robust ABDM-compliant data platform open to industry, academia and policy makers.

III. Integration with "**One Health**"- a mission with an integrated approach that observes humans, animals and the environment to monitor and prevent diseases. By identifying gaps, the team envisages to contribute significantly in prevention as well as early detection and instituting appropriate response to control such public health emergencies. **Pandemic-preparedness suite** and **AMR** dashboards (amongst others) developed by the team are well aligned to the core objectives of the mission to thwart pandemics in future and to obtain optimal health for people, animals and the environment.

One Health

Coordinating

Communicating

Collaborating

People who protect human, animal, and environmental health, and other partners

To achieve the best health outcomes for people, animals, plants, and our environment

ONE HEALTH PRIORITY AREAS

| Integrated disease surveillance | Targeted R&D for gaps in disease preparedness (vaccines, therapeutic, diagnostics, and platforms) | Joint Outbreak Response | Pandemic preparednes (human and animal) | Streamlining the regulatory aspcts | Mechanisms for data/ information sharing | Linking appropriate activities to the global efforts | Strengthen-ing routine prevention programs |

Publications

Publications & Reports

I. Pandey et al, A machine learning application for raising WASH awareness in the times of COVID-19 pandemic, Scientific Reports, 2022, https://www.nature.com/articles/s41598-021-03869-6

II. Sargun Nagpal, Ridam Pal, Ashima, Ananya Tyagi, Sadhana Tripathi, Aditya Nagori, Saad Ahmad, Hara Prasad Mishra, Rishabh Malhotra, Rintu Kutum, Tavpritesh Sethi, Genomic Surveillance of COVID-19 Variants With Language Models and Machine Learning, Front Genet, 2022, DOI: 10.3389/fgene.2022.858252

III. Raghav Awasthi, Keerat Kaur Guliani, Saif Ahmad Khan, Aniket Vashishtha, Mehrab Singh Gill, Arshita Bhatt, Aditya Nagori, Aniket Gupta, Ponnurangam Kumaraguru, Tavpritesh Sethi, VacSIM: Learning effective strategies for COVID-19 vaccine distribution using reinforcement learning, Intelligence-Based Medicine, 2022, https://doi.org/10.1016/j.ibmed.2022.100060

IV. Ridam Pal, Harshita Chopra, Raghav Awasthi, Harsh Bandhey, Aditya Nagori, Amogh Gulati, Ponnurangam Kumaraguru, Tavpritesh Sethi, Predicting Emerging Themes in Rapidly Expanding COVID-19 Literature with Dynamic Word Embedding Networks and Machine Learning, Journal of Medical Internet Research, 2021, doi: 10.2196/34067

1.5

Sustainable Mobility

The dual approach of switching to electric vehicles and wider use of public transport can help India reduce emissions directly attributable to mobility

The nation has been at the forefront of aligning its policies with its commitment to the Paris accord on climate change, signed in 2016 by rapidly adopting electric mobility and significantly cutting down greenhouse gas emission. NITI Aayog, the government think tank, has devised a plan to stop the registration of internal combustion engine (ICE)-driven three-wheelers and two-wheelers under 150cc within the next few years with a vision to conceive a mass electric energy-based transport system in India. This will also greatly reduce the import of crude oil.

Furthermore, with more than 8 million passengers tripping in public transit in Delhi NCR every day, increasing accessibility to public transport is becoming extremely crucial. Rapid urbanisation and increase in private vehicle ownership (>10 million registered private vehicles in Delhi alone) have added to the problem of congestion, increase in pollution level and road accidents. However, the passenger count of transit agencies has seen a decline, especially the bus-based public transit. Not just Delhi, similar trends are visible throughout the country. With the increasing evidence of climate change, the focus towards public transit should be renewed.

1.5.1

Switch to E-Mobility : to win the battle against climate change

Major impediments for EV adoption

- ⦿ Cost intensive EVs and batteries, reliance on imported components and parts
- ⦿ Inadequate infrastructure and range anxiety
- ⦿ Lack of standardization (no universal charger and ecosystem)
- ⦿ Temperature issues
- ⦿ Lack of quality maintenance and repair options
- ⦿ Will increase overall electricity demand
- ⦿ Incentives linked to local manufacturing

National Electric Mobility Mission: the vision and roadmap for faster adoption of EVs

FAME India

Securing a Greener future

Supports the hybrid/electric vehicles market development and manufacturing eco- system

1,51,928
electric/hybrid vehicles given direct support

Fuel saving of **14,83,380** litres

CO_2 reduction of **3,71,87,255 kg**

Demand incentives amounting to **₹192.56** Crore (approx.)

More EVs on Indian roads by 2025

By 2025, electric two-wheelers are expected to account for 34.5% of all two-wheeler sales in India, while electric buses will make up 25% of all buses sold.

Penetration of electric two-wheelers in India
- Sales in units
- As % of overall two-wheeler sales

2017	2020*	2025*
0.2	1.5	34.5
41,000	338,000	11,618,000

Penetration of electric buses in India
- Sales in units
- As % of overall bus sales

2020*	2025*
5	25
2,700	157,000

*Projected

Source: Acma, Roland Berger

The National Electric Mobility Mission Plan (NEMMP) was launched with the following objectives fostering India to emerge as a leader in the electric two wheeler and four wheeler market in the world by 2030 to encourage electric and hybrid vehicles by ensuring the national fuel guarantee in the country.

EV technology in India is highly dependent on innovation and government incentives. NEMMP 2020 envisions reliable and affordable EV architecture through Government-Industry collaboration for the promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness, and technology (https://heavyindustries.gov.in-/writereaddata/Content/NEMMP2020.pdf). The genesis of National Electric Mobility Mission was via recommendation of Prime Minister's Office on **Technology for fast-tracking the introduction and manufacture of full range of electric vehicles, including hybrids, in the country**. To make EV adoption easier in India, Faster Adoption and Manufacturing of **Hybrid and EV** (FAME) programme in 2015 has been launched followed by its second iteration FAME II, with a $130 million to $1.4 billion investment in electric car subsidies.

"

Helping India to emerge as a leader in the xEV Two Wheeler and Four Wheeler market in the world, with total xEV sales of 6-7 million units thus enabling Indian automotive Industry to achieve global xEV manufacturing leadership and contributing towards National Fuel security

"

1.5.1.1

DRIIV's focus on contributing towards clean mobility

While there is no dearth of government incentives in India, the lack of adequate infrastructure and unaffordable price of EVs are felt by both industries and consumers alike. Recognizing that the creation of a robust charging infrastructure is central to the promotion and adoption of EVs in India, the **Electric Mobility** vertical of DRIIV led by **Prof. B K Panigrahi, Head, CART, IIT Delhi** designed, developed, and deployed multiple smart, secure and sustainable solutions for EV charging.

Innovations towards a smart, sustainable and secure EV infrastructure in the city

The thematic focus was to develop a multi-objective optimization formulation to decide the optimal locations of the charging stations for a given penetration of the EVs. In addition to minimizing the cost for charging infrastructure installation, it will further reduce the time to locate the nearest charging station. The solution developed by the team will potentially entail where to build charging station infrastructure and how many charging ports are required to be installed. The team will explore different solution methods ranging from non-linear integer programming to convex relaxation approaches for finding optimal solutions.

To enable the **development and eventual deployment** of the solutions for a robust charging infrastructure, a collaborative approach was envisaged under the aegis of DRIIV. The conceptual prowess and deep knowledge base of the researchers at CART, IIT Delhi were coupled with the entrepreneurial expertise of EVI Technologies, an emerging startup in the e-mobility domain from IIT Delhi. The team addressed the following key issues prohibiting the adoption of Electric Vehicles in India :

(A)   **The concerns of inadequate charging infrastructure in the cities and the difficulties in locating the charging stations – through the development and deployment of fast EV chargers across the city**

(B) The concerns of range anxiety and battery issues - through the development of battery swapping technologies for densely populated areas in Delhi

I. Electric Vehicle charging management

One of the major challenges in promoting e-mobility among the users, in particular, for the use of e-bikes and e-rickshaws is the range anxiety of the user. The lack of easy availability and accessibility of charging facilities when needed is the bottleneck for ev adoption (2W and 3W). An additional challenge is the significant amount of time required to recharge the battery once the SOC is below a threshold. In order to solve the problems of range anxiety, unavailability of charging facilities, reduction of waiting time to charge the battery, battery swapping technologies is one of the best choices.

A robust battery-swapping infrastructure

Battery swap, used by the fleet operators and logistics companies, is the fastest way to charge EV batteries. Battery swapping facility (compliant with AIS 138-1, Bharat AC charger standards). Battery swapping stations capable of handling diverse battery types, fast swapping of depleted batteries with fully charged ones on the go, was developed by the team. Other impactful advancements towards EV infrastructure were :

(A) Development of ARAI and ICAT approved flame-resistant battery for the swapping system

(B) Successful deployment of battery swapping station at Janakpuri, Delhi (Now in Ranibagh) - batteries and system integrated with OEMs like Hero Electric, Sarthi (vendor for Uber) etc. 10-12 EVs use Ranibagh battery swapping station daily resulting in a cumulative 60 battery swaps/per day, swap charges (INR 110/swap)

(C) Awareness campaign for E-rickshaw operators on using the swapping station

II. Development of a range of EV chargers

With the e-mobility and energy sectors in India growing rapidly over the last few years, a dire need has been felt for industry-academia partnerships to promote innovation, research and talent in these sectors. In perfect alignment with this, a collaborative effort between EVI Technologies and CART, IIT Delhi led to the development of a suite of EV chargers (fast and slow) and swapping facility (after thorough testing and validation) which work through the user authentication process via a mobile app on the user/operator side.

Range of EV chargers for varying uses

LEV-AC charger

This charger can charge all-EVs compliant with AIS 138 Part-1 standards and OCPP 1.6J, user-friendly and safe. After plugging in, only user identification is required to initiate charging. It is capable of measuring output energy that can be used for information and monitoring purposes.

AC Type 2 charger 22 kW

Ideal for EV 4-wheelers at commercial and residential parking areas, compatible for load management/demand, mobile cum web app based connectivity with server through Wifi or Cellular Network (2G/3G/4G) to locate the nearest charging facility and book charging slot.

AC Type 2 home charger

This single output AC charger is perfect for charging (2/3/4 Wheelers) at home or in residential societies where parking is available for longer hours, enabled with timer functionality, TOD settings, scheduling for night charging using mobile/web app, equipped with class 1 metering for grid responsive billing.

1.5.1.2

DRIIV as a local solution provider in the EV space

The range of EV chargers and battery swapping stations developed under the aegis of the E-Mobility vertical of DRIIV are being commercially deployed across multiple locations in India.

(A) 380+ chargers installed across 17 cities in India by EVI Technologies

> Successful installations of 380 EV chargers in 17 cities including, Delhi-NCR, Rampur (Himachal Pradesh), Patna, Ranchi, Raipur, Dantewada, Hyderabad, Thane, Madurai, Trivandrum, Chennai, Ahmedabad, Bhopal, Haldwani, Rudrapur, Hapur, Shillong, and Sonipat by EVI Technologies. Going forward, more EV chargers will be installed in other metropolis cities across India as per the demand.

(B) Battery Xchange System (BXS) developed by EVI Technologies serves electric three-wheelers plying inside the IIT D campus.

> The BXS offers the EV users to exchange their discharged batteries for a fully-charged ones in just two minutes. Currently, the BXS is being implemented for electric rickshaws to understand the challenges and user behaviour associated with the service.

(C) Charging management system (CMS) deployed and tested at IIT D –An application that helps the user locate, book a charging slot and also pay for the charging services.

(D) **A battery swapping station** has successfully been installed at **Ranibagh** revolutionising the concept of BaaS (Battery as a Service) in India in line with NITI Aayog's battery swapping policy.

> *The country is likely to have 10,000 public charging stations by the end of 2025.*

1.5.1.3

Impacting nation's EV drive

(A) In partnership with HPCL and IOCL, a range of chargers is being deployed by EVI Technologies at 150+ locations in major cities and highways in Uttar Pradesh, Bihar, Uttarakhand, and various other states of India.

EV charging stations at Hindustan Petroleum Corporation Limited (HPCL) fuel pumps on major highways and cities in **Bihar, Uttarakhand,** and **Uttar Pradesh** are being set up in collaboration with EVI Technologies. This partnership will contribute towards the goal of reducing carbon emission, provide an opportunity for easy availability of charging solutions at various locations across India thereby not just helping EV users get rid of the range anxiety, but can also create awareness among other car owners to start using EVs.

(B) The battery swapping station at Ranibagh caters to the daily charging requirements of 10-12 electric vehicles resulting in a cumulative 60 battery swaps/per day

(C) An android application (**EVI Grid**) has been launched to boost EV charger accessibility. The EVI Grid is a personalized mobile app that enables its users to find the nearby compatible EV charging point for electric vehicles. It can be downloaded by android users from Google Play Store.
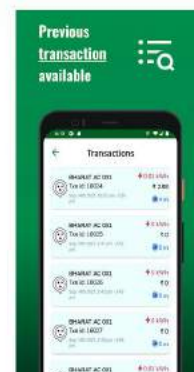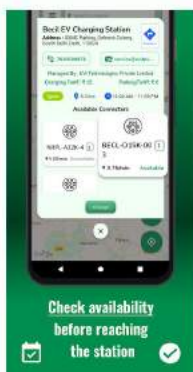
EVI Grid stands to be a tailor-made app for an EV user, providing multiparametric facilities. EVI Grid works on the internationally recognised technology that is based on connecting different charge point operators (CPO) to the electric mobility service provider (eMSP) by means of Open Charge Point Protocol (OCPI). Consequently, the EV user is equipped to connect with the maximum possible chargers in a city.

(D) Green Campus Initiative : DRIIV has started promoting sustainable and eco-friendly practices in the IIT Delhi campus, in collaboration with its Log 9 Materials Scientific Pvt Ltd. This initiative will be extended to other campuses of DRIIV's partner institutes (IIIT Delhi, Ashoka University, etc.) soon.

1.5.1.4

Way Forward: the commitment to green drive continues...

❝

Public fast charging, complemented by AC chargers of capacity ranging from 3-22kW at workplaces, shopping malls, and restaurants will be needed to support the charging infrastructure in India.

❞

I. Universal charging infrastructure

Standards are crucial for interoperability and compatibility of any EV Supply Equipment (EVSE) with all EVs. While Indian standards for EV charging, as formulated by The Bureau of Indian Standards (BIS), are compliant with global standards, local climate considerations and the difference in vehicle types available in the country, necessitate modifications that are specifically applicable to India. Towards this, India requires of a multistakeholder governance for EV charging (which can be classified as public, semi-public and private). DRIIV, through active consultations with renowned industrial players in EV

charging domain, government representatives, and experts from the departments and researchers/ innovators from a consortium of five IITs is in the process of developing a project blueprint for a Universal Charging Infrastructure with mixed energy inputs (including renewables). A technology pilot of this system with joint industry-academia participation is also being planned.

II. Power electronic machines and drives

R&D work is currently underway on power electronics (which deals with the flow of electrical energy in hybrid and plug-in electric vehicles and also controls speed) of EV covering the following areas :

i. Design and development of high torque density and compact motors for two-wheelers fulfilling the need of localized development of EV components, in line with the objectives of NEMMP 2020.

ii. Design and development of a commercially deployable high compact power module for EV charger applications in association with a prominent PSU.

III. Battery chemistry

Sustainable and efficient energy storage devices are crucial to meet the soaring global energy demand. In this context, Na-ion batteries (NIBs) have emerged as one of the excellent alternatives to the Li-ion batteries, due to the uniform geographical distribution, abundance, cost-effectiveness, comparable operating voltage as well as similar intercalation chemistry.

Research is underway to develop a battery-technology for EV, having superior operational performance, driving range, fire-safety and longevity. Efforts will be given to optimize these next-generation batteries for size and EV-cost sensitivities by substituting imported rare elements with indigenous components.

Publications

Publications & Reports

I. Choudhary A.;Mishra R.K.;Fatima S.;Panigrahi B.K, **Multi-input CNN based vibro-acoustic fusion for accurate fault diagnosis of induction motor**, Engineering Applications of Artificial Intelligence, 2023, DOI:10.1016/j.engappai.2023.105872

II. Singh S.;Narayanan V.;Singh B.;Panigrahi B.K., Single-Stage 3- Grid Synchronization with BES System, IEEE, 2022, DOI:10.1109/SeFeT55524.2022.9908990

III. Roy S.;Chishti F.;Singh B.;Panigrahi B.K., **Synchronization and Power Quality Improvement of 2SPV-BES Based Microgrid**, IEEE, 2022, DOI:10.1109/SeFeT55524.2022.9908880

1.5.2

Sustainable Urban Mobility : mobilizing all through public transportation

National Urban Mobility Mission

The National Urban Mobility Mission shapes the 'Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan'. It is focussed on 'encouraging integrated land use and transport planning in all cities so that travel distances are minimized and access to livelihoods, education, and other social needs, especially for the marginal segments of the urban population is improved.' **Multi-modal connectivity infrastructure master plan** is a step of the government in the direction of ensuring seamless connectivity between multiple modes of transportation.

> The national master plan, providing multi-modal connectivity to various economic zones, is currently under preparation.
>
> ➤ It will include roads, railways, inland shipping and civil aviation within its ambit.
>
> ➤ It will boost productivity, infrastructure, economic progress and employment opportunities for youth.

Sustainable Urban Mobility Plans are defined as a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life.

State of Public Transit in India

- Almost no information to passengers - No ETAs of buses - No PIS on bus stops	- Lack of efficiency - Highly sub-optimal routes
- Multi-modal route planning requires data - Little data available and the ones available are not even accurate.	- Lack of coordination amongst various agencies - Absence of multi-modal connectivity

Passengers are not the center of anything!

1.5.2.1

DRIIV's role ensuring accessibility to public transport

Improving the efficiency of public transit rests on two pillars - optimal planning and efficient implementation, which in turn is heavily dependent on the supporting IT systems. Under the aegis of DRIIV, the **Public Transport and Pedestrian Safety** subtheme, led by **Prof. Pravesh Biyani, IIIT D** has been conceptualized based on the following objectives :

➤ **Improving operational efficiency of bus systems :** Integration of different public transport modes and improvement in operational efficiency of public transport in Delhi is of utmost importance to address mobility, air pollution and traffic safety problems faced by the citizens of the national capital. Efforts of various organizations running the public transport systems (DTC & DIMTS) can be integrated to maximize the benefits of the 21 bus systems. Data generated by GPS & AFC in buses can be used to develop a **"supervision cockpit"** for both operators and public transport authorities.

The project aims to develop a comprehensive fleet management system for promoting public transport

➤ Integrated Multimodal Transit Data

➤ Depot Management

➤ Cockpit Development for bus systems in Delhi

➤ Measuring Sustainable Integration Index (SII) among public transportation modes in Delhi

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1.5.2.2

Solutions creating impact on ground

A. Chartr (One Delhi) App developed by DRIIV, for Integrated Multimodal Transit Data and Depot Management, has been adopted by the Delhi Government. This app digitises public transport and makes it easy for the public to use buses with features such as tracking of arrivals in real-time and e-ticketing. Furthermore, it also allows depot managers to track and manage fleets, for all 7000+ buses, running on 2000+ routes. https://depot.chartr.in/overview

i. A comprehensive fleet management system for **DTC depot management** comprising open data for all **6700 buses in Delhi**

ii. Increase in efficiency by **digitization (cost saving)**, more riders in transit (additional revenue), cost saving for passengers

iii. First and only one in India - Open Transit Data with Delhi Government, for enterprises, third-party developers, researchers, and other members of the public to promote collaboration & co-creation of innovative and inclusive transport solutions.

https://play.google.com/store/apps/details?id=in.chartr.transit&hl=en_IN&gl=US

B. Sustainable Integration Index : An index comprising a total of 12 identified indicators under three main domains of sustainability (economic, social and environmental) which will measure the existing level of integration between metro rail and buses in the process of development.

i. Sustainability Integration Index estimated for **metro rail and bus in Delhi.**

ii. Sustainability Integration Index for **Moolchand Metro Station** was found to be higher. Bus frequency index increased higher compared to relocating bus stops and mobility card.

Live Bus Tracking
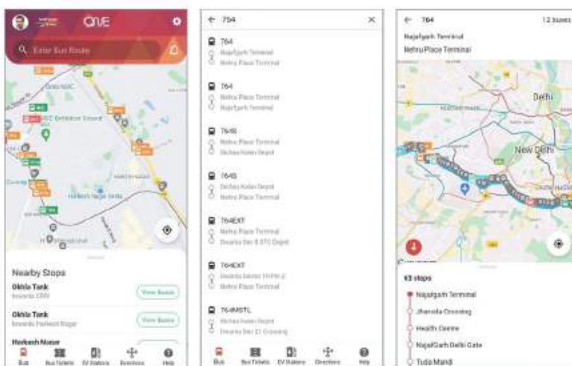
Public Information System

Ticketing
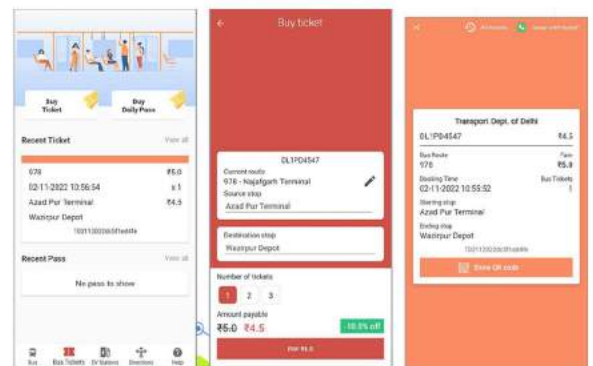
Trip Planner
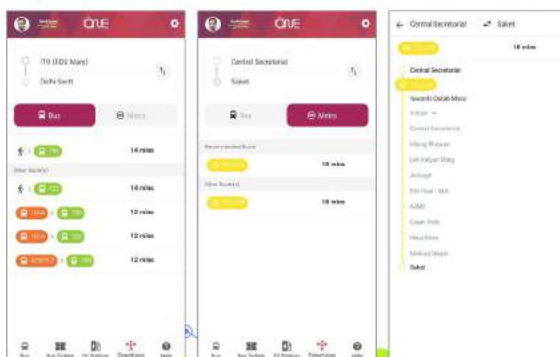
EV Chargers discovery
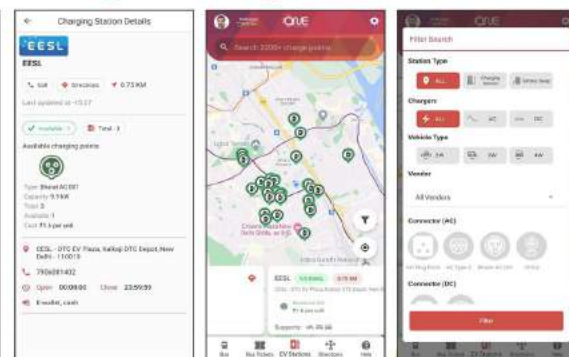
Feedback / Grievance Portal
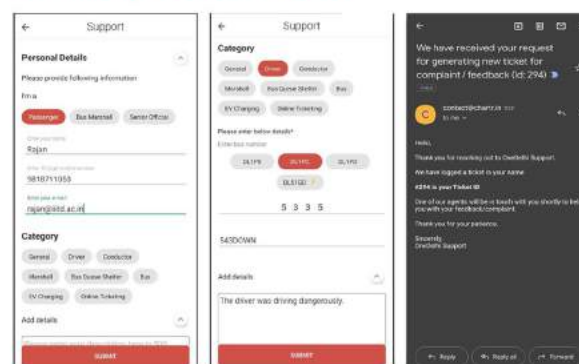
1.5.2.3

Moving forward

Deployment and replication of Chartr App in India

i. Agreement with Orissa State Road Transport Corporation (**OSRTC**) for implementing Chartr.

ii. **CRUT** (Bhubaneswar) has made GPS available in their buses, data from which can be easily accessed and an easy ITS system along with ticketing can be easily implemented.

iii. **TSRTC** (Hyderabad) has shown keen interest in working with the team on their problems.

Publications

Publications :

I. Majumdar, N. Ansari, H. Agarwal and Pravesh Biyani "**Impulse Denoising for Hyper-Spectral Images: A Blind Compressed Sensing Approach**", ELSEVIER Signal Processing, 2015.

II. Pravesh Biyani, Shankar Prakriya, Amitkumar Mahadevan, Surendra Prasad, "**Cooperative alien crosstalk cancellation in VDSL**", IEEE Transactions on Communications, 2013.

1.6

Effective Education – implementing NEP 2020

Education is the most important driver which brings social change, increases human potential and developes society towards national growth. The Sustainable Development Goal (SDG4) of the 2030 Agenda for Sustainable Development, adopted by India in 2015, also emphasizes quality education for achieving the learning outcomes and for building an equitable and resilient community. Science as a subject is important to learn as it helps to develop scientific temper and scientific literacy. It also helps in understanding some of the day-to-day phenomena that we see happening in daily life and provides us the reason behind the same, such as earthquakes, floods, diseases, tidal waves, leaves falling in autumn, etc. However, science needs to be taught in a process-oriented way rather than a didactic classroom practice. In order to understand the 'Method of Science', it is imperative that teaching of science takes place in a natural setting giving ample scope for observation, experimentation, hypothesis formation, analysis and drawing inferences.

National Education Policy (NEP) 2020

NEP 2020, the first education policy of the 21st century, envisages to address many growing developmental imperatives of India. This Policy proposes revision and revamping of all aspects of the education structure, including its regulation and governance, to create a new system that is aligned with the aspirational goals of 21st century education. It lays particular emphasis on the development of the creative potential of each individual and is based on the principle that education must develop not only cognitive capacities - such as critical thinking and problem solving – but also social, ethical, and emotional capacities and dispositions.

Salient Features of NEP 2020

- ➤ Quality
- ➤ Affordability
- ➤ Equity
- ➤ Access
- ➤ Accountability

How **NEP 2020** is Going to Change the Education System in India?

1.6.1

DRIIVing Effective Education (NEP 2020) in the National Capital Region

Effective Education Vertical, under the leadership of **Prof. Jyoti Sharma, CIC, DU** and her team aims to promote advanced knowledge and expertise in S & T for the overall benefit of Delhi NCR. It also ensures effective contributions of Indigenous Research & Development toward sustainable development of the nation.

The theme aspires to improve education at the school and college/university levels in order to increase students' competence in analytical ability and critical thinking by involving them in research and innovation and enhancing their employability skills in the long run. While doing so, the goal is to ensure that the proposed academic activities and outcomes for the Effective Education theme are interconnected and integral to the other themes of DRIIV in order to achieve holistic transformation.

Effective Education vertical aims to contribute in the following areas

I. Mitigate day-to-day challenges of Delhi NCR via education & research

II. Training the next generation students to work on sustainable growth & development

III. Enable academia-R&D-industry-government inter-linkages

IV. Mapping of workshop contents with the present curriculum at school/college level

V. Provide support and benefit of R&D across all sub-themes and encourage a self sufficient ecosystem of research, incubation, and high R&D investments

VI. Connect school/college learning with real-time localised problems and create a scientific knowledge base to solve problems for environmental sustainability etc.

VII. Enhance employment opportunities for students by skills upgradation

VIII. Enable accessibility, inclusivity & equitability in education & skills development

IX. Cultivate culture of innovation, startups, entrepreneurship

(A)   Teachers' continuing professional development through the "TRAIN THE TRAINER" model

The model is being used to equip teachers from various regions of Delhi & NCR schools and colleges. Under this theme teachers are formally trained in teaching science, content enrichment interventions for clarifying scientific concepts and the latest advances in their disciplines. The main stakeholders and facilitators are the science teachers.

In order to achieve the objectives of Effective Education theme, school as well as college teachers are brought in as **Master Trainers** for conducting workshops for training teachers in research based pedagogical tools to develop critical thinking and logical interpretations of problems.

Train-the-Trainer Model

| 1. Learn | 2. Co-Teach | 3. Takeover | 4. Deliver |

= Master Trainer   = Potential Trainer   = Student
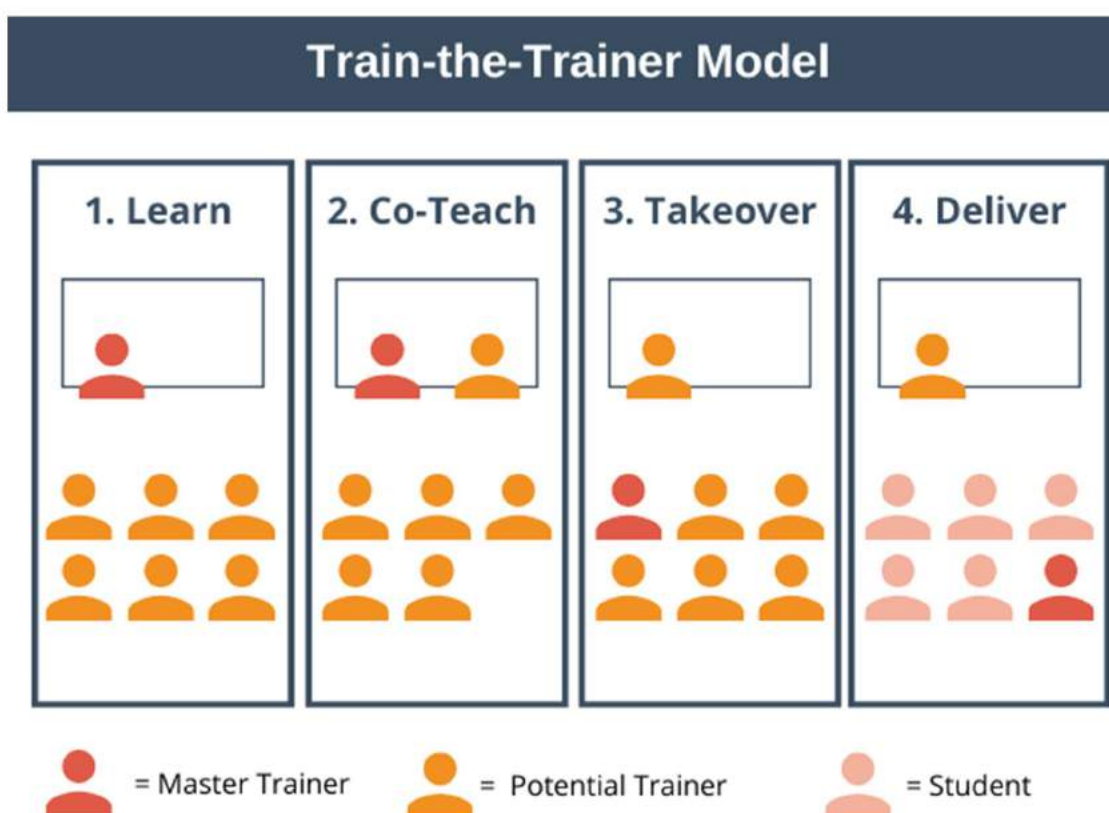
> *The ultimate purpose of "Training the Trainer"*
> *is simply to train trainers and instructors.*
> *They're taught the best ways to deliver training*
> *materials to other employees.*

College teachers do not receive any formal training to teach science and pedagogy. They are experts in their domain but may not be aware of the best practices in lesson planning, instructional design and assessing learning outcomes of their students. Hence, the Effective Education vertical has undertaken a series of workshops for the teachers at the school and college levels. Workshops on **digital pedagogy, basic AI/ML skills, skill development, gamefication** in education, multidisciplinary understanding of **public health**, inter-disciplinary understanding to address the problem of **Air Pollution** etc., are being held on a monthly basis.

Effective outcomes

I. Mitigate day-to-day challenges of Delhi NCR via education & research

II. Opportunity to interact with experts from different fields of science & technology

III. Getting hands-on training in various software and technological tools for creating engaging science lessons

IV. Training in inquiry-based and problem-based learning strategies

V. Act as master trainers to strengthen the skills of fellow teachers to update their teaching based on the principles of Activity-based teaching, Project-based teaching and Inquiry oriented teaching

VI. Learn newer and engaging ways of evaluation and assessment of students' needs & skills

VII. Foster an inclusive teaching & learning environment

VIII. Get an opportunity to develop modules and pedagogical activities to improve cognitive, behavioural and effective skills of students.

IX. Develop integrated school projects-with KVPY, national science competition, science fairs, projects addressing problems that are of local relevance (drinking water), global relevance (pandemic spread), conceptual textbook understanding etc.

Impact

Critical thinking skills, analytical ability, and logical reasoning

Improving innovation skills and creating a repository of STEM-based resources

Adopt inquiry based pedagogical techniques

Clarify conceptual understanding of students in STEM-sustainability

(B) **A series of workshops has been conducted in different thematic areas of science and technology, aligned with the current curriculum.**

Over hundred teachers across Delhi NCR have participated in the workshops held so far.

Few successful workshops on various themes are :

I. Designing classroom pedagogy with digital tools

The workshop's goal was to train teachers in digital tools, specifically G-Suite tools, while keeping the educational context in mind. Teachers were trained in Microsoft tools to use in conjunction with data gathered and analysed from schools in order to improve educational outcomes. As part of the workshop, a course on 'Designing Classroom Pedagogy with Digital Tools' was held. This course incorporated teaching and learning using MS Excel as a software tool, along with data awareness, visualization and interpretation for everyday classroom practices.

Designing classroom pedagogy with digital tools

Impact

➤ More than 100 school teachers were trained, out of which 93.5 % of the teachers felt confident to apply their learning.

➤ Lesson plans were prepared by the teachers for future use, such as developing assessment papers, making report books, planning classroom teaching and learning, video editing as needed in the classroom.

II. Making education AI/ML Ready for school teachers

This workshop which was organized for school teachers from Delhi NCR, emphasised the mandate of the National Education Policy (NEP)-2020 to understand the need for learning and integrating research.

Impact

➤ Development of AI/ML-integrated lesson plans aligned with the current curriculum.

➤ Training of approximately 40 school teachers in basic AI/ML and over 60 undergraduate teachers in the discipline of public health.

➤ Integration of public health components and writing projects into the mainstream curriculum.

III. Understanding public health from an interdisciplinary perspective for undergraduate teachers

The primary objective of this workshop was to help teachers understand the interdisciplinary nature of public health, as well as to brainstorm methods and best pedagogy for imparting public health education. It also provided teachers with the necessary skills to carry out curriculum enrichment and data-driven research projects, as envisioned in the NEP-2020. Teachers were also introduced to the applications of AI/ML in public health.

> **Impact**
>
> ➤ Training of approximately 60 undergraduate teachers for integration of public health components into mainstream curriculum. Also writing projects based on public health.

IV. Sustainability Education (elementary and secondary school teachers)

The primary goal was to provide an understanding of the fundamental concepts of sustainability education. Diverse topics for integrating the concept of 'sustainability' into activities were covered as mentioned below :

- ⊙ Digital pedagogy
- ⊙ Gamified learning

Additionally, development of innovative strategies for solid waste management were covered. Creating a lesson plan on sustainability education was also highlighted during the workshop.

> **Impact**
>
> ➤ Approximately 40-50 teachers participated.
> ➤ At the end of the workshop, teachers were able to integrate the topic covered with the currciculum.

V. National seminar on Innovation in Education Through Public-Private - Partnership (PPP) Model in Higher Education

The seminar aimed to facilitate and sensitize the concept and scope of the Public-Private Partnerships (PPP) model in higher education with respect to NEP 2022. The seminar also covered topic like effective skills in writing proposals for bringing PPP into education. It also aimed for serious deliberations by stakeholders from academia, industry, policy planning, innovators, practitioners and experts from legal fields to create effective, transparent and sustainable models of PPPs in higher education. As part of the seminar plenary sessions, presentations by R&D groups, a session on a few exemplary PPPs, and a panel discussion were also held.

Dr Jitendra Singh, Minister of State (Independent Charge) for S & T and other dignitaries at the National Seminar on Innovation through PPP model in Higher Education

VI. Effective Education for long-term Sustainable Solutions to the problems of waste management/air pollution

The workshop aimed to look into the effect of air pollution on human health, the environment, biodiversity, society, and the economy, as well as to identify the locally disseminated sources of air pollution in Delhi. One of the objectives of the workshop was to develop Research-Based Pedagogical Tools (RBPT) for effective teaching. It also aimed to provide sustainable solutions for controlling air pollution and to assess the implementation strategies for reducing the same.

1. Programme for Blue Planet fellows and their SPOCs

This orientation programme was organized to implement a Collective Responsibility Drive (CRD) for solid waste management. The aim was to nudge school and college students towards sustainable waste collection and segregation activities. More than 27 colleges participated and over 755 students were nominated for the drive.

2. Sustainable Air Quality Workshop towards enhancing understanding of the educators on air pollution and mitigation measures

The workshop was part of project **SAMEER**. The initiative was led by DRIIV and Arun Duggal Centre of Excellence for Research in Climate change and Air Pollution (CERCA), IIT Delhi. Workshop was attended by 70+ school teachers and principals.

3. Awareness workshops on Air Quality and Health Impacts of air pollution

Effective Education in collaboration with Lung Care Foundation conducted a series of sensitization and awareness workshops on Health Impacts of Air Pollution in various colleges and schools of Delhi NCR region. The workshops were on educating students and teachers about the impact of air pollution on them and their family's health and livelihood. This initiative aimed to encourage them to take simple individual steps to improve the air quality and engage with local leaders. Workshops were held across 7 colleges of Delhi NCR with combined participation of **1000+ students and 100+ teachers.**

Additional themes covered by the vertical

i. Reinventing education system for futuristic teaching and learning

ii. Where are the Women and Girls? Gender disparity in education

iii. Enhancing skills of educated Youth for today's job market

iv. Introduction to Python programming

v. "Bridging Workshop" on CSR grants to strengthen Academia - Industry Partnership in Delhi NCR

1.6.2

Future vision and areas of focus

- ⊙ Under this theme training sessions are being developed to establish **custom-designed STEM laboratories** in schools and colleges that are aligned with **NEP 2020**.

- ⊙ Partnership with educational experts, NGOs and philanthropic organizations are being explored and worked upon to develop innovative pedagogical interventions.

- ⊙ The theme's goal is to improve the learning outcome among underprivileged population of the society and to improve the retention of girls in **STEM** education.

- ⊙ It also aims to bridge the widened gap in learning-outcomes due to the pandemic and to prepare the students with skills needed in a fast-changing world.
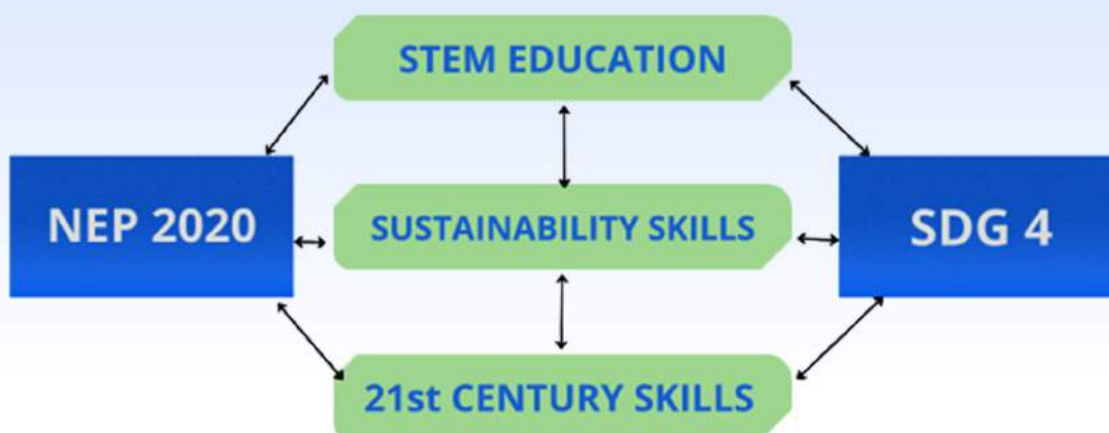
(A) Impactful collaboration

The vertical signed a number of Memorandums of Understanding (MOUs) with prominent institutions to facilitate the cluster's goal of identifying inadequacies & work towards overall professional development of the teaching community.

MoU signed with the following NCR schools and colleges

1. Gargi College for higher education

2. Hansraj College for teacher training programmes

The Effective Education team joining hands with Hansraj College for various teacher training programmes

3. Govt. College for Girls, Gurugram - for girls education

4. Navodaya Vidyalayas - for collaboration in the areas of data analytic skills, digital pedagogy course, STEM labs, green curriculum, gamification and maths circles

(B)   Thematic areas for upcoming projects for effective implementation of NEP 2020

1. Foundational numeracy & literacy

The theme encourages young learners to develop fundamental understanding and competencies in numeracy and related concepts. Under this theme, learners' skills will be developed to better integrate their outside-of-school experiences into their classroom learning in order to achieve foundational literacy and numeracy.

2. Gamification in education (non-digital)

Setting up gamification cafeterias/labs in selected schools with table-top games, wall-mounted games, and floor games for hands-on learning. Mathematics curriculum has already been mapped with the games.

3. Sustainability

Under this theme awareness and outreach programs on sustainable development practices, health, air pollution, etc are being held. DRIIV collaborated with organizations like Lung Care Foundation for the one of the programs.

4. Digital pedagogy

The pandemic provided the push towards digitisation of workspaces around the world. The educational systems were suddenly pushed into adopting the online modes of teaching, learning, bringing the question of what, how and when surrounding 'digital pedagogy'. Under this theme training the trainers in digital tools and technologies for enhanced learning outcomes is being done.

5. STEM - Ignite

STEM Education is a teaching philosophy that aims at integrating four disciplines-science, technology, engineering, and mathematics-based upon real world applications (Hom, 2014). Although STEM education has been much discussed and implemented, this project aims to take it one step ahead by combining the same with sustainability skills. STEM education integrates the requisite disciplines, and if that is combined with the skills required in the present circumstances and meet future demands, it's more effective and relevant for the students. It also promotes interdisciplinary thinking, innovation, and entrepreneurship skills.

This project aims at broadening the benefits of STEM education to impart sustainability skills, through improvised STEM curriculum, development and establishment of new generation STEM labs and adoption of innovative pedagogical techniques and project-based learning.

1.7

Sustainable Energy : for a better today & greener tomorrow

Solving the energy crisis is one of the most crucial endeavours of the 21st century. However, fulfilling the demands of existing and future energy in a sustainable and environmentally friendly way is a critical challenge for the global goal of halting/ limiting climate change while maintaining economic growth and enabling steady increase in living standards. Renewable energy sources are essential to sustainable energy, as they generally strengthen energy security and emit far fewer GHGs than non-renewable resources like fossil fuels. Renewable energy which get generated from existing resources (like, solar, biomass, wind, hydropower, geothermal) that naturally sustain or replenish themselves over time, has a positive impact on our environment and will potentially be able to supply our energy needs indefinitely.

Renewable Energy: Indian perspective

Renewable energy has emerged as a defining factor in every country's energy advancement. Countries around the globe are working on building and incorporating greater amounts of renewable resources (wind, solar, hydro, storage) into their energy mix to save Mother Nature. With a population of 1.3 billion, India has a massive demand for energy to fuel its rapidly growing economy. Currently, India spends over $160 billion of foreign exchange every year for energy imports. These imports are likely to double in the next 15 years without remedial action. **India's ambitious hydrogen missions** are driven by its need to achieve **emission reductions towards NET ZERO,** seize opportunities for economic development and technology innovation and secure energy independence and security.

Green Hydrogen, the new global buzzword in the energy industry

Hydrogen is the oldest, lightest and most abundant element in the universe. Hydrogen is a key industrial fuel and a clean source of energy that has a variety of applications including the production of ammonia (a key fertilizer), in energy-guzzling industries like steel manufacturing, refineries, for electricity generation and in fuel cells for cars. **Green hydrogen is produced from renewable sources like solar energy, biomass, etc., and not from fossil fuels.** This is an important distinction that sets it apart from **Blue/Turquoise/Pink** and other shades of hydrogen which are not carbon free due to their production process. Green hydrogen is a versatile and clean energy carrier that only emits water vapour and leaves no residue in the air, unlike coal and oil. It is one of the cleanest sources of energy with close to zero emission. As the world is facing its biggest ever energy crisis and the threat of climate change is turning into a reality, the need for green hydrogen is more now than ever.
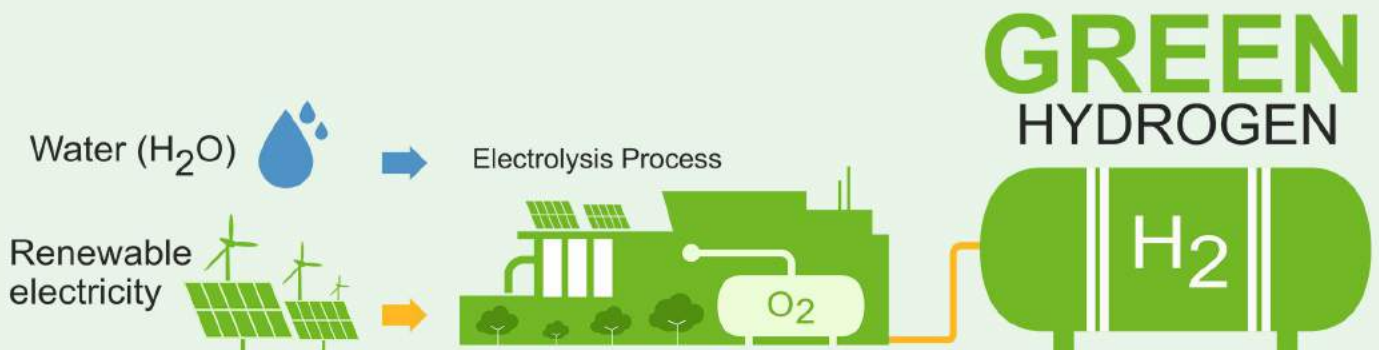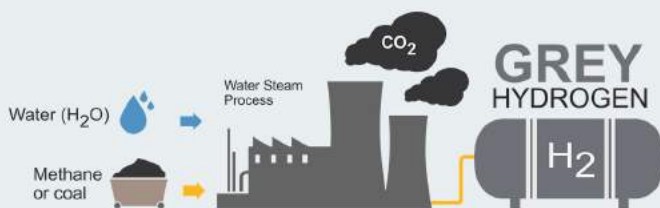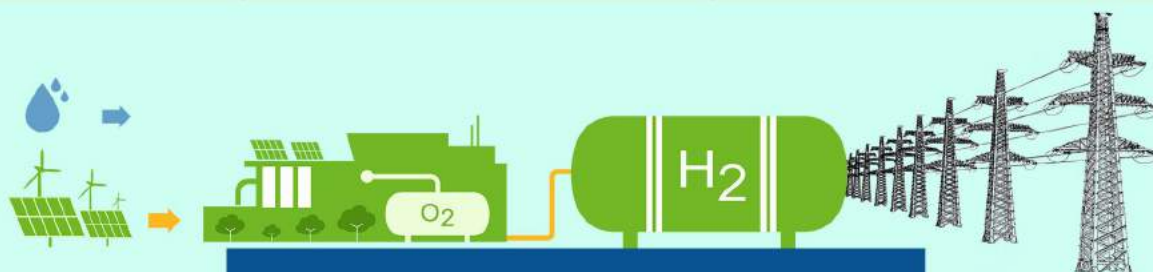
National Green Hydrogen Mission :
facilitating demand creation, production, utilization and export

EXPECTED DELIVERABLES BY 2030

At least **5 MMT GH$_2$** Annual Production	**60–100 GW** Electrolyser Capacity	**125 GW** RE capacity for GH$_2$ generation and associated transmission network

Total outlay approved: ₹19,744 crore

Rs. **1 Lakh Crore** Import Savings

50 MMT CO$_2$ Annual Emissions Avarted

6 Lakh Jobs

Rs. **8 Lakh Crore** Investment

Presently, green hydrogen accounts for just 0.1% of the overall energy production in the world (IEA, 2019). This huge underutilization of one of the best technological innovations to tackle climate change has to be overcome through investing in various R&D initiatives focusing on efficiency improvement, cost reduction etc. related to green hydrogen. The first financial commitment towards green hydrogen has been announced by our Hon'ble PM Shri Narendra Modi. Although the task is daunting, but the benefits from zero-cost inputs, clean air, and energy security continue to provide impetus for this change.

India's green H$_2$ production capacity is likely to reach at least 5 MMT per annum by 2030 (and expected to grow 10 times to 50 MMT in subsequent 5 years), with a related renewable energy capacity **addition of about 125 GW**.

> "
> *National Green Hydrogen Mission envisages to incentivise the commercial production of green hydrogen and make India a net exporter of the fuel.*
> "

Sub-schemes of NGHM:

i. Strategic Interventions for Green Hydrogen Transition Programme (SIGHT) will fund the domestic manufacturing of electrolysers and produce green hydrogen.

ii. States and regions capable of supporting large scale production and/or utilization of hydrogen will be identified and developed as Green Hydrogen Hubs.

Through the nation's maiden green hydrogen policy (Details of the policy can be accessed in this report):

https://static.psa.gov.in/psa-prod/publication/Green%20Hydrogen%20Mission_Jan%202023%20by%20MNRE.pdf

the government wishes to promote renewable energy transmission and set up green hydrogen facilities near the consumption sources.

1.7.1

Integrated approach to NGHM and role of DRIIV

All concerned ministries, departments, agencies and institutions of the Central and State Government will undertake focused and coordinated steps to ensure successful achievement of the Mission's objectives. Scientific departments and agencies, and MNRE and the Office of the Principal Scientific Adviser to the Government of India, among others, including public research and innovation institutions, will pool resources to build a comprehensive goal-oriented research and innovation programme in collaboration with the private sector.

DRIIV, being the umbrella body for the Delhi S & T cluster set up by the PSA Office, will play a pivotal role in creating industry-academia collaborations for commercializing green hydrogen technologies. Additionally, DRIIV will identify viability gaps and work with policymakers to address them - e.g. gap funding requirement, tax incentives, reduction in soft costs of hydrogen production, ensuring minimum feed inputs to early adopters etc. Finally, DRIIV will work on entrepreneurship and skill development programmes related to green hydrogen.

The way forward with DRIIV

With NGHM, the stage is set for India to become a global champion in green hydrogen. This can only be achieved by collaborative efforts by key industry players and renowned academic institutions. In line with its renewable energy aspirations, DRIIV aims to work with relevant stakeholders (the market leaders) in renewable energy for successful commercialization of green hydrogen production.

In this regard, DRIIV will :

i. Introduce high TRL technologies for converting biomass to hydrogen that are available with the research institutes within the country (IITs, TERI, NISE, NPL etc.).

ii. Facilitate relative assessment of those technologies on their efficacy and efficiency such as yield, cost (capex/opex), scalability etc.

iii. Facilitate engagement with researchers/experts for feasibility studies and pilots.

iv. Facilitate pilots via Centre of Excellence or any other mode of industry-academia partnership.

v. Helping industry partners set up green hydrogen plants utilising MSW and/or agri-residue as input.

vi. Providing technical expertise on hydrogen storage and transport (in addition to production).

vii. Facilitate policy interventions to create appropriate incentives, such as viability gap funding, assured input of biomass feed, soft cost reductions etc. for industry partners for early adoption.

viii. Liaison with other stakeholders for downstream utilization of hydrogen

Novel technology solutions within the cluster

H_2 can be produced using a number of different processes of which electrolytic hydrogen production in electrolysers is well developed, robust and most viable. Green hydrogen production through biomass utilization has emerged as an attractive alternate which helps in recycling the existing agri/ municipal waste. This section provides a brief overview of some of the high TRL, patented technologies for conversion of biomass to green hydrogen, which are ready for scale up in collaboration with industry partners.

H_2 production from natural sunlight through photocatalytic reaction

A "high-tech and low-carbon" innovation for green hydrogen production through harnessing solar power by utilizing a novel carbon-nitride based polymeric catalyst...

Production of green H_2 by hydrolysis through integrated closed-loop S-I process

Water splitting by a Sulphur-Iodine (S-I) thermochemical hydrogen cycle using novel catalyst to generate low-cost, clean hydrogen fuel for industrial consumption...

Biomass derived H_2 production through novel microbial consortium

Green H_2 production along with valued metabolites from sugarcane blackstrap molasses by unique microbe through dark fermentation under anaerobic condition...

Alkaline electrolyser based Green H_2 production, storage & dispensing

India's first solar integrated hydrogen generating facility, where H_2 station is directly coupled to the solar power plant feeding electricity to the electrolyser...

Energy storage: key to utilising green energy

Innovation in energy storage is a critical requirement for transition to renewable energy. Various solutions such as fuel cells, batteries, capacitors etc. exist for storing energy in various forms. However, researchers are currently working on making these solutions more efficient, cost effective and less reliant on rare earth materials. DRIIV, **through its ecosystem of researchers, startups and MSMEs will be focussing intensely on battery storage technologies** to scale and commercialise them.

2

Enabling Innovation Ecosystem through Impactful Collaborations

Whilst the institutional venture capital funding landscape is well evolved in India, for digital marketplace startups funding is still scarce for core R&D based ventures. With a mandate to take innovations from **'lab-to-market'**, DRIIV aims to create an enabling ecosystem for such startups **by providing** access to expert researchers for **product validation, industry partnerships** for scale-up & commercialisation and mechanisms for **institutional funding**.

The economic power, population growth, technological advancements, environmental pressures and changing customer expectations of our nation are demanding innovative approaches and innovations, for continued growth toward $5 trillion mark by 2025. The timing couldn't be better for the innovation ecosystem to take a forward momentum and help India reach its aspiring goals.

With continuous support from the government, India has started gaining attention as one of the leading startup hubs globally. According to recent reports, India is home to over 60,000 startups, and the country has witnessed a significant increase in the number of unicorns (startups with a valuation of over $1 billion). **"Startups and the entire innovation ecosystem are the engines of growth for any country"**. The government has taken several measures and initiatives such as providing funding and mentorship programs, easing regulatory and compliance requirements, and promoting innovation and entrepreneurship to support startups and entrepreneurs.

Aligned to this, DRIIV has undertaken various initiatives and forged multiple partnerships, with many more in the pipeline.

2.1

Piloting opportunities and technology adoptions by public bodies

DRIIV has worked with various agencies to develop innovations that are being adopted in the System in various areas such as Air Pollution, Healthcare (AI/ML) etc.

Pilot project - **SAMEER** (Solutions for Air-pollution Mitigation through Engagement, Engineering, and Research) - a first of its kind initiative, has brought together local Government authorities, researchers, tech startups, corporates, NGOs and communities to collectively address the air pollution menace in Delhi NCR. This project is currently operational in collaboration with Gurugram Metropolitan Development Authority (**GMDA**) and Delhi Pollution Control Board (**DPCC**) to deploy tech-based solutions in various hotspots for monitoring and mitigating PM 2.5 and 10 levels.

SAMEER has successfully achieved the three objectives it was designed to deliver. Firstly, the well-structured pilot with clearly defined outcomes, brought together **startups and public bodies** - DPCC and GMDA- to address the problem of air pollution monitoring and mitigation in Delhi NCR. Such an engagement, without any mediating platform such as DRIIV, would not be possible.

Secondly, a framework for **technology validation** has been established where startups can get their solutions validated in real life conditions from the country's premiere institutes such as IIT Delhi and AIIMS. Hence, this pilot project will be unique in its construct that provides a platform to startups and MSMEs to test their products in rigorous, real-life environment and also access govt./public bodies, which otherwise is not easy, to say the least.

Finally, a number of corporations and government bodies have come forward to **adopt the technology solutions and/or financially support their adoption**. Encouraged by its success, DRIIV will replicate this model in other areas of environmental concerns such as waste management and water security.

Industry roundtable event as part of the air pollution pilot SAMEER

2.2

Investment opportunity/Entrepreneurship infrastructure programs

I. Scope with India Health Fund (IHF)

DRIIV has partnered with India Health Fund - an initiative of TATA Trusts through its legal entity-CHATF (Confluence for Health Action and Transformation Foundation) - a collaborative initiative to leverage the power of collective impact and catalyse India's fight against Infectious Diseases. The aim is to **support effective business models, enable collaboration** and **funding mechanism** with overall objective of ensuring wide scaling up of solutions that can deliver extensive and significant outcome in healthcare.

Both have joined hands to initiate activities such as developing **joint innovation programmes on technological themes, joint fund-raising efforts** through external sources, acceleration of healthcare technologies and work towards market access.

Objectives :

⊙ **Translate and apply technology innovation in public health** setting to cater under privileged communities in rural & urban areas.

⊙ **Work collaboratively** to bring interested partners to **create implementable solutions** (including IHF portfolio innovation) across priority geographies.

⊙ Work collaboratively for **scalability and financial sustainability of** healthcare innovations.

⊙ **Build consortium of partners** within healthcare domain - hospitals, bio-incubators, for product development and lab support.

⊙ Technical partner for DHEL (**Digital Health Evidence Lab**) - focus on reducing gap between end users & innovators, enabling evidence generation towards accelerated adoption and scale-up of digital health solutions.

⊙ To explore **piloting opportunities** for implementable solutions through joint fundraising can be potentially applied in real health settings in relevant geographies.

MolBio Truenat : a fast PCR-based TB detection method to find the under-diagnosed

II. Scope with Central Park

DRIIV has collaborated with Central Park - a part of Le Meridien Group Hospitality & Real Estate arm through it's legal entity - **St. Patricks Realty Private Limited** – leading in the business of establishing Technological Parks, Software Economic Zones (SEZ), Information Technology/software parks. They have come up with technology hub - a platform for buding startups for incubation support.
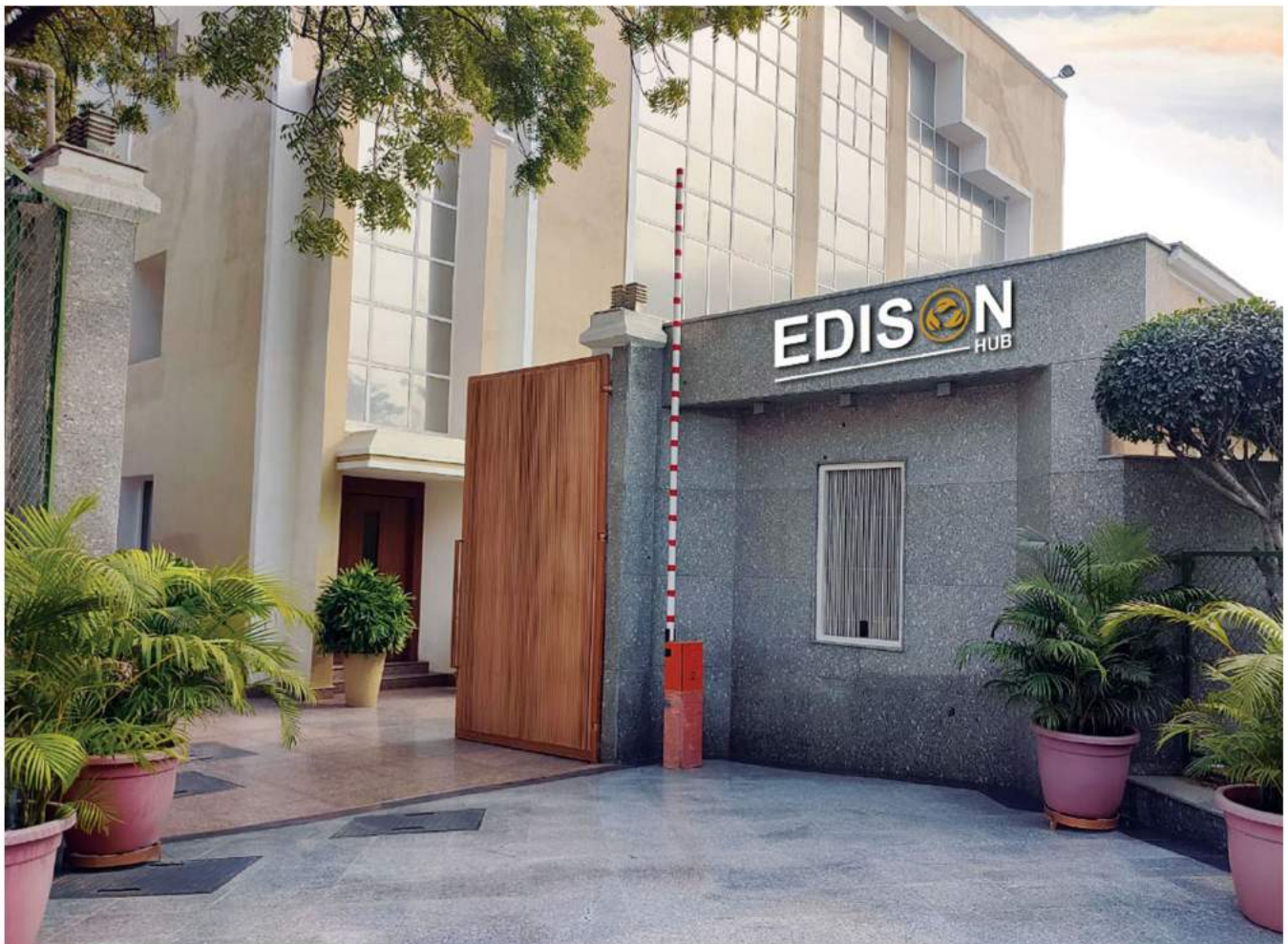
Their initiative, **Edison Hub**, is based on 6C's approach (Capital, Coaching, Consultancy, Co-working Space, Camps & Conclave, Curating Business Strategy) providing a foundation for startups to innovate and work towards solutions that solve problems of national importance. The group is backed by the enviable legacy of the multi billion dollar and multi sector Bakshi Group, lead by Mr. Amarjit Bakshi - an IIT Delhi alumnus.

Both entities will be working for various initiatives supporting pre-incubation and incubation activities for startups. This involves developing a network of experienced services including technical, financial and legal support.

Objective :

⊙ Providing infrastructural platform to startups focused on development through scientific networking, and incubation support.

⊙ Central Park initiative aims at fostering collaboration within corporates, incubators etc. through networking events and leadership talks. The platform may provide services and opportunities such as :

   i. Offers support to budding startups/entrepreneurs aspiring to develope extraordinary business.

   ii. Provides all the necessary tools and connections to grow and break new grounds.

   iii. Helps to build a collaborative and creative environment that enhances the morale and productivity of budding entrepreneurs.

   iv. Provides a workspace that is flexible, affordable and provides best solutions for instant scalability.

   v. Helps startups thrive and scale-up by providing solid backing.

2.3

Partnership with Social Alpha

DRIIV has joined hands with Social Alpha - a multistage innovation curation and venture development platform focused on addressing the most critical social, economic, and environmental challenges. With their deep community engagement, partnerships, and ecosystem leadership, Social Alpha has evolved into a societal platform for promoting high-impact innovations to fight poverty, disease and climate change.

Social Alpha architecture is built around a not-for-profit platform, **Foundation for Innovation and Social Entrepreneurship (FISE)** and operates through a nationwide network of technology and business incubation infrastructure, sponsored and enabled by **TATA Trusts, Government of India** and a number of academic, philanthropic and corporate partnerships.

They scout for innovators willing to take the entrepreneurial risk and support them as they build compelling solutions to address India's intractable development sector challenges.

Platform architecture : lab to market

Social Alpha's comprehensive architecture is designed to catalyse the "lab to market" progression of high impact innovations. It consists of product innovation labs, venture incubators, accelerator programmes, capital pools and market access mechanisms. Capital pools include grants (**non-dilutive**) as well as early-stage catalytic equity (**dilutive**). Startups also get access to sandboxes for pilots and validation, product management guidance, technical, business and regulatory expertise, design and manufacturing support and entrepreneurial mentoring.

Social Alpha has built a **large partner network** across the innovation and investment ecosystems, with significantly deep engagement with the Central and State governments, private sector, academic institutions, R&D labs, philanthropic foundations, investors, NGOs/non-profits and community organisations. Some examples of the **incubation**, **accelerator** and **investment programmes** operating within the Social Alpha architecture are mentioned in the following section.
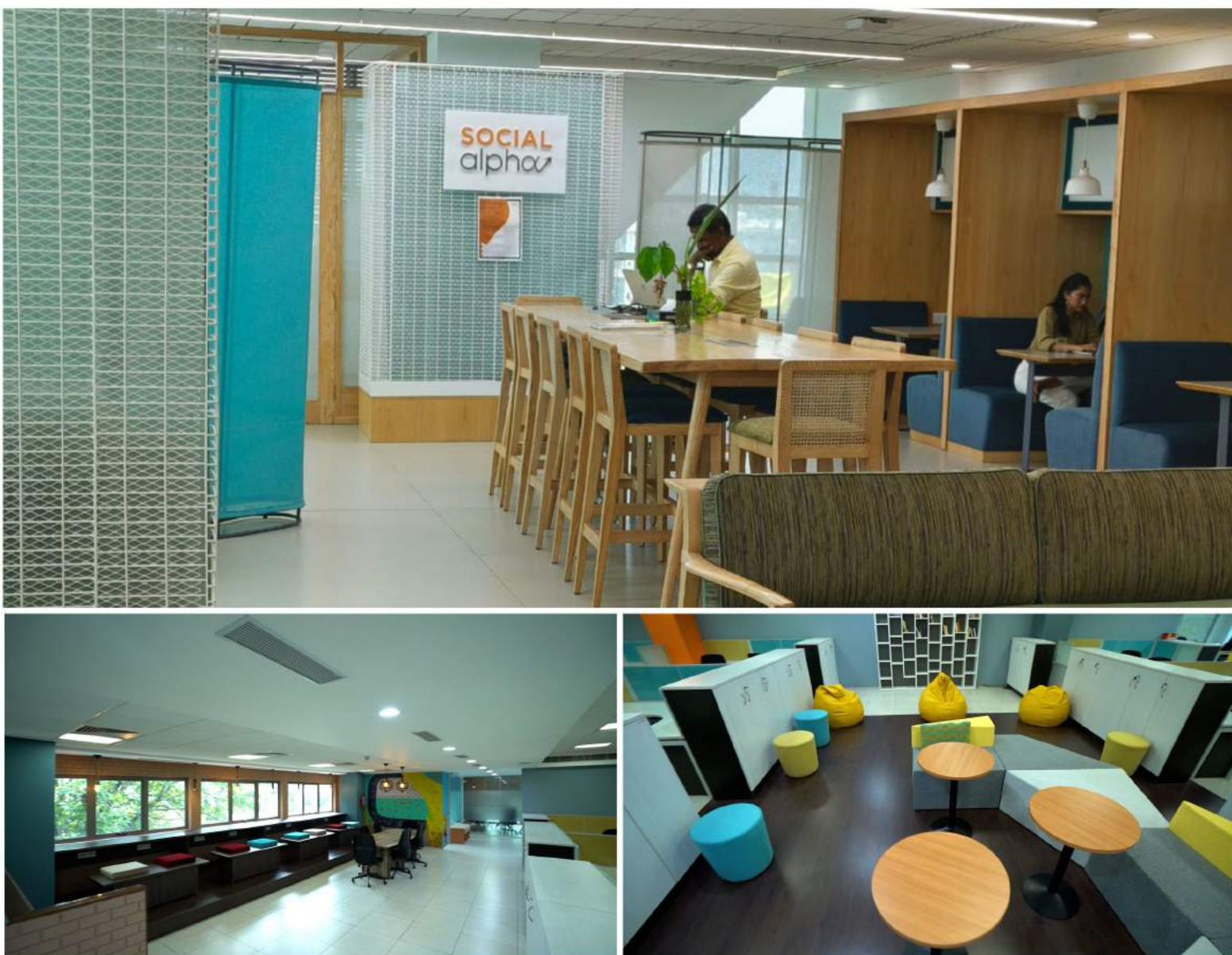
Glimpses of networking spaces offered by Social Alpha

Some examples of the incubation, accelerator and investment programmes operating within the Social Alpha architecture :

CEIIC	Innovation and Incubation infrastructure and Programme in partnership with GOI under Mission Innovation. https://www.iea.org/reports/how-governments-support-clean-energy-start-ups
Mach33.aero	Deep science and technology incubation, a joint venture with CSIR-NAL, GOI https://economictimes.indiatimes.com/small-biz/entrepreneurship/tata-trusts-backed-social-alpha-sets-up-aerospace-accelerator-and-incubation-platform/articleshow/88430266.cms
Quest for Agritech Innovations	National incubation network in partnership with Bill and Melinda Gates Foundation that was piloted in aspirational districts in UP and is now being extended to Odisha. https://www.youtube.com/watch?v=_0oTc6r0Eel
CEIBIC	Extending the CEIIC innovation model to state governments in a hub and spoke model, starting with Kerala https://www.newindianexpress.com/cities/kochi/2022/feb/05/govt-signs-deal-to-develop-clean-energy-tech-in-kerala-2415453.html
Social Alpha Waste Innovations Acclerator	A first-of-its-kind program, focusing on businesses accelerating waste management in partnership with H&M foundations and JSW https://yourstory.com/2020/12/hm-foundation-social-alpha-innovation-waste-management
Krishi Mangal	A scale up programme for high impact Agritech innovations in partnership with Cisco https://yourstory.com/2021/06/cisco-social-alpha-krishi-mangal-support-agritech-startups
Innovations in Assistive Technology	An innovation curation programme in partnership with SBI foundation, focussed on solving the needs of persons with disability, structured to support early-stage TRL 3 innovations to include experiential, immersive, and instructional components https://www.iea.org/reports/how-governments-support-clean-energy-start-ups

Exploring new innovation programmes with them will help unlocking this potential and support early-stage startups to solve the nation's complex socio-economic and environmental challenges **(power of entrepreneurship and innovation).**

2.4

Upcoming initiatives :

I. 'Entrepreneur-in-residence' programme to create a commercialisation plan for applied research lying in labs

DRIIV plans to launch **"Entrepreneur-in-residence' programme (EIP)"** which provides tremendous opportunities for innovative entrepreneurs to expand lab-based innovations towards commercialization (Lab to Market) and promoting their entrepreneurial goals and aspirations.

This **long immersive commercialization programme** which will equip passionate 'entrepreneurs-in-the-making' with end-to-end capacity building and resources to leverage India's deep science, innovation, and entrepreneurship environment. It will be anchored in solving chronic and emerging problems, providing technology development support, business planning and venture building assistance, and an in-depth understanding of the domain sector.

The programme is designed to bring together entrepreneurs, innovators & other stakeholders to foster collaboration amongst some of the top educational, technical, and philanthropic institutions in the country. Aim is to inspire the best talents to be entrepreneurs, to minimise the risk involved in pursuing **startups**, and to partially set off their opportunity costs of high paying jobs.

EIP opportunities :

  i. Guidance from experienced, innovative and highly successful entrepreneurs on the business concept, strategy or venture and insight into specific industries or markets.

  ii. Best practices for starting a business and broaden the professional network.

  iii. Co-working spaces for developing an idea into a marketable product.

II. Cleantech accelerator programme for climate entrepreneurship

As part of new initiatives, DRIIV will be launching a "Cleantech accelerator programme" - an unique program designed to identify a bunch of startup technologies working towards India's most pressing issues in environmental, societal and governance areas through innovative solutions enabling holistic ecological and sociological impact.

The program will be launched in association with leading sustainability hub dedicated to mainstreaming environment action, wellness and co-existence. It will function in collaboration with the existing TBIs (incubators of top technology institutes) and provide a common platform for cross pollination of ideas and support.

Objective :

i. Cleantech accelerator programme is a designed and focused initiative that will help nurture the climate action-led innovation ecosystem of India, giving it all that it takes to be successful and create a massive impact.

ii. Fast-track 6-month long regional acceleration program for innovative & enterprising startups helping them accelerate their growth, enhance their valuation and enabling them for subsequent rounds of funding.

iii. The program also aims to **showcase India's breakthrough climate solutions** at the global stage of G20 Presidency.

3

Executing Sustainable Projects through **CSR**

Through Corporate Social Responsibility (CSR), a company proves its commitment to the environment and the social landscapes in which they operate by practicing environmental and social sustainability initiatives. CSR is a bridge connecting the production and profit with the sustainability of society and environment and implements the success of science and technology (Technological Investment) in business with peace and prosperity in life.

> *Corporate Social Responsibility of companies - both private and public - has become one of the main sources of nation building in recent years. Cumulative spending in CSR has reached Rs 50,000 crore in just 4 years since the legislative mandate was implemented. (India CSR Network, 03/03/2019).*

Over the years DRIIV has consolidated partnerships as well as curated projects that brought together stakeholders to deliberate on the critical themes on green transitions.

3.1

Delivering on National Missions and UN SDGs

Towards delivering on the drive of AtmaNirbhar Bharat, DRIIV is creating strong linkages between Govt. bodies, academic institutions and industries by leveraging Science & Technology to address issues aligned with the UN SDGs. In addition to tethering public bodies and research communities, private capital is being mobilised under CSR.

DRIIV is creating opportunities for researchers and startups to take use cases from local government bodies. Pilots in the areas of waste management, air pollution, water security, e-mobility and healthcare are being executed in collaboration with local Govt bodies and corporates and innovative solutions in all these areas would be utilized for environmental sustainability and public good.

3.1.1

Executing sustainability projects at scale to create significant on-ground impact

Project title : Collective Responsibility Drive (CRD)

Location : **Delhi NCR**

Impact : Mobilising 10 million school and college students to collect 1 billion tonnes of plastic waste, which will be recycled into desks for donation to deprived government schools. So far, 1000 such benches have been delivered to 27 govt. schools.

Funded by : Rural Electricity Corporation (REC)

DRIIV in collaboration with Blue Planet Environmental Solutions (BPES) India Pvt Ltd, (a waste management company) has initiated behavioural nudging of school children for plastic waste collection and segregation through organizing Collective Responsibility Drive (CRD)-Recycling. This drive aims to mobilise **10 million youth and collecting 1 billion tonnes plastic waste** thereby preventing them from going to landfills and impacting the environment and climate change. The drive, in true sense depicts a perfect example of circular economy wherein the accumulated waste will be upcycled and transformed into school benches and donated to the deprived government schools of Delhi and Haryana. **CSR support from REC FOUNDATION** has kick-started CRD in Gurugram, Haryana, which has already delivered **1000 school benches** (impacting a total of **3000 students**) made from recyclable plastic waste in **27 government schools** and conducting awareness programme in 50 schools towards climate change & sustainability.

❝

CSR has the ability to reorient business and turn the tide of climate change, deliver economic opportunity for all and build connected societies in which all people can live in dignity and with respect.

❞

Project SAMEER : Pilot for Clean Air in Delhi NCR

Location : **Delhi NCR**

Impact : SAMEER is currently operational and following a 3-pronged approach to tackle air pollution in Delhi NCR (Awareness and community engagement; S&T interventions for monitoring & mitigating the hazardous PM 2.5 and PM 10 emissions; Industry roundtables mobilising sustainability champions to deploy tech solutions).

Funded by (partially) : RSPL Group

Project SAMEER (Solutions for Air Pollution Mitigation through Engagement, Engineering and Research) is a great example where DRIIV has collaborated with GMDA to pilot technology solutions for monitoring and mitigating air pollution in Gurugram and Delhi. DRIIV is transforming the sustainability paradigm, keeping science and technology at its core. Project SAMEER is a first of its kind initiative bringing together Government authorities, IIT Delhi researchers, tech startups, corporates, NGOs and communities to execute impactful environmental pilots at scale.

SAMEER is currently operational and following a 3-pronged approach to tackle air pollution in Delhi-NCR (Awareness and community engagement; S&T interventions for monitoring & mitigating the hazardous **PM 2.5 and PM 10 emissions**; Industry roundtables mobilising sustainability champions to deploy tech solutions). Air pollution mitigation and monitoring devices have been installed in **public buildings such as schools, offices and on vehicle rooftops** to gather relevant data and effectively address the issue. As part of this project, a host of startups have also been mobilized to deploy their technological solutions (please see below the list) across the major hotspots of Delhi NCR. A scientific approach will be followed by IIT Delhi to validate these observations and the successful solutions will be scaled up.

On the awareness and community engagement front, DRIIV has organized series of workshops and webinars on Sustainable Air Quality to engage various communities such as farmers in Punjab and Haryana (to disincentivise stubble burning via raising awareness on adverse health impact caused by it through NGOs and medical fraternity such as Lung Care Foundation), school and college students, RWAs, urban slums etc. connecting educators with air quality experts, technology partners, regulators & scientists.

An industry roundtable, attended by ~15 organisations (from sectors such as automobile, power, energy, etc) and 15 startups to initiate an action plan in tackling environmental problems has been conducted. For the first time, factors like meaningful engagement with government/civic bodies, scalable technology solutions, financial support and resource commitment from the industry through CSR have been successfully brought together. It was delightful to see corporations offering financial support to project SAMEER and adopting technology solutions.

List of technologies piloted :

i. Umeandus : APS (Ambient Purification System): Filterless, modular ideal for highly polluted industrial areas, marketplaces

ii. Omnilon : APC (Air Pollution control) Device: Ionization based, ideal for traffic crossroads

iii. Active Buildings: Open-Source Air Purifier & Sensors: ideal indoor solution

iv. Rena : Affordable Indoor Air Cleaner Retrofit

v. Airth : Indoor clean air module

vi. Indus AAQMS: Ambient Air Quality Monitoring System

vii. PrKruti : Smart Air Quality Monitoring System

viii. Oizom : Smart Air Quality Monitoring for Sustainable Future

ix. Shudhvayu : Air Filter for vehicular roof-tops

x. Outdoor Dust Suppression with Misting Solution

xi. Aurassure : AQI Monitors (both indoor and outdoor)

xii. Smart water sprinklers for water tankers

In order to truly solve the problem of air pollution, it is important to control emissions at source and DRIIV is working on renewable energy and sustainable mobility technologies to help achieve that. However, project SAMEER has successfully achieved the three objectives it was designed to deliver.

Firstly, the well-structured pilot with clearly defined outcomes, brought together startups and public bodies - DPCC and GMDA- to address the problem of air pollution monitoring and mitigation in Delhi NCR. Such an engagement, without any mediating platform such as DRIIV, would not be possible.

Secondly, a framework for technology validation has been established where startups can get their solutions validated in real life conditions from the country's premiere institutes such as IIT Delhi and AIIMS.

Finally, a number of corporations and government bodies have come forward to adopt the technology solutions and/or financially support their adoption. Encouraged by its success, DRIIV will replicate this model in other areas of environmental concerns such as waste management and water security.

Startup technologies piloted by SAMEER
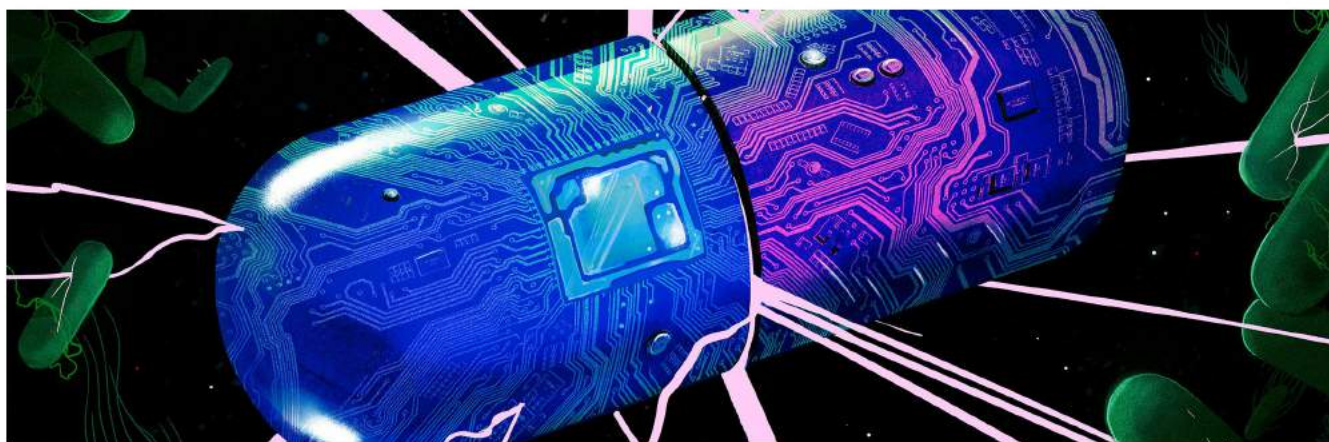
Project: Developing a Scalable, NDHM compliant, and AI-enabled Infectious Disease Tracker

Location : **Pan India**

Impact : An AI model for predictive modelling in (re) emerging epidemics such as COVID waves; Web-application for state-level covid models using graph neural networks and Bayesian networks; Extendable technology for antimicrobial resistance and infectious disease surveillance.

Funded by : MongoDB

Creating an infectious disease surveillance system for infectious diseases and antibiotic resistance is ongoing. COVID-19 pandemic has exposed vulnerabilities in the health systems all across the globe. On the other hand, the threat has also provided an extra-ordinary opportunity for a collective multi-sectoral response achieved with systems thinking and coordinated local execution. Global and National Action Plans for tackling AMR recommend active surveillance of antibiotic use and emerging resistance. However, these rely upon descriptive approaches such as antibiograms and expert reviews. A data-driven, scalable model with temporal visualizations and predictive modeling is the need of the hour. In this project, the researchers will develop an NDHM compliant application, potentially scalable across the country. The application will include data visualizations and temporal tracking of antimicrobial resistance carried out upon datasets curated by us. This is especially relevant in the post-COVID era due to the high usage of antibiotics in the hospital and home-care settings. The current reports generated are limited to standard descriptive statistics such as antibiograms. However, these don't include temporal patterns and predictive modeling. The applications developed will leverage the Consent Manager (CM), Health Information Provider (HIP) and Health Information User (HIU) APIs provided by NDHM sandbox to ensure scalability through NDHM artefacts. A pilot version of such a COVID-19 data integration and authentication framework has already been developed at the investigator's lab using publicly available datasets and deployed using a multi-tenant architecture. For the proposed project, the investigator has access to a database with 0.7 million records globally and antibiotic resistance data from AIIMS New Delhi. The interpretability and explainability of the model will be the main USP of the project. This will help establish trust with the clinicians and enable workflow integration. For the AMR and infectious disease components, the project will involve :

➤ Big-data analytics and modelling

➤ Data architectures and Digital Health products

➤ Knowledge synthesis

➤ Innovations in education and skilling for sustained multi-disciplinary engagement
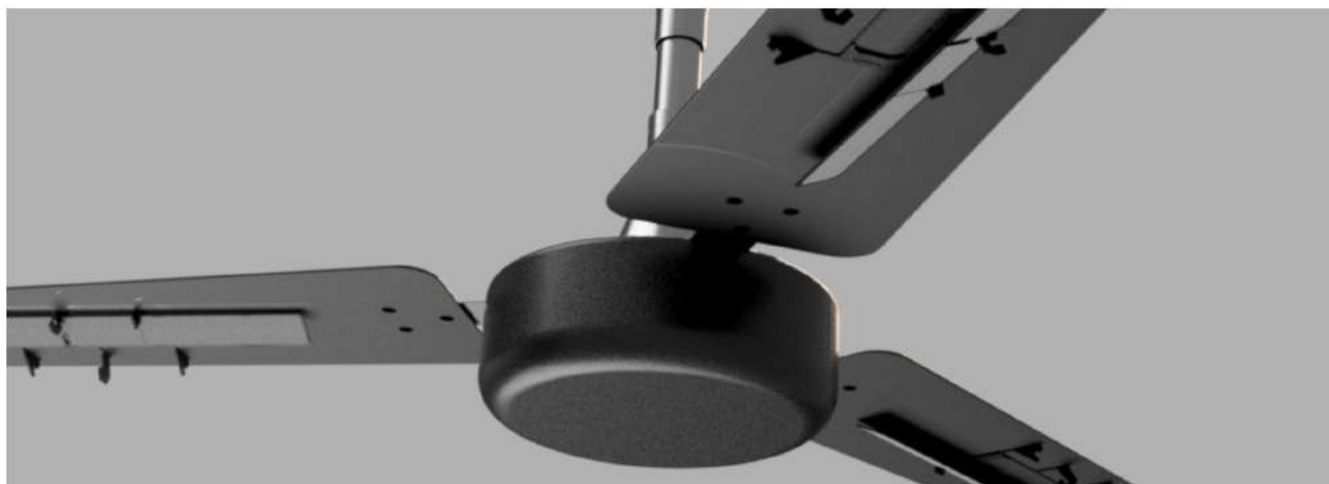
Project: Air Pollution Education, Mitigation & Monitoring for Schools and Colleges

Location : **Delhi NCR**

Impact : Impacting pollution hotspots in Delhi NCR (East Delhi, Noida, Ghaziabad and North Delhi) with students of government schools and colleges as target group of intended beneficiaries.

Funded by : HUDCO

The project that is being initiated with HUDCO, is an air pollution education, reduction, mitigation and monitoring program in Delhi NCR schools that will tackle indoor air pollution in various pollution hotspots. The project: a. educates students, teachers and administrators about the dangers of air pollution, b. implements multiple technologies such as ceiling fan air purifiers, indoor air purifiers and outdoor misting to improve indoor air quality in schools and c. provides continuous monitoring for air quality. Approximately 45 government schools and colleges will be fitted with a highly affordable and multi-layered air pollution mitigation solution, including, but not limited to, technologies such as ceiling fan air filters, outdoor misting nozzles and CR-box air purifiers etc. The project's objective is to improve indoor air quality by 50% (as measured by a reduction in AQI) across school classrooms within the implementation scope. This exact improvement in indoor air quality can be measured via the provided air quality sensors for each school. A 50% magnitude pollution reduction significantly reduces the instances of asthma, bronchitis, chronic disease and deterred cognitive development in children – improving health, absenteeism, and learning outcomes.

Project: Delhi Air Pollution: Health and Effects (DAPHNE)

Location : **Delhi NCR**

Impact : Side effects of air pollution in Delhi through exposure-response relationships between ambient air pollution exposures and health effects (birth weight, acute respiratory infections in children < 2 years) and asthma exacerbations in adolescents aged 12-18 years.

Funded by : UK Research and Innovation

LINEAR DIAGRAM

DELHI AIR POLLUTION
Adverse health effects of air pollution

1 RESPIRATORY PROBLEMS
2 CARDIOVASCULAR ISSUES
3 DAMAGE TO REPRODUCTIVE ORGANS
4 DAMAGE TO SPLEEN, LUNGS, BLOOD, AND LIVER
5 REDUCE LIFE EXPECTANCY BY 10 YEARS

DAPHNE is a consortium of doctors, scientists, and technologists drawn from 9 institutions (six in India and three in the UK), to study the effect of air pollution in the city of Delhi on the health of pregnant mothers and their new-born children, and asthmatic adolescents. This group is particularly vulnerable because of their greater intake of air with respect to body weight, and an underdeveloped immunity system; and, also, the adolescents have greater outdoor exposure when traveling to school and during play times. The project aims at estimating the amount of suspended particles and gaseous pollution inhaled by subjects using existing networks of stationary air quality monitors and satellite data. In Addition, the project also introduces novel devices worn by the person to measure exposure to suspended particles and noxious gases and monitor their breathing rate and breathing effort when the subjects are out and about in their every-day lives. This will estimate the impact of air pollution on their asthma and how different levels of activity could contribute to changes in their condition. Biomarkers in samples of blood and urine taken from the subjects will be used as further evidence to estimate the effects of air pollution on changes in their well-being. Finally, a panel of stakeholders drawn from India and the UK will advise on how best the research results can be translated into interventions to help mitigate the effects for the benefit of the citizens of Delhi in the first instance, with potential for worldwide application in the future.

Project : Modeling Air Quality at Hyperlocal Scale for Identifying Dispersed and Continuous Sources in and around Monuments in Kolkata

Location : **Kolkata**

Impact : Evidence-based identification of dispersed air pollution sources in Kolkata city

Funded by : Environmental Defence Fund (EDF)

The project aims to carry out air quality monitoring in and around monuments in Kolkata to identify dispersed sources and track air quality at a hyperlocal scale. The overall strategy involves both static and mobile monitoring. On the static front, continuous monitoring at selected locations (identified based on the population density, distribution of local sources, and locations of monuments) in two regions - Central and North Kolkata, is being done. 40 static sensors will be deployed, out of which 20 would cover Howrah Bridge to Sealdah region and the remaining 20 would cover the region surrounding Victoria Memorial in Central Kolkata. For mobile monitoring, 3 sensors (on 3 different buses) would be deployed in one bus route and the project would cover 5 bus routes running through north and central Kolkata. The identified, heavy traffic, routes cover the whole of the city covering the extreme North-South-East-West boundaries. Additionally, 5 units driven by cycle rickshaws would be deployed to measure PM at the residential neighborhood level. For ground truthing, 4 Junior Technical Assistants would conduct field visits to map the changes in PM2.5 at a hyperlocal scale at locations wherein sensors are installed and capture the local source characteristics.

4

Events & Conferences :
A sneak peek into DRIIV's diary

Over the years, DRIIV has been instrumental in organizing/participating in many impactful events by bringing together a consortium of startups, academic institutions and corporates to collectively address various societal and environmental issues by implementing sustainable and smart cities initiatives on ground.

4.1

Inaugural flagship event :
RESOLVE : Rendering S&T Solutions for AtmaNirbhar Bharat

DRIIV hosted its inaugural flagship conference **RESOLVE** at India International Centre on 7th December 2022. The day-long conference was action-packed with several rounds of interactive panel discussions on thematic areas in the spaces of smart citites, climate resilient growth, sustainable technology innovations, creating innovation ecosystem and circular economy.

Prof. VijayRaghavan inaugurated the event while **Prof. Ajay Sood**, PSA to The GoI delivered a virtual keynote. "Technology alone cannot solve these problems unless there is a collective effort of all the stakeholders... I am glad that DRIIV is now beginning to mobilize all the stakeholders, as is apparent in their recent collaboration with GMDA... Cases directly from these public bodies need to be taken up..." said, **Prof. Ajay Sood,** in his keynote.

RESOLVE was attended by key dignitaries including a team of Swedish delegates led by **DG Per-Arne Hjelmborn**, DG for Trade, Swedish Ministry for Foreign Affairs and industry leaders from various cross-sectors; **Mr. Pradeep TP**, Robert Bosch; **Mr. Saurabh Rai**, Tech Mahindra; **Mr. Rajesh Dhar**, HP Enterprise; **Mr. Aman Singal**, JK Tyres; **Mr. Arun Karna**, AT&T Global Network Services; **Dr. Rajesh Jain**, Panacea Biotec; **Mr. Bimal Jindal**, L&T; **Mr. Amarjit Bakshi**, Central Park; **Mr. Anurag Agarwal**, Source Global; **Mr. Sanjiv Kumar**, Resustainability; **Ms. Prachi**, HCL/Shivnadar Foundation etc.

RESOLVE showcased DRIIV's initiatives in sustainability and breakthrough tech innovations through highlighting members of the ecosystem who are instrumental in delivering on DRIIV's objectives. The conference was adorned by a technology exhibition by startUp innovators with tech solutions addressing perennial environmental problems like air pollution, waste management, mobility and healthcare.

As aptly put by **Prof. K VijayRaghavan**, former PSA to The GoI, "In the process of transforming the sustainability paradigm, keeping science and technology at its core, DRIIV's RESOLVE successfully brought together Government authorities, researchers, tech startups, corporates, NGOs under one roof to pave the way in executing impactful ideas into meaningful solutions under aegis of UN SDGs on the ground." The event was sponsored by corporate bodies like **Central Park Billions**, **TATA Steel** and **Murli Krishna Pharma**. Speaking on DRIIV's priorities, **Ms. Shipra Misra** said "Lack of piloting opportunities and absence of a funding mechanism for mid TRL technologies are two major hurdles for innovators in research-based technologies. DRIIV is focussed on solving these problems by engaging public bodies, such as GMDA and MCG to provide real life use cases on the one hand and mobilising corporates by pooling their CSR resources toward sustainability projects based on such use cases."

*Glimpses of technology exhibition and panel discussion during **RESOLVE** at IIC*

4.2

Shifting the sustainability paradigm at national platforms

DRIIV, the premier knowledge community of the nation is operating in a multi-stakeholder framework (industry/ academia/government bodies/startups) to forge a dynamic collaborative culture, neglected so far in the nation as a consequence of a truly competitive academic landscape. The cluster has built a network of c. 100+ (and counting..) cluster members, working collaboratively towards developing an interdisciplinary ecosystem critical to propelling India as an innovation leader. DRIIV's presence at various national platforms, from participating in interactive panel discussions on thematic areas in the spaces of renewable energy (**Renewable Energy India Expo**, **Launch of India Energy Green Hydrogen Council** etc.), smart cities (**Indo-German Forum on Sustainable Urban Mobility**), climate resilient growth (Round table on **Targeted Action for Air Quality Improvement using Real Time Source Apportionment Data**), to being technology partner for **Atal Harit Vidyut Rashtriya Mahamarg**, to mediating 'meaningful CSR engagements to strengthen Academia-Industry-Partnership', to sharing insights on Govt. and academia initiatives to promote SMEs and startups (**India First Tech-Startup Conlave**), is becoming increasingly prominent. These associations will not only accelerate technological progress without reinventing the wheel, but also help mobilise public/private funding enabling true innovations across disciplines.

4.3

Building international bridges by inter-cluster collaborations

Global problems require solutions that are only possible through cross-border collaborations. DRIIV offers an ideal platform for anchoring such **international collaborations** involving multiple stakeholders across countries. We have built deep cluster-to-cluster engagements with **Sweden** and have hosted several delegations, including delegates led by the DG of Trade, Swedish Ministry of Foreign Affairs, H'ble Per-Arne Hjelmborm and Head of Science and Innovation, Swedish embassy in India, Counsellor Per-Arne Wikström at the first edition of our annual flagship conference 'RESOLVE'. Alongside delegates from **CLEAN**, a Danish environmental cluster, European Clusters visiting under the **PERCY** (PolymER ReCYcling) Program, **Trilateral Commission and the Raisina Dialogues**, members from **Finnish Hydrogen Cluster** visited DRIIV with a shared hope and determination to leverage international innovation bridges to counter environmental menaces. Likewise, our delegates explored partnerships in healthcare, genomics and mobility during Sweden Innovation Days at **Lund University** in March this year. Similar engagements are progressing with **Poland, Germany and UK**, particularly in the areas of exchanging knowledge, technology scale up/co-creation etc. sustainable mobility and healthcare (esp. One Health) respectively.

5

DRIIV in the **News**

"Commitment to environment protection is something that should come from within... DRIIV has consciously chosen to work on National Missions, aligned with UNSDGs, for environmental and societal relevance. National Green Hydrogen Mission, Waste to Wealth Mission, One Health mission etc are such examples where DRIIV will be playing a crucial role in steering the right policy interventions... Our overarching aim is to create a thriving ecosystem, where industry-academia-government bodies work seamlessly and contribute to India's journey towards Atmanirbhar Bharat."

-Shipra Misra

THE TIMES OF INDIA
Bridging the void: Innovation from paper to people
February 14, 2023, 4:02 PM IST / Shipra Misra in Voices, India, TOI

THE TIMES OF INDIA
Can't recycle legacy waste? Now, a plan to turn it into hydrogen fuel in Gurugram
Ipsita Pati / TNN / Updated: Jan 8, 2023, 08:54 IST

THE NEW INDIAN
Permanent solution to Delhi pollution lies in shift to green energy: Official

THE TIMES OF INDIA
CSIR scientists develop tiles to pave roads using waste material

The Statesman
DRIIV & GMDA join hands to implement environmental sustainability initiatives

DRIIV & GMDA signs MoU to implement environmental sustainability initiatives
December 3, 2022

mint
'Can adapt our covid model to any infectious disease'
1 min read • 07 Dec 2022, 08:28 PM IST
Leslie D'Monte

Hindustan Times
In works: Sustainable solutions to address Delhi's crucial challenges
By Risha Chitlangia, New Delhi
Mar 14, 2022 12:06 AM IST

ThePrint
India on the Cusp of Entrepreneurial Revolution: Amarjit Bakshi

THE TIMES OF INDIA
It's so unique: These cars clean Delhi's air
A Delhi-based startup has developed mobile air filters to curb the pollution in the national capital
TNN / Last updated on - Mar 23, 2023, 14:50 IST

Hindustan Times
Outdoor purifiers to help assess Delhi's pollution load
By Jasjeev G
Mar 30, 2023 11:55 PM IST

The Statesman
DRIIV's AnnualConference RESOLVE- Rendering S&T Solutions for Atma-Nirbhar Bharat

BW BUSINESSWORLD
June 05, 2023
Environmental Issues Can't Be Solved Without Tech: Govt's Principal Scientific Adviser

United News of India
Need collective efforts to achieve environmental sustainability goals, says PSA Ajay Sood

THE ENVIRONMENT
Let's Save Climate
Technology cannot resolve environmental issues alone, need collective efforts, says PSA Ajay Sood

SME STREET — DRIIV's Annual Flagship Conference RESOLVE– Rendering S&T Solutions for AtmaNirbhar Bharat

THE TIMES OF INDIA — IIT-Delhi, central initiative try steps to curb pollution

ThePrint — Armed with science & tech solutions, govt & IIT-Delhi come together to fight air pollution

THE NEW INDIAN — DRIIV, IIT Delhi Join Hands To Tackle Air Pollution

shiksha — IIT Delhi, DRIIV collaborate to tackle air pollution in Delhi-NCR

FREE PRESS JOURNAL — IIT Delhi, DRIIV collaborate to control air-pollution levels in Delhi-NCR region

Doctors for Clean Air and Climate Action (Haryana Chapter) & City Action Group Gurugram launched

URBAN TRANSPORT NEWS — Tech for Circular Economy brings Delhi – Jaipur E-Highway Trial Run in September: NHEV

IIT-D likely to be House knowledge partner; keep MPs updated on 5G, climate

THE TIMES OF INDIA — EV-ready by March? Bus trial held on Delhi-Jaipur highway

6

Our People

Project Review & Monitoring Committee

The PRMC regularly engages with the Science and Technology Clusters to monitor their progress and steers them ahead.

Review & Advisory Committee

The RAC comprises of influential industry experts and government partners.

Board Members

This is the governing body of the section 8 company DRIIV Foundation which is the umbrella body of the Delhi Science and Technology Cluster.

DRIIV Core Team

Project Review & Monitoring Committee

Dr. Swati Basu
Scientific Consultant (Climate & Environmental Science) & Former Scientific Secretary, O/o the PSA to the GoI

Dr. Dinakar Kanjilal
DAE Raja Ramana Fellow & Former Director, Inter-University Accelerator Centre, (IUAC)

Prof. V Ramgopal Rao
Vice Chancellor, Birla Institute of Technology & Science, Pilani & Former Director, IIT Delhi

Prof. Anil K Gupta
CSIR Bhatnagar Fellow 2018-21, Founder Honey Bee Network, SRISTI, GIAN & NIF, Visiting Faculty, IIM A & IIT B and Academy Professor ACSIR

Shri Anand Nayak
Independent Director on Board of ITC Ltd. & Former Executive Vice President, Human Resources of ITC Limited

Prof. Kalpana Balakrishnan
Dean Research, Director, WHO Collaborating center for occupational & environmental Health, Chennai

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Dr. Arun Bhardwaj
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Review & Advisory Committee

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Hon. Distinguished Fellow & Former Scientific Secretary O/O PSA to the GoI

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Distinguished Chief Scientist TCS Research, TCS Ltd.

Dr. G U Kulkarni
President, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore

Dr. Jatinder Kaur Arora
Executive Director/Chief Executive Officer/Member Secretary Punjab State Council for S & T, Punjab Research & Innovation, Punjab Biodiversity Board

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Professor and Head, Dept. of Civil Engineering, Indian Institute of Technology Kanpur

Dr. Seema Kapoor
Professor, Department of Paediatrics Lok Nayak Hospital and MAMC, New Delhi

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Effective Education

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MVSV Sai
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Vanita
Sr. Manager, CSR & Partnerships

Ataur Rahman
IT Manager

Garima Joshi
Account Associate

Ujjwal Kochar
Project Attendant

7

DRIIV Ecosystem :
empowering S & T endeavours

DRIIV is a thriving ecosystem of c. 100 stakeholders which continues to grow and emerge as the nation's premium knowledge community. DRIIV's premier member base is comprised of renowned academic institutions of international repute like IIT Delhi, IIIT Delhi, AIIMS, JNU etc., R&D labs (CSIR NPL,IGIB etc.,) corporates (Renew Power, TATA PAWER, Edison Hub, etc.,), Govt. Agencies (MOHUA, MOFECC, MEITY, etc.,), philanthropic organisations/NGOs (LCF, IPS, etc.,) and other constituencies. It's startup community is growing fast and so is its incubator ecosystem. With such an enviable member base, DRIIV is making rapid strides in creating a vibrant S&T ecosystem and envisaging to replicate the success stories of international clusters in solving issues aligned with UN SDGs.

DRIIV Ecosystem

Team Members	Affiliation

I. Solid Waste Management

Team Members	Affiliation
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Prof. Virendra Kumar Vijay	IIT Delhi
Prof. Vivek Kumar	IIT Delhi
Prof. Priyanka Kaushal	IIT Delhi
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Prof. S K Singh	Delhi Technological University
Prof. Deepak Pant	Central University of Haryana
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Prof. Piyali Das	TERI-Delhi
Prof. R R Sonde	IIT Delhi
Prof S. Fatima	IIT Delhi
Prof. Siksha Khushwa	NSUT-Delhi

II. Water Security

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Prof. Manoj Khanna	ICAR-IARI
Prof. D K Singh	ICAR-IARI
Prof. A. Sarangi	ICAR-IARI
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Prof. Leena Nebhani	IIT Delhi
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III. Air Pollution

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Prof. Mayank Kumar	IIT Delhi
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Prof. S. Yadav	JNU, Delhi
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Prof. Sumit Sharma	TERI
Prof. Meena Sehgal	TERI
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Prof. Pratima Singh	CSTEP
Prof. Naveen Arora	CSIR-IGIB
Prof. Meghna Agarwala	Ashoka University
Prof. Vidhu Gupta	TERI
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IV. AI/ ML in Healthcare

Team Members	Affiliation
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Prof. Jayadeva	**IIT Delhi**
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Prof. Alok Bhattacharya	Ashoka University
Prof. Sundar	IIT Delhi
Prof. Kedar Khare	IIT Delhi
Prof. Ravikrishnan Elangovan	IIT Delhi
Prof. Ishaan Gupta	IIT Delhi
Prof. Vivekanandan Perumal	IIT Delhi
Prof. G. P. S. Raghava	IIT Delhi
Prof. Gaurav Ahuja	IIIT Delhi
Prof. Debarka Sengupta	IIIT Delhi
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Prof. Debasis Dash	CSIR-IGIB
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Prof. Shandar Ahmad	JNU
Prof. Raghava Mutharaju	IIIT Delhi
Prof. Ponnurangam K	IIIT Hyderabad
Prof. Suneel Kateriya	JNU
Prof. A. P. Pratosh	IIT Delhi
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Prof. Amit Mehndiratta	IIT Delhi

Team Members	Affiliation

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Prof. Geetam Tiwari	IIT Delhi
Prof. K. Ramachandra Rao	IIT Delhi
Prof. Manoj M.	IIT Delhi
Prof. A Choudhary	JNU
Ms. Roli Agarwal	Google Research India
Prof. Vikas Kumar	DMRC Ltd.
Mr. Arnab Biswas	Innovant Infocom Pvt. Ltd.

VI. E-Mobility

Team Members	Affiliation
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Ms. Ashu Verma	IIT Delhi
Prof. M. K. S. Verma	IIT Delhi
Prof. Rajesh Kumar	MNIT, Jaipur
Prof. R. R. Sonde	IIT Delhi

VII. Effective Education

Team Members	Affiliation
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Prof. Jayshree Oza	Central Square Foundation
Prof. Beena Pillai	CSIR-IGIB
Prof. (Ms.) P. Hemalatha Reddy	Delhi University
Prof. Simona Sawhney	IIT Delhi
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Startup Community

Name	Designation	Startup
Dr. Akshay V Singhal	CEO & Founder	Log9 Material Scientific
Mr. Rajeev Chanan	Director	Umeandus Technologies
Mr. Rupesh Kumar	CEO	EVI Technologies
Prof. Neeta Doshi	Director	Ominiion Technologies
Mr. Anil G. Mathews	MD	Indus Scientific
Mr. Priyans Murarka	COO	Pirhoalpha Research
Mr. Ravi Kaushik	CEO	Airth Research
Dr. Pooja Goswami	Director	Ramja Genosensor
Mr. Andrews G Stephens	Director	MongoDB Software
Mr. Sushant Pattnaik	CEO & Director	Cappatery
Mr. Abhinav Gupta	CEO	Active Buildings Solutions
Ms. Akanksha Priyadarshini	CEO & Co-Founder	Aurassure Technologies
Dr. Deepak Goyal	Director	Avyatha Medical Research
Mr. Vignesh Kaneria	CEO & Co-Founder	Jal Technologies
Dr. Narendra K Teotia	Co-Founder	Innotekverse
Mr. Abhay Oswal	CEO & Co-Founder	Slic NextGen Batteries
Mr. Amit Bhatnagar	MD & Founder	ShudhVayu Technologies
Mr. Raghuvansh Saxena	CEO	Earthwatch Institute
Mr. Karan Rao	CEO & Founder	Suave Agro Tech
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