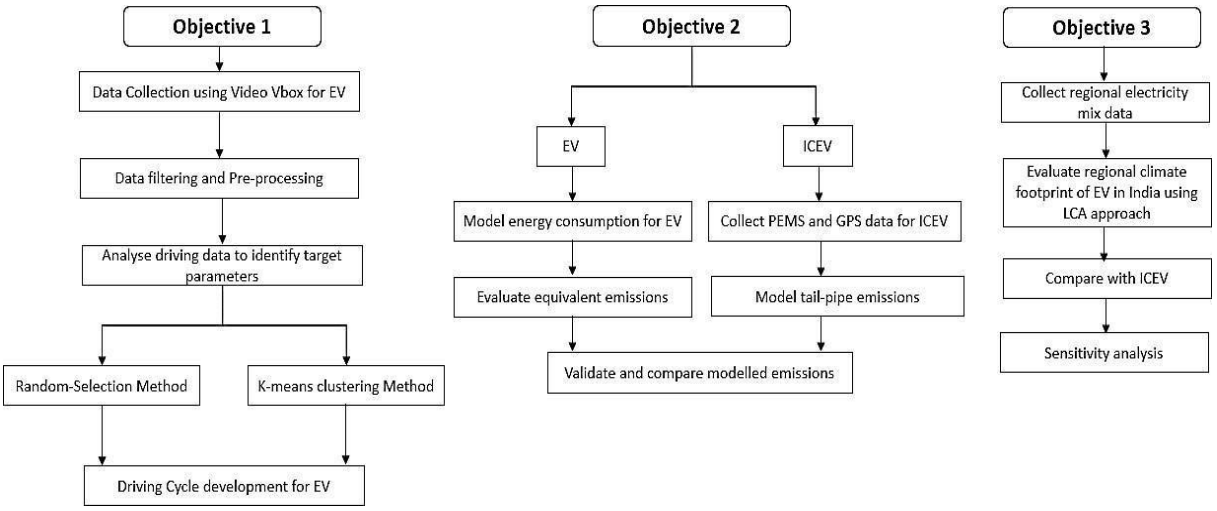
1. **Title of the Project** – Emission Reduction and Energy economy by electric vehicle on Indian Roads- Driving cycle-based study
2. **PI details with Dept and Designation** –

   Dr. Pritha Chatterjee, Assistant Professor, Department of Civil Engineering, Head, Department of Climate Change

   Dr. Digvijay S. Pawar, Associate Professor, Department of Civil Engineering
3. **Origin /Background Problem** – The transportation industry has significantly contributed to the deterioration of air quality and the increase in greenhouse gas emissions (Dharmala et al., 2022). Electrification of the transportation sector can contribute to climate mitigation, reduce air pollution, and advance global climate goals (Shafique et al., 2022). Electric vehicles (EVs) offer a promising alternative, but their integration into the Indian traffic environment requires a tailored understanding of their performance and environmental impact (Moreira et al., 2022). A comprehensive emission modelling approach, considering factors such as vehicle characteristics, traffic characteristics and driving behaviour, can provide valuable insights into the environmental performance of vehicles (Chandrashekhar et al., 2022). In the context of India, a rapidly developing nation, the need to address the environmental challenges posed by transportation is paramount. The Indian traffic environment has unique characteristics, including congested road networks, diverse driving patterns, and varying climatic conditions across regions. Thus, it is essential to develop models specifically tailored for EVs in the Indian context to accurately capture the real-world driving behaviour and traffic conditions. Additionally, assessing the emissions of EVs based on a refined driving cycle, coupled with the regional electricity mix and climate data, enables a comprehensive evaluation of their contribution to regional climate change mitigation efforts.
4. **Aim and Objectives** –
   - To analyze and develop driving cycles for two-wheeler and four-wheeler battery electric vehicles in Indian road conditions
   - To model electric vehicle energy consumption and equivalent emissions from the developed driving cycle and tail-pipe emissions from ICEV
   - To evaluate the life-cycle carbon footprint of electric vehicles in India considering electricity generation sources and regional climate conditions
5. **Current Status of your work (including TRL)** – Significant progress has been achieved in the development of representative driving cycle for electric vehicles (EVs) in the dynamic Indian traffic environment and modelling the emissions for internal combustion engine vehicles (ICEVs), reaching a Technology Readiness Level of TRL 4.
6. **Proposed Work** –



7. **Thematic areas covered under SDGs**– The research aligns with SDGs 7 (Affordable and Clean Energy), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), 12 (Responsible Consumption and Production), 13 (Climate Action), and 17 (Partnerships for the Goals). It estimates EV energy consumption and emissions (SDG 7), supports sustainable urban mobility (SDG 9 and 11), addresses environmental impact (SDG 12 and 13), and fosters collaborations for sustainable transportation (SDG 17).

8. **Budget Details**

Item	1st year	2nd year	3rd year	
Data Collection	150000	100000		
Personnel (1 JRF for one year to do data collection, we will use existing students for the rest of the work)	492000			
Digital Multimeter	120000			
Portable Flue Gas Analyzer	350000			
Software (LCA)	200000			
Contingency	50000	50000	50000	
Consumables	50000	50000		
Total	1412000	200000	50000	1662000

9. **Social Impact (*Qualitative and Quantitative*)** – This research work will bring qualitative impacts by promoting sustainable transportation and societal behaviour change. It also delivers quantitative benefits through climate change mitigation, emissions reductions, health cost savings, empowering individuals and policymakers, and contributing to a sustainable and healthier future.

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1. **Title of the Project** – Recycling Fiber Reinforced Polymer (FRP) Waste for Infrastructure Use

2. **PI details with Dept and Designation** –

   Dr. Anil Agarwal, Associate Professor, Dept. of Civil Engineering (Structural Engineering)

3. **Origin /Background Problem** –

   Fiber reinforced polymers have become an integral part of our daily lives. FRP is being used extensively in automobiles, airplanes, wind turbines, and to a lesser extent, in infrastructure applications. A large number of wind turbines are being decommissioned in the recent days as they have started reaching the end of their service lives. More are likely to reach the end of their service lives as there is a constant push to install larger wind farms with bigger wind turbines. Similarly, modern cars and airplanes use a large amount of FRPs. After the completion of the service life, disposing the GFRP (glass fiber reinforced polymer) blades of these wind turbines in an environmentally responsible way is a major challenge. The use of plastics in these composites makes them unsuitable for landfill. It is proposed to study the possibility of recycling used FRP components in infrastructure applications such as reinforcement in concrete structures.

4. **Aim and Objectives** –

   The proposed project aims to study the feasibility of recycling GFRP composites in infrastructure applications. The proposed research will involve:

   - Developing a method to characterize the residual strength and service life of the salvaged FRP material.
   - Developing the technique to allow the recycled material to act as reinforcement in concrete structures.
   - Developing guidelines for using the recycled material as internal reinforcement in RC members.

5. **Current Status of your work (including TRL)** –

   A pilot study has been conducted to evaluate the bond behaviour of salvaged FRP material with concrete. The current TRL level is 2.0.

6. **Proposed Work** –

   The following methodology will be employed to reach the above objectives:
   - In collaboration with one of the industries mentioned above, used FRP components will be salvaged.
   - The salvaged components will be cut in shapes and sizes that makes them suitable for use as a reinforcement material in concrete structures.
   - These parts will be characterized for mechanical properties such as strength and stiffness, and remaining service life characteristics through fatigue tests to assess their suitability in infrastructure applications.
   - These components will then be embedded into concrete components as a reinforcement material and the strength of these reinforced concrete members will be tested in compression and bending.

7. **Thematic areas covered under SDGs** ***(Please mention SDGs separated by comma)*** –

Responsible Consumption and Production, Sustainable Cities and Communities, Life on Land.

8. **Budget Details** (***Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

	Year 1	Year 2	Year3
Budget (in Rs lakhs)	10,00,000	10,00,000	10,00,000
Milestones	1. Identifying the FRP component to be salvaged in collaboration with the partnering industry. 2. Studying the material characteristics and remaining service life of the salvaged material. 3. Shaping the component in a suitable way to be used as internal reinforcement.	1. Testing the recycled material for available strength, stiffness, bond strength, and fatigue life. 2. Preparing the concrete specimens and studying the behaviour of the reinforced concrete system in compression and flexure.	1. Testing the recycled FRP bars for bond with concrete. 2. Testing the RC members in compression, bending, and fatigue life. 3. Development of the guidelines for use of recycled FRP as rebars in concrete.

9. **Social Impact (*Qualitative and Quantitative*)** -

The outcome of the research will help keep the polluting plastics away from landfills. The users of the FRP components such as wind farm owners, automobile industry, etc. will be the direct beneficiaries of this research.

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Indian Institute of Technology Hyderabad

Title: Development of Sustainable Dual-Ion Energy Storage Devices

2. PI details

Dr. Narendra Kurra
Assistant Professor, Department of Chemistry
Indian Institute of technology Hyderabad
Kandi, Sangareddy-502284
Telangana State, India
Email: narendra@chy.iith.ac.in

3. Origin/Background Problem

The present global energy requirements are highly dependent on the fossil fuels which are non-sustainable and causing harmful effects to humankind. Due to intermittency and geographical dependence, the success of renewable energy resources (solar, wind and thermal) is primarily impacted by the development of efficient energy storage solutions.[1] Matured lithium-ion batteries (LIBs) are the key technologies for portable electronics market and there is a huge demand for electrification in transportation and grid scale sectors.[2] The ever-increasing energy demands in various **energy sectors pose a challenge on insufficient supply of lithium reserves and materials availability worldwide.** Since energy density is a product of capacity and voltage window, exploitation of high-capacity materials and unlocking the high voltage window operation of electrode/electrolyte interface are the two key directions. Beyond Li-ion chemistries led to exploration of multivalent metal-ion chemistries with the earth-abundant charge carriers such as Mg, Zn, Al and Ca. Multi electron transfer across electrode/electrolyte interfaces signifies the theoretical feasibility of higher charge storage capacities over monovalent metal ions.[3] However, in practical perspective, the high charge density nature of charge carriers not only have strong affinity with its counter-anions within the electrolyte but also suffer from the sluggish diffusion kinetics across the solid charge storage hosts.

Dual-ion batteries show promise as sustainable technologies and better alternatives to Li-ion batteries due to wide availability of materials (typically, carbon) in the earth crust besides safety.[4] Dual-ion batteries (DIBs) offer higher voltage window of operation over LIBs, thus possibly improving the energy density. Moreover, safe, and environmentally benign operation with wide availability of materials and low cost make DIB attractive over LIB.[4] Since anion (de)intercalation happens across positive electrodes at high anodic potentials (>4.5 V vs. Li/Li^+), large voltage window of operation is guaranteed. However, the robustness of the electrode materials and electrochemical stability of electrolytes must be needed towards the design of sustainable dual-ion energy storage devices.[5]

4. Aim and Objectives

- Development of laser-derived expanded graphitic materials and their modifications towards developing high-rate Dual-ion batteries and hybrid metal-ion capacitors
- Optimization of carbon precursor composition and laser parameters towards controlling the structure and surface chemistry of expanded graphitic carbons
- Development of electrolyte formulations for high voltage operation
- prototype demonstration of dual-ion batteries and capacitors using laser derived graphitic electrodes.

5. Current Status of your work (including TRL) We have employed a variety of precursors such as commercial polymers and synthetic polymers and transformed them into graphitic carbons. We have demonstrated prototype sodium batteries.[3] It is currently at TRL-3 level. We would like to further progress with support to demonstrate the long- lasting sodium-ion based energy storage devices where conventional graphite may not work well.

6. Proposed work

Laser Derived Graphitic carbon host for anion intercalation

Graphitic carbons are known to exhibit redox amphoteric characteristics (capable of intercalating cations and anions at cathodic and anodic potentials, respectively) but their narrow interlayer spacing (3.35 Å) may not be suitable for the insertion of polyatomic large anionic species ($AlCl_4^-$, BF_4^-, PF_6^-). Volumetric changes during charge/discharge would limit the cycling stability, hence it is required to enlarge interlayer spacing for high degree of reversibility. **I propose to develop laser derived graphitic (LDG) carbon** electrodes for electrochemical storage of metal cations as well as anions.

Prototype Device demonstration. Optimized electrode| electrolyte combinations will be employed in demonstration of protype dual-ion batteries and/-or hybrid capacitors and evaluate their electrochemical performance with respect to the state-of-the-art. Due to scalability of the laser manufacturing process and highly abundant nature of Na-, Zn- and Mg-ions; these technologies would turn out to be alternatives to LIBs and moreover sustainable in nature

7. **Thematic areas covered under SDGs**: SDG 7 and SDG 13

8. Budget Details

	Year 1	Year 2	Year3
Budget (in Rs lakhs) (minor equipment/consumables)	10	3	3

9. <u>Social Impact (*Qualitative and Quantitative*)</u> -

Sodium, Zinc, and Magnesium is highly abundant in nature unlike the case of Lithium. Sustainable battery technologies beyond Lithium-ion batteries are much needed at this moment. As electrification is being pursed in transportation and grid storage sectors, it is the right time that we put efforts to develop indigenous technologies that are sustainable and serve the society in a big way. The goal is to build “fossil-fuel free society”, which not only benefits the human health in specific and our planet overall. Such kind of efforts also greatly benefit the future generation by keeping the planet clean and green.

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1. **Title of the Project** - A Real-time Urban Flood Information System for the city Hyderabad

2. **PI details with Dept and Designation** – Dr. Satish Regonda, Associate Professor, Department of

   Civil Engineering and Department of Climate Change

3. **Origin /Background Problem** – Many cities come to a standstill when there is rain, and Hyderabad is no exception for most of the time. In addition, oftentimes, the cities experience heavy rainfall, consequently flooding which results in significant human losses and huge property losses disrupting economic activity in great amounts. While the former scenario can be dealt with good coordination among traffic and disaster management personnel with real-time rainfall information, the second scenario, which is of a much larger order problem, clearly highlights having a system that provides both rainfall and flood inundation information in real time as well as in advance. The India Meteorology Department (IMD) Hyderabad has been providing rainfall information from its weather radar and other meteorological products. Similarly, Telangana Stage Development Planning and Society (TSDPS) hourly rainfall data provides information during and after the rains. Both resources have been helpful in several aspects, but do not provide reliable information on flooded areas either at current or future times. In that way, the city currently lacks a flood information system, which further emphasizes the need to develop a system for the city Hyderabad. Also, the October 2020 catastrophic floods which incurred significant losses, recent floods in the October 2021 which resulted in knee-to-waist height flood waters and projected urban climate changes in combination with rapid haphazard expansion of the urban areas with poorly maintained data further stresses the importance of developing a real-time flood information system for the city Hyderabad.

4. **Aim and Objectives** – Develop an urban flood information system that monitors urban flood relevant information, models including forecasting, develops products as per city's needs and allows to disseminate information in different types. The proposed system is envisaged as a combination of several components including *data collection* of several variables relevant to weather, hydrology, drainage, topography, etc., *data analysis, modelling* of various processes, *nowcasting and forecasting* of various variables, e.g., rain, runoff and temperature, *data products generation* such as flood inundation maps, *data communication* and *active involvement* of decision makers of different levels including the general public. Further, the proposed system enables to draft resilient strategies so that the city and its society becomes climate and flood resilient.

5. **Current Status of your work (including TRL)** – Our research efforts over the past

several years improved our clarity on the complexity and associated challenges of the proposed flood information system for the city of Hyderabad. Our analysis of city's hourly rainfall over the recent years provided insights on city's rainfall characteristics, for example, the rain in the city, on the average, does not go beyond six hours. Further, analysis of rainfall with respect to synoptic circulation patterns provided dominant mechanism that results in floods. In the process, we developed a flood inventory for the city as well. We also explored possibility of using satellite, radar- and instruments- based rainfall data. Machine learning techniques such as Self Organizing Maps (SOMs) are employed, and new data collection techniques including twitter- and newspaper- based methods are developed. We are in the process of identifying potential hydrologic- and hydraulic- models that are core of the proposed system. Importantly, we established connections with various government agencies such as city's enforcement vigilance and disaster management (EVDM) wing, TSDPS, IMD Hyderabad and National Remote Sensing Centre (NRSC). The mentioned agencies are potential stake holders developing a near real time flood forecasting system, therefore, the measures are taken to have active collaborators involving them in the proposed work.

6. **Proposed Work** – Broadly, tasks of the proposed work are relevant to data collection, data analysis, modelling and forecasting techniques, data products generation and data dissemination. The tasks include installation of weather and hydrologic relevant instruments, drone-, LiDAR-, model-, satellite- and weather radar- based data collection, development of hybrid methodologies combining AI/ML methods with physically based traditional models, development of software platform for digital twin, series of half-day workshops with multiple stake holders to identify products and strategies to disseminate information.

7. **Thematic areas covered under SDGs –** SDG 6 - Clean Water and Sanitation, SDG 9 - Industry, Innovation and Infrastructure, SDG 11 - Sustainable Cities and Communities, SDG 13 - Climate Action

8. **Budget Details (*Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.* –** Understanding that firms like to involve in different stages, I prefer to talk with the firms that have interesting in funding this type of work. We can prioritize the tasks starting from 25 lakhs and much more.

9. **Social Impact (*Qualitative and Quantitative*)** - The proposed flood information system provides information of various aspects, for example, it assists traffic police and disaster

management personnel in their effective deployment of resources so that the city runs with reduced damages. Not only that, with the reliable information available, the public takes appropriate action reducing health risks, human and property losses, whereas the officials take measures reducing infrastructure losses. Thus, the urban flood information system benefits not only citizens including commuters, shopkeepers and residents but also government administrators in flood mitigation efforts. Also, over a long run, the benefits that achieved are much greater than the finance losses incurred by the flood damages, particularly in the context of climate change which attributed to rains of increased intensities. At the end, importantly, as the city Hyderabad is going to become one of the mega cities across the world, therefore, the proposed system may yield benefits of different types and large in nature.

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1. **Title of the Project** – AI empowered IoT enabled wearable lead-less system for 24x7 Cardio-pulmonary Disease and Sleep Disorders Monitoring and Management
2. **PI details with Dept and Designation** –

PI Name: Dr. Amit Acharyya

Designation: Professor

Department: Department of Electrical Engineering, Indian Institute of Technology, Hyderabad

3. **Origin /Background Problem** –

OSA and cardiopulmonary diseases become a serious health concern due to high prevalence and mortality rate worldwide. Technological advancements cannot reduce the number of prevalence due to the lack of proper healthcare facilities, delayed diagnosis, and unavailability of reliable diagnostic modules. Conventionally these diseases can be interpreted by patient's airflow, SpO_2, ECG, EEG, and EMG and regular monitoring of parameters like heart rate, respiration rate, blood pressure, SpO_2, stress level, and blood sugar level. All these require several leads and device attachment to patient's body which is extremely uncomfortable, intrusive and unsuitable for long-term continuous and ambulatory monitoring.

4. **Aim and Objectives** –

The aim and objectives of the proposed work are-

i) Development of smart IoT based lead-less and patch-less wearable band device for cardiopulmonary (CPD) and OSA detection
ii) Derivation of new benchmark features for CPD and OSA from PPG signal
iii) Development of continuous remote health monitoring device for early identification of CPD and OSA
iv) Simultaneous monitoring of HR, RR, BP, SpO_2, blood glucose level from PPG using AI based framework
v) Extraction of single lead to 12 lead ECG from PPG for cardiac monitoring using lead-less and patch-less wearable band device only

5. **Current Status of your work (including TRL)** –

The proposed methodology consists of two main parts- i) Extraction of 12 lead ECG and other vital parameters from PPG, ii) Identification and classification of cardiopulmonary diseases and OSA. Our R&D has already developed phase space reconstruction-based CVD classifier that classifies six different CVDs (AF, MI, BBB, cardiomyopathy, dysrhythmia, and hypertrophy). Recently, our R&D demonstrated an efficient deep learning model (PP-Net) to estimate HR, systolic and diastolic BP simultaneously from PPG signal. This is further extended to simultaneous estimation of HR, RR, BP and ECG reconstruction from PPG. The estimation of other parameters, and the development of the wearable device is under process. All the research works of PI since the last 10 years, push the technology readiness level (TRL) from level 1 to level 5. It is expected that the proposed project on AI empowered IoT based smart system development for OSA and CPD detection will push the current TRL to level 8.

6. Proposed Work

In this work, an AI empowered, IoT enabled PPG-based wearable monitoring system is proposed for cardiopulmonary and OSA disease detection. The wire-less, patch-less device for PPG acquisition ensures patient comfort and is suitable for ambulatory and long-term monitoring. PPG will be further processed in cloud and identification of those diseases will be done using the cloud-based AI engine for reducing hardware complexity and cost of the proposed device. The outcome will be converted into an assistive report and end user can access it securely from cloud. We have also planned to use our own indigenous chip that can be used inside the proposed device for extracting vital parameters even in offline mode where internet facility is unavailable. The vital parameters will be used for primary monitoring of health condition of patients and abnormalities in those parameters might be used to identify onset of any serious instability of internal condition.

7. Thematic areas covered under SDGs –

Good Health and well being (SDG 3)

8. Budget Details (*Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.*

Non-recurring Component	Year 1	Year 2	Year 3	Total A
Equipment				
1. Bio-signal acquisition device (PPG, EEG, ECG, GSR, Respiration) comprising of sensor, amplifier, and allied electronics	1300000.00			1600000.00
2. Embedded system for prototyping and validation	300000.00	-	-	

Recurring Component	Year 1	Year 2	Year 3	Total
Human Resources	1324320	1324320	1324320	3972960
Consumables	300000	300000	300000	900000
Field trial	50000	100000	100000	250000
Contingency	350000	350000	350000	1050000
Travel	50000	60000	75000	185000
Total (B)	**2074320**	**2134320**	**2149320**	**6357960**

Total Budget (A+B) = Rs. 7957960.00

9. Social Impact (*Qualitative and Quantitative*) -

- Focus on developing unobtrusive wireless monitoring system improves overall disease management and support to healthy lifestyle.
- Access of medical assessment via cloud anywhere and anytime will increase the reachability of doctors to a greater number of patients.
- Develop novel medical service models to support transferability of healthcare outside hospitals.
- Reinforced leadership and innovation capability of the industry in the area of personal health system, wearable medical devices, and services through introduction of new business models, creation of spin-offs and better exploitation of intellectual property contributing to products, standards and regulation

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1. **Title of the Project** – Identifying and Quantifying Pharmaceutically Active Compounds and other Micropollutants Present in Surface and Groundwater Resources near the Industrial Areas of Hyderabad
2. **PI details with Dept and Designation** – Dr. Debraj Bhattacharyya, Associate Professor, Department of Civil Engineering, IIT Hyderabad
3. **Origin /Background Problem** – Hyderabad is one of the largest hubs of generic drugs in the world. A series of chemical reactions occur in the drug manufacturing process resulting in the formation of wastewater containing Pharmaceutically Active Compounds (PhACs). Due to the persistent nature of the contaminants and poor wastewater treatment infrastructure and practices, PhACs end up in receiving waterbodies and eventually contaminate the surface and groundwater resources. This causes in health hazards to humans and aquatic life forms and also results in the development of antimicrobial resistance bacteria (ARB) and antibiotic resistance genes (ARG). It is important to identify and quantify the PhACs and other micropollutants in water resources so that an effective mitigation strategy can be developed.
4. **Aim and Objectives** – The goal of this research is to develop a database of PhACs and other micropollutants present in the surface and groundwater resources near the industrial areas of Hyderabad and present the findings to the regulatory bodies, technology providers, generators of the pollutants and other stakeholders with an aim to – (a) create public awareness regarding the danger posed by these anthropogenic chemicals, (b) motivate research to develop technologies to effectively remove these pollutants from industrial effluents, and (c) assist in developing mitigation strategies including waste minimization at the source, and (d) help in developing regulations in order to minimize environmental health hazards.
5. **Current Status of your work (including TRL)** – One M. Tech student has been working on identifying PhACs in different stretches of river Musi which is heavily contaminated with industrial effluents. Another MTech student is trying to identify the same in a sewage treatment plant. Several

micropollutants have been identified. However, in order to suitably address this environmental and health menace, it is essential to include more number of sites and extend the period of the research to at least three more years in order to capture the spatiotemporal variation of the pollutants.

6. **Proposed Work** – Adequate number of surface and groundwater sources will be selected in the Pashamylaram, Patancheru and Bollaram industrial area after discussing with the local people. Samples will be collected every month from the selected sites over a span of three years and micropollutants will be identified and quantified using HRMS and other state-of-the-art facilities available at IIT Hyderabad. Samples will also be outsourced to commercial laboratories for studying antibiotic-resistant genes and microorganisms. Data will be carefully preserved interpreted and presented in a suitable format in the form of a report to the stakeholders. A project fellow will be hired for sample collection and sample analysis. The data analysis will be done by the PI and other research scholars of the group.
7. **Thematic areas covered under SDGs** – Goal 6: Clean water and sanitation.
8. **Budget Details** – IIT Hyderabad has adequate research facility and state-of-the-art research equipment

   to carry-out most part of this research. However, for analysis related to microbiology some samples will be outsourced. Here, we seek funds only for manpower and recurring expenses.

Head	Year 1	Year 2	Year 3
Manpower (@ Rs. 30,000 per month)	360000	360000	360000
Non-recurring expenses (consumables, outsourcing, travel to sites, and contingency)	640000	640000	640000
Total	**1000000**	**1000000**	**1000000**

9. **Social Impact (*Qualitative and Quantitative*)** – This research aims at addressing a socially relevant

   issue. The impact of this research has been already mentioned under section 4 (Aims and Objectives) of the proposal.

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1. **Title of the Project** –

   Investigating the State of the regional AI Ecosystem for sustainable development

2. **PI details with Dept and Designation** –

PI: Lohithaksha Maniraj Maiyar, Co-PI : Dr. Nakul Parameswar, Co-PI : Dr. M. P. Ganesh

3. **Origin /Background Problem**

   Adoption of Artificial Intelligence (AI) based approaches in different areas (mobility, healthcare, law, agriculture, governance) requires a strong collaborative effort between research institutions, deeptech solution providers, trained manpower and proactive leadership which when comprehensively considered can be visualized as important elements of a larger AI ecosystem. Adoption of AI in these areas has been foreseen to bring significant value to all the stakeholders involved. The Government of Telangana aims to make Hyderabad as one amongst the Top 25 Global AI Innovation Hubs and had declared 2020 as the "Year of AI" to provide impetus to develop the ecosystem to achieve this objective (T-AIM, 2022). There is a growing need of industry to match with sustainability goals and requirements set by national and international organisations. A thorough and integrated functioning of AI systems is necessary to propel the execution of sustainable development goals towards building a eco-friendly and socially aware organisation.

4. **Aim and Objectives** –

The specific objectives of the study are as follows

1) Evaluate the constituents of regional AI ecosystem and understand the contribution of each constituent in strengthening the AI ecosystem for sustainable development considering Telangana state
2) Understand the impact of the existing AI supported state initiatives on key stakeholders for promoting sustainability and suggest ways to improve their experiences.
3) Study sectors who have adopted AI technology in Telangana state vis - a - vis other states (Tamil nadu, Maharashtra, Delhi and West Bengal) and suggest measures for further enhancing the use of AI in those sectors for improving sustainability.
4) Undertake a SWOT analysis to evaluate the existing AI ecosystem of the state to build eco-friendly and socially aware businesses and suggest strategies for utilizing strengths to capture opportunities and deal with threats, overcome weaknesses to capture opportunities and minimize threats.
5) Suggest measures of improving the overall AI ecosystem for driving sustainability in Telangana with emphasis on inclusion of institutions, startups, entrepreneurs from Tier II and Tier III locations.

5. **Proposed Work** –

   Secondary data from various government records will help us understand the current state and strategies used in implementation of AI in the state of Telangana and identify the sources of primary data for this study. Primary data collection using field visits, surveys and focus group interviews would help the researchers understand the perspectives and experiences of the key stakeholders. Based on the insights from the field visits, surveys will be conducted with primary consumers which

will help us quantify both the positive impact and pain points of the AI experience. Focus group interviews with key stakeholders like government officials, policy makers, representatives of interest groups and technocrats will help us bring in rich data which can be used in opportunity recognition, future policy making and inclusive implementation of AI in various possible areas for the larger social good.

6. Thematic areas covered under SDGs –

The proposed idea of the proposal aligns with the 9th, 11th and 12th United Nations Sustainable development goals.

7. Budget Details

Head	Sub Head	Number of Personnel	Salary Per Month Per Person	Number of Months	Total (Rs.)
Man power	Research Assistants	3	35000	12	12,60,000
Travel, Accommodation and Food	Local Travel				1,00,000
	Accommodation and Food				1,00,000
Data Entry, Processing and Publication Charges					1,50,000
Computer and Software					1,50,000
Stationary and Consumables					1,00,000
Contingency					1,00,000
Total Without Institute Overheads					**19,60,000**

8. **Social Impact (*Qualitative and Quantitative*)** -

With the ever growing interest in AI, the adoption and utilization of AI across different domains have been on the rise. However, Governement and Non Government entities have no clue on whether these efforts are contributing to upliftment of societal living. This study has a direct impact on the social well-being of the various stakeholders of the AI ecosystem as identified by the objectives of the study. This will be evaluated by considering and studying socially relevant variables and constructs such as social inclusion, employee overtime reduction, and behavioural changes that contribute to social development. Further, the analysis shall lead policy decisions to be prudent and increase the chances of the investments to gain appropriate socially driven outcomes.

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Indian Institute of Technology Hyderabad

1. **Title of the Project** – Artificial intelligence based assistive technology for visually impaired

2. **PI details with Dept and Designation** –

Dr. Srijith P. K. (PI), Associate Professor, Computer Science and Engineering, IIT Hyderabad
Dr. Maunendra Desarkar (Co-PI), Associate Professor, Computer Science and Engineering, IIT Hyderabad.

3. **Origin /Background Problem** –

More than 300M people in the world have visual impairments. It's important to develop cost-effective technologies which will assist their mobility and consequently improve their quality of life. Assistive Technology for visually impaired people to guide them to travel in different environments including indoor and outdoor. We are proposing a Mobile based Assistive Technology using Artificial intelligence. Existing assistive technologies require online volunteers, and/or external hardware. The proposed system provide assistance without requiring these and only requires a regular smartphone. The proposed system combines various machine learning and deep learning techniques for computer vision (CV) and natural language processing (NLP) to enhance the efficiency and accuracy of the mobility tasks in both indoor and outdoor environments.

4. **Aim and Objectives** –

The key aspect of the technology is the ability to process the information about the world in the form of images and convert it into natural language of the user's choice, enabling intuitive communication between the world and the visually-impaired person. We aim to develop light weight object detection models for aiding the mobility of users and image captioning models to understand the environment round them. We make use of the latest deep learning algorithms and bring advances in the field of vision and language such as object detection and image captioning, to help us to develop such assistive technologies. We aim them to be deployed in memory limited mobile devices which will aid in developing a cost effective assistive system. We also plan to make the system useful for Indian users by providing Indian language specific instructions and descriptions.

5. **Current Status of your work (including TRL)** –

Our technology will consist of two components: describing the scene in natural language and converting it into speech in real time, and an object detection system that would detect all kinds of objects in front of the user and tell them about their location and instruct the user to navigate/move accordingly. Currently we are working on the object detection part, aiming to make them useful for navigation in the IITH campus environment. Currently, we are in TRL level 1.

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6. **Proposed Work** – The proposed system consists of the following subsystem/components. The duration of the project is for 3 years. We aim to develop the system over a period of 2 years (indoor navigation in 1st year and outdoor navigation in second year) and then refine and fine tune the systems in the third year. We aim to bring algorithmic advancements in the area sof object detection, image captioning , depth estimation etc. We also aim to develop data sets specific to Indian setting for training the models.

a. Object Recognition: We plan to use lighter version of YOLO(You Only Look Once), and Tiny YOLO. Apply quantisation and network pruning on Region-based Convolutional Neural Networks (R-CNN), Faster R-CNN etc. without compromising the accuracy.
b. Depth estimation: For the depth estimation use lightweight models for Monocular Depth estimation like Edge Guided Depth Estimation Network (EGD-Net) and use LiDAR sensors when available in smartphones (Iphone 12&+)
c. Image captioning: Generating the lighter models of Neural Image Captioning and Diffusion models like ControlNet then check accuracy with BLEU (BiLingual Evaluation Understudy- is a metric for automatically evaluating machine-translated text)
d. Speech Recognition and speech generation in Indian languages.

6. **Thematic areas covered under SDGs** ***(Please mention SDGs separated by comma)*** –

SGD 3 - Good Health and Well-being, SGD 10 - Reduced Inequality

7. **Budget Details** **(*Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

	Year 1	Year 2	Year 3	subtotal
Manpower (2 JRF/SRF)	967200	967200	1092000	3026400
Equipment	1500000	0	0	1500000
consumable	25000	25000	25000	75000
Contingency	100000	100000	100000	300000
travel	150000	150000	150000	450000
subtotal	2742200	1242200	1367000	5351400

8. **Social Impact (*Qualitative and Quantitative*)** -

- According to WHO around 246 million people are blind, and the majority (about 80%) live in low-income countries, Because of that people can't afford Assistive Technology for Mobility Aid.
- Our main USP's are
  - Accessibility: Our solution can be used in both Indoor as well as outdoor.
  - Avoidance of Social stigma: There may be stigma surrounding the use of mobility aids
  - Can easily used by any user with a smartphone
  - Specific to Indian setting and languages
  - Works without internet
- **Commercialization** : Provide subscription based service to the end user. The current market size of the mobility assistance is around USD 3.9 billion and we expect it to become 13.2 billion by 2030

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1. **Title of the Project** –

   Assessing the Efficacy of Different Approaches of ***Social Venture Capital*** in Driving ***Social Entrepreneurship*** and Sustainable Development

2. **PI details with Dept and Designation** –

   Dr. Ranapratap Maradana, Assistant Professor, Dept. of Entrepreneurship and Management.

3. **Origin /Background Problem** –

   In recent years, social venture capital (SVC) has emerged as a significant strategy for tackling social and environmental issues. It combines the principles of venture capital investment with a mission-driven focus on generating financial returns and seeing a positive social impact (Nicholls,2008). Social venture capital plays a vital role in supporting social entrepreneurship initiatives that address social and environmental challenges while trying to achieve sustainable development goals.

   Many entrepreneurs and business investors in India are still not fully aware of the concept of SVCs. There is a need for increased awareness and education about social venture capital and its vital role in attracting more entrepreneurs and investors to the sector. Assessing and measuring the social impact of social ventures can be complex and challenging. Establishing standardised metrics and methodologies for measuring social impact is crucial for building credibility and attracting investment in the SVC sector. The regulatory framework for SVC in India can also be complex and not always conducive to social entrepreneurship. Simplifying regulations and creating a supportive policy environment can help foster the growth of SVC and create an enabling ecosystem for social enterprises.

4. **Aim and Objectives** –

   This research proposal aims to explore the influence of social venture capital (SVC) on social entrepreneurship and its role in fostering sustainable development. By analysing the interaction between SVC and social entrepreneurship, this study aims to provide insights into the capacity of these models to drive positive societal transformation. The broader objectives of this study are as follows.

   - To examine the motivations and investment criteria of social venture capital firms.
   - To study the role of social venture capital on the growth and sustainability of social enterprises.
   - To propose a standardised and new mechanism to do valuation of SVCs and suggest recommendations for stakeholders, including social venture capitalists, social enterprises, and policymakers, to enhance the effectiveness of social venture capital.

5. **Current Status of your work (including TRL)** –Having conducted extensive research in the field of venture capital and innovation, including studying the causal relationship between these two factors at both the firm-level and macro level, we have made significant contributions to the literature. Our findings have been published in the reputed journals in this field. Building upon our previous work, we are now interested in exploring a specific aspect of venture capital investment: SVCs and social entrepreneurship businesses.

This study employs a survey-based approach and also uses quantitative data from secondary sources such as the Indian Venture Capital Association, Venture Intelligence, and other relevant databases in the field. By delving deeper into this area, we aim to provide further insights, expand our understanding, and contribute to the ongoing discourse in the field of venture capital, SVCs and social entrepreneurship.

6. **Proposed Work** –

In this study, we will conduct a comprehensive review of the available literature on social venture capital and social entrepreneurship, assessing the factors influencing SVCs. The data is collected through surveys, interviews, or other appropriate methods. This data collection involves social entrepreneurs, social venture capitalists, investors, and other relevant stakeholders. The current study will propose a new mechanism to access SVC investments for entrepreneurship businesses and develop a new valuation method to measure performance.

Stage 1: Exploring the literature on social venture capital, social entrepreneurship, and its social impact in an Indian context.

Stage 2: Understanding the causal relationship between social venture capital and social entrepreneurship and developing a suitable methodology to attract more investments in this context.

7. **Thematic areas covered under SDGs –**

SGD 1 - No Poverty; SGD 10 - Reduced Inequality; SGD 8 - Decent Work and Economic Growth; SGD 9 - Industry, Innovation, and Infrastructure; SGD 17 - Partnership to achieve the Goal.

8. Budget Details

Particulars	**Year 1 (Rs)**	**Year 2 (Rs)**
Research Assistants Remuneration (2 Nos.)	4,00,000	4,00,000
Equipment and Software	3,00,000	
Field Visits and Travel for Data Collection	2,00,000	2,00,000
Contingency	1,20,000	80,000
Social Venture Capital Investments Workshop (30 Participants)	4,00,000	
Total	21,00,000 (Twenty One Lakh rupees)	

9. **Social Impact (*Qualitative and Quantitative*)** -

The study can help social venture capitalists and investors in selecting approaches that have proven to be more effective in driving social entrepreneurship and creating positive long-term social impact. This may empower social entrepreneurs by providing them with guidance on accessing social venture capital and optimising their impact on sustainable development goals. Ultimately, the study intends to contribute to the creation of a more inclusive and sustainable society.

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1. **Title of Project:** Healing and performance benchmarking of warm mix asphalt

2. **PI details with Dept and Designation**:

Dr. Mullapudi Ramya
Sri Assistant Professor
Civil Engineering
Department IIT
Hyderabad

3. **Background/Origin of problem:**

Warm mix asphalt technology is being used for preparation of asphalt mixtures to reduce the production temperatures. Due to this reduction in the production temperatures, deterioration of the mixes due to aging is reduced to certain extent. Reclaiming asphalt pavement (RAP) material to prepare bituminous mixtures is ever increasing to safeguard the natural resources. Use of Higher percentage of RAP comes with a challenge in terms of the mixes fatigue resistance. Hence, use of WMA technology with RAP mixes will reduce the damage caused due to use of RAP with hot mix asphalt mixes. WMA-RAP mixes are being considered in place of regular hot mix asphalt mixes with RAP material. The healing ability and performance of the WMA-RAP mixes has not been studied in detail. Also the effect chemical makeup which is an important influencing factor has also not been examined with respect to WMA-RAP mixes. The current study is a step forward to understand different factors influencing the healing ability and performance of WMA-RAP mixes and influence of chemical makeup on the healing ability and performance of these mixes.

4. **Aim and objectives of the project:** The overall objective of the proposed study is to examine the effect of WMA additives and RAP content on the healing ability and performance of the WMA-RAP mixes. The influence of chemical makeup of the binder on the healing ability will also be examined.**1. Current status of the work:** warm mix additive identification has been completed and a part of the healing studies are in progress. The project is in the TRL level 4.

5. **Proposed work:** Two WMA additives and their optimum dosage are already identified. Mix designs will be carried out for both dense and gap graded mixes (mixes allowed for surface course layers by IRC specifications). The chemical makeup of the binder blends prepared with varying percentages of RAP will be determined using FTIR spectrometer. Cohesive surface free energies will be evaluated using the drop shape analyzer (DSA). The healing ability and fracture resistance of the WMA-RAP mixes will be evaluated using the indirect tensile strength tests conducted on the original set of specimens and healed specimens. Performance characteristics (rutting, fatigue and moisture damage) of the WMA-RAP mixes will be evaluated. The influence of the chemical makeup and the cohesion characteristics on the healing ability and performance characteristics will be interpreted towards the end of the research study. Benchmarking of the WMA-RAP mixes will be done by comparing their characteristics to the regularly used hot mix asphalt mixes.

6. **Thematic areas covered under SDGs:** Identification of sustainable materials which will be better resistant to the distresses that occur during the design life of a bituminous pavement. This will assist the use of new kind sustainable materials for road construction. The project

will fall under SDG industry innovation and infrastructure (9); sustainable cities and communities(11) and responsible consumption and production (12)

7. Timeline and Budget:

	Year 1	Year 2	Year 3
Budget (in Rs lakhs)	15 lakhs (For equipment (Brookfield viscometer), material procurement, contingency, Travel, and JRF)	7 lakhs (For material procurement, contingency, Travel and JRF)	8 lakhs (For material procurement, contingency, Travel and SRF)

8. Social impact: Entire nation will be benefited in terms of reduction in fuel consumption for the hot mix preparation and due to the improved performance lower thickness of layers will be required. By using the WMA mixes in road construction is going to consume less materials (10 to 15%) for a stipulated design life.

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1. **Title of the Project** –Translating a Low-Cost 3D Ultrasound Imager compatible with Commercial Ultrasound Systems

2. **PI details with Dept and Designation** – Avinash Eranki, Ph.D., Department of Biomedical Engineering, Assistant Professor

3. **Origin /Background Problem** – Ultrasound imaging has long been a valuable diagnostic tool in the field of medicine. However, traditional 2D ultrasound imaging techniques have inherent limitations in visualizing complex anatomical structures, especially in 3D. This can make it challenging to precisely identify and characterize abnormalities, particularly in intricate anatomical regions. The limitations of traditional 2D ultrasound imaging underscore the pressing need for more advanced imaging technologies, specifically those capable of generating precise and comprehensive 3D models of anatomical structures such as vascular networks, solid tumors, etc. Though 3D/volumetric ultrasound probes are commercially available, they are substantially more expensive than 2D ultrasound transducers, accompanied by proprietary software. They have little flexibility to acquire different modes (color Doppler, b-mode, elastography, etc.) of ultrasound images. On the other hand, extended 2D ultrasound imaging can be performed to obtain 3D volume. Still, these techniques are often operator-dependent due to the manual movement of the transducer, meaning that the image quality and diagnostic accuracy can vary based on the expertise and experience of the ultrasound operator. Free hand scanning of the 2D transducer to construct volumes are also time-consuming and subject to inconsistencies in volume reconstruction and diagnoses, potentially leading to misinterpretations and subsequent variations in treatment decisions.

4. **Aim and Objectives** – We propose to develop a 3D ultrasound imager using a 2D ultrasound transducer with computationally light software and hardware.

   The specific objectives of the project include:

   a. Calibrating a custom case to hold any 2D ultrasound transducer and allow controlled movement.
   b. Developing a software program to acquire 2D ultrasound images and reconstruct them into coherent 3D volumes.
   c. Validating the performance of our 3D ultrasound imager with images obtained from the commercially available 3D ultrasound transducer using tissue-mimicking phantoms and *ex vivo* tissues.

5. **Current Status of your work (including TRL)** – Our prototype features an ingenious clip-on design transducer holder for any 2D ultrasound probe, irrespective of the ultrasound system manufacturer. The holder is attached to a mechanical system, ensuring the high-precision movement of the transducer. All components are housed in a user-friendly 3D-printed casing, providing ease and ergonomic use for

clinicians and technicians. The programming package includes python modules for efficient DICOM file handling and analysis. It enables 2D to 3D ultrasound reconstruction, including coronal and sagittal frame generation as well as 3D volume reconstruction. We are also building a user-friendly GUI to facilitate seamless processing, from loading and analyzing DICOM files to interactive visualization.

6. **Proposed Work** – The proposed work involves a multi-faceted approach combining hardware design, mechanical engineering, and software development. We are improving our design by building an ergonomic transducer holder that securely grips the 2D ultrasound transducer and incorporates the ability to choose the spatial resolution (elevation direction) and sweep volume. Our holder is expected to allow for controlled movement and precise 2D transducer positioning during image acquisition. The mechanical design will be optimized for ease of use and compatibility with various ultrasound transducer models across different ultrasound systems/manufacturers. Simultaneously, we will develop a software program that interfaces with the ultrasound transducer and controls the ultrasound transducer motion to acquire a series of 2D ultrasound images. These images will be processed and reconstructed using proprietary image processing algorithms to generate a 3D volume. The software will also provide user-friendly visualization tools to explore and analyze the reconstructed 3D volume or individual 2D slices stacked one next to another. We will also conduct iterative testing and validation to assess the performance and precision of our 3D ultrasound imager. This will involve comparisons with existing commercial 3D ultrasound imaging and quantitative evaluation of image quality, spatial accuracy, and anatomical fidelity. By the end of this project, we aim to have a functional prototype of the 3D ultrasound imager, along with comprehensive validation results demonstrating its potential clinical utility and advantages over existing imaging techniques.

7. **Thematic areas covered under SDGs** –

   SGD 3 - Good Health and Well-being (treating non-communicable diseases)

8. **Budget Details** (***Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

Budget Head	Year 1	Year 2
Equipment	₹ 12,60,000.00	₹ 0.00
Personnel	₹ 7,20,000.00	₹ 7,20,000.00
Consumables	₹ 1,00,000.00	₹ 1,00,000.00
Travel	₹ 50,000.00	₹ 50,000.00
Grand Total		**₹ 30,00,000.00**

9. **Social Impact (*Qualitative and Quantitative*)** – This work and device are built to have a significant societal impact since our setup can help patients get improved anatomy imaging in 3D, helping better diagnostic decisions at a significantly cheaper cost and accessible in primary care centres that lack sophisticated ultrasound imaging systems for diagnostics.

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1. **Title of the Project** – Ultrasound Device for Triple Negative Breast Cancer Therapy

2. **PI details with Dept and Designation** – Avinash Eranki, Ph.D., Assistant Professor, Department of Biomedical Engineering

3. **Origin /Background Problem** – Breast cancer is one of the most common cancers globally, with over 627,000 deaths yearly. Breast tumors are classified as triple-negative breast cancer (TNBC) when they lack estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor type 2 (HER2). TNBC represents 20% of all breast cancers and tends to have a poor prognosis (>80% mortality) for aggressive and histologically high-grade tumors. Women suffering from TNBC, unfortunately, do not benefit from endocrine therapy or trastuzumab (anti-HER2). Chemotherapy is currently the mainstream approach in medical treatment, but patients with TNBC disease tend to have poorer outcomes, possibly due to a lack of specific targets.
   A new non-invasive, nonionizing, disruptive technology called boiling histotripsy (BH) has been recently characterized by the PI to perform spatially precise mechanical fractionation of tumor tissue in vivo under real-time ultrasound image guidance, with little or no thermal effects often observed in other thermal ablative technologies. Preliminary work done by the PI demonstrates converting a nonimmunogenic 'cold' tumor into an immunogenic 'hot' tumor with a significant pro-inflammatory immune response using BH alone. This technique has also demonstrated a critical adaptive antitumor response in a refractory model of neuroblastoma.

4. **Aim and Objectives** – This proposal aims to improve and translate an in-house-built novel coaxial image-guided ultrasound device for BH therapy. In this proposed work, we will follow these specific aims (SA):

   SA1: Build a novel ultrasound transducer for BH therapy with co-axial imaging capability.

   SA2: Test this device on tissue-mimicking phantoms and *ex vivo* tissues for eventual translation to treat breast tumors.

5. **Current Status of your work (including TRL)** – **Current TRL for our device is 4/5**. We built a first-of-its-kind device that can automatically perform BH therapy in solid tumors under real-time image guidance with minimal human intervention. This device includes a robotic arm, which will house a holder with a HIFU transducer, imaging ultrasound (US) transducers, and necessary electronics paired with a graphical user interface, which acts as a unified controlling system for the whole setup. The setup could treat breast tumors non-invasively by having contact only on the skin proximal to the tumor. Our device can also be controlled using a gaming joystick in three-dimensional space, which helps position the therapy module over a patient's anatomy. In addition, it can be programmed to perform minute motions and patterns with greater accuracy. We have programmed the robotic arm to generate patterns of geometric shapes such as squares and hexagons with millimeter-level precision to perform HIFU therapy. The spatial repeatability of our device (end effector) is ~ ±0.1mm, making it more precise than human intervention or control. There are at least four patents filed on this device. We currently have a HIFU transducer that can target tumors around depths of <5 cm, and the ability to target deeper locations is vital since we will have a coupling media between the tissue and HIFU transducer that adds to the total penetration depth.

6. **Proposed Work** – Herein, we are proposing to build a novel HIFU transducer with a potential capability of focusing at different depths within the tumor along with a central relief to allow for a ~45 mm imaging transducer or a passive cavitation device (SA1, above). This will significantly help make our system more flexible in terms of treating breast tumors in spatially different locations. We will design our holder and all other electronics to make sure this new transducer is integrated into the entire device with appropriate coupling with the skin surface and curvature. We will then test the entire system on tissue mimicking ultrasound phantoms, and *ex vivo* tissues for targeting precision and efficiency (SA2). This proposed outcome will be an image-guided therapeutic ultrasound device capable of BH and ready to be translated (pending regulatory approvals).

7. **Thematic areas covered under SDGs** –

SGD 3 - Good Health and Well-being (treating non-communicable diseases)

8. **Budget Details** (***Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

Budget Head	Year 1	Year 2
Equipment (HIFU Transducer and PCD)	₹ 20,00,000.00	₹ 0.00
Personnel	₹ 7,20,000.00	₹ 7,20,000.00
Consumables	₹ 2,00,000.00	₹ 2,00,000.00
Travel	₹ 50,000.00	₹ 50,000.00
Grand Total		**₹ 39,40,000.00**

9. **Social Impact (*Qualitative and Quantitative*)** – The proposed work and device are built to have a significant societal impact since the therapy of breast tumors using this device is entirely non-invasive and with nonionizing radiation. This helps make this therapy an outpatient procedure, reducing overall patient costs and the need for antibiotics and reducing the financial burden on patients. The device is also mounted on a mobile cart, making it easy for the physician or nursing team to move it to the patient's bed for therapy. The entire device would be powered off a standard power socket, reducing hospitals' need for specialized power supplies. These characteristics make this device easy for physicians and with a low cost of therapy for patients.

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1. **Title of the Project** – A low-cost, portable sensor system to monitor breast cancer in women
2. **PI details with Dept and Designation** – Dr. Suresh Kumar Garlapati, Assistant Professor, Materials Science and Metallurgical Engineering department, IIT Hyderabad. Email: gsuresh@msme.iith.ac.in
   Co-Investigators: Dr. Venkata Rao Kotagiri, Dr. Avinash Eranki, Dr. Gajendranath Chowdary.
3. **Origin /Background Problem** – Breast cancer is the uncontrollable growth of cells in the lobules or ducts of the breast, and it can spread to the remaining parts of the body through blood and lymph vessels. If it is not treated in the early stages, it will lead to death as well. In fact, among women, it is the leading cause of cancer deaths. For example, in 2020, more than 2.3 million women were diagnosed with breast cancer and 685000 deaths were reported across the world. Breast cancer has become common cancer, and the survival of breast cancer patients after diagnosis is much lower in India and African countries compared to high-income countries. Especially, women in rural areas are more vulnerable due to the lack of awareness, myths, ignorance, and screening tests. Detecting cancer in the early stages and timely treatment can reduce the risk significantly. The most common screening tests are mammography, magnetic resonance imaging (MRI), thermography, tissue sampling, etc. These methods are invasive, time-consuming, costly, and need expert personnel to understand the results of the tests. In addition, the women must visit the diagnosis centers or hospitals frequently for monitoring tests, which may not always be feasible as they lose daily wages and find it stigmatic. Therefore, developing a low-cost breast cancer monitoring system for self-diagnosis resolves the above-mentioned issues to cater to the need for home-based screening and awareness to find the pathology at early stages. Herein, we propose a low-cost sensor technology for rapid, non-invasive, and real-time continuous monitoring of analytes such as formaldehyde from exhaled breath. In addition, a number of advanced breast cancers become infective and purulative skin conditions are also neglected until the late stage, all emitting a lot of volatile organic compounds (VOC). Interestingly, the organic field-effect transistors (OFETs) based sensors with conjugated microporous polymer (CMP) semiconductors with tunable pore volume and high surface areas (300-1000 m^2/g) are highly sensitive to formaldehyde in exhaled breath. Moreover, CMPs with different functional groups sensitive to particular analytes will be incorporated to obtain high selectivity. The prepared OFETs will be tested under humidity conditions in order to eliminate the humidity effect on the detection of formaldehyde. To reduce the fabrication costs of sensors, low-cost additive manufacturing techniques such as inkjet printing will be used to fabricate the OFETs on flexible plastic substrates. These devices are portable, disposable, and do not need any expertise. Therefore, the printed, flexible sensor array paves the way for portable, low-cost sensors for non-invasive real-time monitoring of breast cancer. In addition to the sensor system, breast cancer awareness programs will be conducted in rural areas in Telangana.
4. **Aim and Objectives** – Our major aim is to reach women in rural areas, where knowledge and testing for cancer are not available. We believe both sensor systems and awareness programs reduce the risk of breast cancer, infective skin conditions like mastitis, and ulcers in women, especially in rural areas. As these women seek less medical care, and are mostly neglected by household males, our proposed therapy might find the early pathogens related to breast cancer or internal skin conditions in rural women in home-care based early screening methods. The objectives of this project are,
   1. Preparation and characterization of low voltage (≤3 V) operated organic field-effect transistor-based sensors using an inkjet printing technique.
   2. Testing OFETs based sensors with formaldehyde, humidity, and other relevant volatile organic compounds of exhaled breath.
   3. Integrating the OFETs based sensors with microcontrollers and a display and testing the entire system with exhaled breath.
   4. Conducting breast cancer awareness programs in rural areas.

5. **Current Status of your work (including TRL)** – We have already fabricated the OFETs using poly(3,6-di(2-thien-5-yl)-2,5-di(2-octyldodecyl)-pyrrolo[3,4-c]pyrrole-l,4-dione)thieno[3,2-b] thiophene) (DPPT-TT) in a sensor platform for detecting alcohols and ketones, as these analytes are important VOCs in exhaled breath. The OFETs respond to all four alcohols (Figure 5), and among these, the OFETs displayed the highest sensitivity (limit of detection (LOD)≈1 ppm) towards octanol. The OFETs also respond on exposure to the vapors of ketones such as acetone, butanone, and 2-octanone, and here also the percentage response increases with an increase in concentration as expected. Acetone and butanone show a rapid response and recovery to exposure, but the recovery on exposure to 2-octanone is slightly slower. Among these measured ketones, the OFETs have shown the highest sensitivity (LOD≈6 ppm) towards 2-octanone. The TRL level of these sensors is 3 and now we would like to test VOCs related to breast cancer and develop a portable sensor technology to TRL 4-5.

6. **Proposed Work** – The research plan includes preparation of CMPs by a novel chemical route, preparation of OFET devices, testing of OFETs based sensors with different VOCs, distinguishing responses of sensors using principal component analysis, and integration of sensor array with masks and testing it with exhaled breath. In this work, we plan to synthesize CMPs with various functional groups to target formaldehyde in exhaled breath. To selectively target formaldehyde, we propose a perylene diimide based CMP with amine groups at the imide position. Due to the porous nature of these CMPs, gas molecules can be easily adsorbed compared to the non-porous conventional conjugated polymers. All these CMPs will be synthesized through well know polymerization method such as Suzuki coupling. The OFETs will be prepared on flexible polyethylene napthalate substrates. The components of OFETs include electrodes, dielectric, and semiconductors, which will be deposited by different techniques. First, gate metal (Al or Au) electrodes will be deposited using thermal evaporation or sputtering technique. A high-k/low-k dielectric stack will be prepared by spin coating technique. Next, source and drain electrodes will be deposited using thermal evaporation or sputtering technique. The CMPs will be prepared by dissolving them in suitable solvents and will be deposited by using an inkjet printer. The films of dielectrics and CMPs will be characterized using structural and electrical characterization techniques. A gas-sensing setup will be prepared and the prepared OFETs based sensor array will be tested against different analytes such as formaldehyde, carbon dioxide, and ethanol. To eliminate the effect of humidity, VOCs will be mixed with different humidity levels and the responses will be recorded. Cross-sensitivity towards multiple analytes will be avoided by choosing CMPs with different structures and functional groups. The sensor array will be integrated with a wearable N95 mask and tested against exhaled breath. Finally, the sensors will be tested on healthy and unhealthy (cancer) persons to obtain real data.
7. **Thematic areas covered under SDGs** – *Good Health and Well-being*
8. **Budget Details-** The timeline for this project is 3 years and the total required budget is Rs. 25,00,000.00. The break-up of the budget is mentioned in the following table.

Year	Non-Recurring/ Equipment/	Recurring		Total
		Consumables	Contingencies	
1st	15,00,000.00	4,00,000.00	1,00,000.00	20,00,000.00
2nd	1,00,000.00	2,00,000.00	50,000.00	3,50,000.00
3rd	0.00	1,00,000.00	50,000.00	1,50,000.00
Total	16,00,000.00	7,00,000.00	2,00,000.00	**25,00,000.00**

9. **<u>Social Impact (*Qualitative and Quantitative*)</u>** - The developed sensor systems and awareness programs help women to understand the risks of breast cancer and the importance of early detection. This project can empower women in healthcare. In addition, the developed sensor systems are useful to detect breast cancer in both women and men.

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Indian Institute of Technology Hyderabad

1. **Title of the Project** – Structural coloured paints as sustainable pigment alternatives from repurposed polymeric waste
2. **PI details with Dept and Designation** – Dr. Mahesh Ganesan, Assistant Professor, Department of Chemical Engineering
3. **Origin /Background Problem** – The project seeks to address a two-fold problem related to ecological

   toxicants. First, there is abundance of polymeric waste arising out of innumerable applications and uses that are globally identified ecologically toxicants. Second, conventional paint pigments, consisting of synthetic and inorganic chemical constituents, which are equally used in abundance across several consumer, commercial and industrial applications are also tagged as ecological toxicants. There are limited efforts in addressing these problems in combination.
4. **Aim and Objectives** – The proposal's aims consist of two parts. This proposal seeks to address the first problem mentioned above by repurposing polymeric waste into functional microparticles. Utilizing these recycled particles, we address the second problem above by formulating structural coloured pigments by assembling the particles into ordered assemblies which exhibit brilliant colour solely due their microstructure without requiring any chemical additives.
5. **Current Status of your work (including TRL)** – TRL 3 – Experimental Proof of Concept
6. **Proposed Work** – The proposed work will work with expanded polystyrene waste materials as the starting raw material. Using a combination of Hansen's solubility parameters, the polystyrene waste will be precipitated into microparticles in suitable solvent-non-solvent mixtures and recaptured via particle washing procedures. The recycled particles will be assembled into ordered micro-arrays using evaporation driven assembly and the interlayer spacing will be modulated by controlling the evaporation conditions. The assembled matrix, which will exhibit structural coloration due to Bragg interference will be recovered as micro-flakes using suitable matrices. The flakes will then be considered as replacement to conventional chemical pigments for paint and coating applications.

7. **Thematic areas covered under SDGs** – UN SDG # 12 – Responsible Consumption and Production,

8. **Budget Details** (***Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

Year 1 Equipment: Research grade microscope, Rs 20,00,000

Consumables: Rs 2,50,000

Year 2 Consumables: Rs 2,50,000

Total Rs 25,00,000

9. **Social Impact (*Qualitative and Quantitative*)** – Given the widespread use of paints, coatings and dyes

across a variety of indigenous art crafts such as textile, pottery and painting, introducing a sustainable alternative to the otherwise harmful inorganic colour pigments will be of significant value to the artisans. Especially textile dye is known be harmful to both human and marine life, especially given their water polluting nature. It is therefore hoped that, a recycled sustainable alternative as proposed in this study will create significant societal impact for the above applications and broadly support the sustenance of cultural heritage of the country, in line with the initiatives of the DST, Government of India.

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1. **Title of the Project** – Addressing the Language Gap in Conversational Systems

2. **PI details with Dept and Designation** –
Dr. Maunendra Sankar Desarkar
Associate Professor, Department of CSE
And Head of the Department, Department of AI

3. **Origin /Background Problem** –

There are several conversational systems that are being developed and being deployed in multiple setups. Such systems are assisting users in raising issues with customer support, troubleshooting, finding the right product, resolving queries related to admissions and opportunities etc. However, most of such deployed systems are rule-based, and operate like a flow-chart. Most of these systems are unidirectional, where the systems ask a few questions and users have to choose among a set of fixed responses available, and the conversation proceeds accordingly. Handling of free-flow text from users is not there in many of the systems. Quite often, these systems connect the user with a human agent when the user provides a free- text information with details and specific queries.

Recently, the trend is changing and some of the systems and organizations are adapting to systems that can go beyond flow-chart-like workflow, mostly due to the recent advancements in the field of Natural Language Processing, and the availability of Large Language Models (LLMs) trained with a large volume of data. However, the true potential of using such LLMs for conversational systems is yet to be benchmarked, for domain-specific and fact-based scenarios. Moreover, the LLMs have mostly focused on English language. It is yet to be seen how the models perform on tasks in regional languages such as Hindi. Telugu, Bengali, Marathi, etc. As part of this project, we want to investigate the capabilities of LLMs for domain-specific conversational systems, especially in regional languages, many of which are low-resource in nature.

4. **Aim and Objectives** –

As part of this work, we want to focus on the following

a. The major focus of the task will be towards the development of conversational systems for domain-specific applications (such as travel, tourism, medical, etc.) The exact domain will be picked up after assessing the availability of seed data.
b. Data collection will be an important aspect of the work as we want to cover regional languages. Most of the existing datasets are in English.

5. **Current Status of your work (including TRL)** –

We have done multiple works on NLP for low-resource languages and also on conversational systems. Below is a list of such works with their associated TRLs.

a. Natural Language Generation for low-resource language (TRL-3: Proof of Concept developed and demonstrated)
b. Development of a Transport-domain chatbot for answering code-mixed Hindi-English queries (TRL-4: Prototype built in small environment)

6. **Proposed Work** –

As mentioned in responses to the previous questions, we want to work towards the development of goal-oriented conversational systems to support queries in regional languages. The proposed system will have three major stages: Data Collection, Algorithm Development, and System integration. For Data Collection, we will try to translate some suitable data from existing English-language datasets followed by manual verification of translation quality and appropriateness. This will be followed by contextualizing the translated and verified data to Indian setting. We will also generate/collect data through volunteers to collect "organic" data.

Goal-oriented conversational systems have a few major steps such as intent identification, dialog state tracking, dialog policy identification, and dialog generation. We need to work on each of these steps to make the components suitable for the regional language data, and work on limited examples (as most of these languages are known to be low-resource languages). It is also an observed fact that many of the chatbots either are overly polite with limited information, or provide information in terse manner. Depending on the domain and the setup, we also want to blend aspects of politeness, empathy and informativeness in the generated dialogs.

7. **Thematic areas covered under SDGs** –

Language is a ubiquitous medium for communication. Hence, this work will act as a horizontal platform that will cut across multiple SDGs depending on the end application. It will be helpful for the following SDGs: SDG-10 (Reduced inequality within and among countries) by trying to take the advancements of LLMs and Conversational Systems research to less-represented languages, Goal 11 (Make cities and human settlements inclusive …).

8. **Budget Details** (***Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.***

	Year 1	Year 2	Year 3	Total
Project personnel: One PhD, one MTech student	**7 Lakhs**	**7 Lakhs**	**7 Lakhs**	**21 Lakhs**
Equipment: Workstations	**10 Lakhs**	**-**	**-**	**10 Lakhs**
Travel and conference registration fees	**1 Lakh**	**2.5 Lakhs**	**2.5 Lakhs**	**6 Lakhs**
Contingency	**1 Lakh**	**1 Lakh**	**1 Lakh**	**3 Lakhs**

Total Budget: INR 40 Lakhs + Institute Overhead

9. **Social Impact (*Qualitative and Quantitative*)** -

The work will take the benefits of conversational systems of the large population of the country who are comfortable in conversing in regional languages. Their engagement with the system will also create data that can be used to bootstrap the systems to gain a better understanding of the country and region-specific preferences and nuances. This will in turn help in improving the systems to fulfil the requirement of a wider section of the society. To measure the quantitative impact, we can use the evaluation metrics like BLEU, ROGUE, BERT-Score kind of metrics that are commonly used to evaluate dialog systems.

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1. **Title of Project:** Thermochromic material usage to enhance performance of bituminous mixtures
2. **PI details with Dept and Designation**:

Dr. Mullapudi Ramya Sri
Assistant Professor
Civil Engineering Department IIT Hyderabad

3. **Background/Origin of problem:** Bituminous layers of a flexible pavement are subjected to distresses like permanent deformation due to high service temperatures during summers and thermal cracking due to low service temperatures during winters. The black color of the binder makes bituminous mixtures absorb more heat during the summers which further aggravates the permanent deformation, aging of the mixtures and fatigue cracking due to aggravated aging. To reduce the absorption of heat in the presence of higher temperatures and increase the absorption of heat during low temperature presence, thermochormic material addition to the binders is being considered as a feasible alternative. Thermochromic material addition into the binders is a very recent area of focus to achieve sustainable pavements. The effect of use of this material in a neat or modified binder is to be further studied in order understand the effectiveness of its usage up on the mechanical, rheological and performance characteristics of the binders as well as the mixtures.

4. Aim and objectives of the project: The objective of the current project is to identify compatible thermochromic materials for binders used to construct bituminous pavements and also characterize the performance of the mixtures made using these identified materials**.**

5. **Current status of the work:** Thermochromic material identification for the trial experimentation is in progress. The project is in the TRL level 3.
6. **Proposed work:** Thermochromic materials that shall reverse their colors through their transition temperatures and that are compatible with the binders will be identified. Binders and

mixtures will be prepared using different dosages of the thermochromic materials to characterize mechanical, rheological and performance characteristics. Fatigue resistance, rut resistance and moisture damage resistance will be examined as a part of performance studies. Aging charcteristics of these mixtures will also be examined for short term and long term aging. Optimal dosage of these thermochromic materials shall be identified. Comparison of these mixtures with the performance of the regularly used mixtures will be done. Life cycle analysis shall be carried out to examine the cost benefit that shall be offered by the mixtures prepared using thermochromic materials.

7. **Thematic areas covered under SDGs:** Identification of sustainable materials which will be better resistant to the distresses that occur during the design life of a bituminous pavement. This will assist the use of new kind sustainable materials for road construction. The project will fall under SDG industry innovation and infrastructure (9); sustainable cities and communities (11) and responsible consumption and production (12)

8. Timeline and Budget:

	Year 1	Year 2	Year 3
Budget (in Rs lakhs)	65 lakhs (For equipment (Dynamic shear rheometer, Brookfield viscometer), material procurement, contingency, Travel, and JRF)	7 lakhs (For material procurement, contingency, Travel and JRF)	8 lakhs (For material procurement, contingency, Travel and SRF)
Milestones	Identification of Thermochromic materials and their characterization	Mixture designing and mechanical properties of the mixes at different climatic conditions	Performance characterization of the identified mixtures for varied climatic conditions

9 Social impact: Entire nation will be benefited in terms of using less amount of materials for road construction by having a better performing binder/mixture. By using the thermochromic binders that will change their color according to the temperature, road construction is going to consume less materials (15 to 20%) for a stipulated design life.

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1. **Title of the Project** – **Nutritional Security for Country: Nutraceutical Chewing gum**

2. **PI details with Dept and Designation** – Dr. Mudrika Khandelwal, MSME, IITH

3. **Origin /Background Problem** – While we are trying to achieve food security for the country, nutritional security must be considered in unison. A lot of oral nutraceuticals suffer from low bioavailability. In this regards, medicated chewing gum (MCG) offers a novel drug delivery system containing masticatory gum base with pharmacologically active ingredient and intended to use for systemic absorption through oral mucosa with minimal loss. The medicated chewing gums are solid, single dose preparations with a base consisting mainly of gums that are intended to be chewed or attached to buccal cavity, but not swallowed. Bacterial cellulose is also considered as dietary fibre, approved as a generally recognized as safe (GRAS) food by the US Food and Drug Administration (FDA). Due to high crystallinity and porous structure, required amount of the active ingredients can be loaded and BC can be tuned to set the release profile (sustained or burst release), the non- toxic property of the BC can be fairly used to make suitable MCG. Various Nutraceuticals products can be loaded in BC and can be utilized as MCG for different age forms. The benefits of the BC-MCG can be said as:

    - It enhances the bioavailability of medicines by avoiding first pass metabolism. Fast beginning of effect as a result of the active components' fast release in the buccal cavity and subsequent absorption into the bloodstream.
    - Since the stomach is not in direct contact with highly active substances, there is less chance that the gastric mucosa will become intolerable.
    - Saliva is continuously and routinely released, and it carries a portion of the ingredients that enters the stomach. Action's duration lengthens, because unlike with other drug delivery forms, the active material will be delivered into the oral cavity and remain there for a longer amount of time.

4. **Aim and Objectives** – Develop cellulose based gum with enhanced absorption of vitamins during chewing
5. **Current Status of your work (including TRL)** – We have achieved tunability of bacterial cellulose by various *in situ* and ex-situ modification techniques. We already expertise in drug delivery using this material for various kinds of kinetics and situations.

6. **Proposed Work** – The work will involve post production modification to impart chewing gum like properties. Rheological behaviour will be studies to understand viscoelastic behaviour. Further vitamins/minerals shall be added to maximise loading and release will be performed in simulated saliva in a trans-mucosal apparatus. The release will be optimised

7. **Thematic areas covered under SDGs** –Good health and Well Being, directly contributes to Decent work and Economic Growth

8. **Budget Details: year 1: 20 Lakhs TRL 4, year 2: 20 Lakhs TRL 6**

9. **Social Impact (*Qualitative and Quantitative*)** - Despite India's 50% increase in GDP since 2013,

more than one third of the world's malnourished children live in India. Nutrition shall ensure a healthy working force and society, which shall leads to efficient output and betterment of the nation.

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1. **Title of the Project** – Generalized Multivariate Analysis of Variance (GMANOVA) models for modelling skewed and volatile financial and actuarial data at the time of catastrophes

2. **PI details with Dept and Designation** – Sayantee Jana, Assistant Professor, Dept. of Mathematics

3. **Origin /Background Problem** – Despite normal distribution being the most popular distribution in practice and the most abundant in nature, nevertheless, it is not rare to encounter skewed data in practical problems. Therefore, there has been considerable development of asymmetric and more flexible distributions in the recent past such as the Multivariate Skew Normal (MSN) (Azzalini and Capitanio 1999). However, like the normal distribution, the skew-normal distributions also do not account for volatility in the data. Modelling such data using the classical normal distribution will lead to inadequate model fit and hence poor financial decisions (Fama, 1965; Fung and Heish, 2000; Eling, 2008). Eling (2012) fit several parametric distributions and non-parametric kernels to two well-known actuarial datasets, and on the basis of goodness-of-fit tests and tail risk measurements, concluded that skew *t* distribution gives one of the best model fit to insurance data. In the last several decades there has been a surge in reporting of presence of skewness and kurtosis (volatility) in data in financial literature, with the pioneering studies being von Neumann and Morgensten (1944), Friedman and Savage (1948), Samuelson (1970), Lane (2000). Among these, portfolio selection and asset pricing, in particular, is multivariate in nature (Adcock, Eling and Loperfido, 2015). We plan to model such data using the Multivariate Skew *t* (MST) distribution (Azzalini 2013). In contrast to MSN distribution, the MST distribution offers flexibility in modelling skewness and kurtosis for heavy or light-tailed datasets. Heavier tails, in particular, allow us to model volatile data, frequently encountered in financial returns, for example, property-liability insurance claims (Cummins et al. 1990), insurance risks, especially at the time of catastrophes (Embrechts, McNeil, and Straumann, 2002). Examples of catastrophes include economic recession, natural calamities (cyclones, typhoons, Tsunamis etc.), epidemics such as COVID-19 outbreak etc., whenever insurance firms have suffered unprecedented losses. Catastrophes are particularly damaging to insurers and re-insurers and they impact risk allocation, pricing, and capital structure decisions, since most insurance and re-insurance portfolios contain exposures to catastrophic risks (Froot 2007).

4. **Aim and Objectives** – GMANOVA models were introduced by Pothoff and Roy (1963) and further studied extensively by Khatri (1966), Kollo and von Rosen (2006), Pan and Fang (2002). They have been found to be especially useful in modelling time-varying repeated measures data, that is longitudinal data, with short to moderate time series. It has a bilinear structure, with observations for each time point *p*, on each *n* individuals ($n = \sum_{i=1}^{k} n_i$), where each of the *k* groups being compared have *ni* individuals. The measurements of interest range from blood glucose level, cholesterol level, to capital allocation, actuarial pricing, or tensile strength of a material (Chen and Gupta, 2005; Pan and Fang, 2002). When analyzing such time-dependent repeated measures data, we require a model that not only incorporates the inherent temporal correlation and ordering but also the time-dependency (von Rosen, 1991; Hamid et. al., 2011; Jana et al., 2016), such as the GMANOVA model, which looks like $Y = ZBX + E$ …… *(1)*
where, *Y*: observation matrix, *Z*: design matrix consisting of the time-components to account for the temporal correlation and ordering, *B*: mean parameter or matrix of regression coefficients, *X*: design matrix for comparison across groups, *E*: error matrix/noise.

   Financial and actuarial data, despite being time-varying data, have never been modelled using GMANOVA models. This is despite the fact that, GMANOVA models have extensive applications in the fields of economics, medical science and agriculture. The reason being that the traditional GMANOVA model is based on the multivariate normal distribution, and most financial and actuarial data are skewed and volatile. Previous studies (Jana et al., 2020, 2018) have shown that the GMANOVA model is sensitive to the presence of skewness in the data. Hence tools appropriate for
   GMANOVA model is sensitive to the presence of skewness in the data. Hence tools appropriate for
   skewed GMANOVA models were developed in Jana et al. (2018, 2020). However, such methods may not be optimal for datasets with high volatility. Heavy-tailed distributions, such as the MST, might provide better fit to such datasets to account for the increased volatility. This motivated us to consider the GMANOVA model under MST distribution, to allow for both skewness and volatility in the data.

The MST distribution, regardless of its perceived complexity, is mathematically tractable, robust, parsimonious, and interpretable. Moreover, the MST distribution possesses other desirable statistical properties such as closure under conditioning. Such attributes make the MST distribution an attractive candidate for GMANOVA modelling. Several theoretical arguments, in favour of the skew t distribution, and illustrative examples have been provided in Azzalini and Genton (2008).

5. **Current Status of your work (including TRL)** – The proposed MST model is under construction.

6. **Proposed Work** – In our proposed work, we wish to expand the scope of application of GMANOVA by accounting for skewed and heavy-tailed distributions with MST errors, which we will refer to as the MST GMANOVA model. The procedure involves several steps:
***Step 1*:** Define the model with MST errors, by re-parametrization to accommodate the skewness and tail parameters of the MST distribution.
***Step 2*:** Express the MST GMANOVA model in its stochastic form.
***Step 3*:** Construct the likelihood of the model under the MST distribution.
***Step 4*:** Since closed-form solutions of the likelihood equations, may not be feasible for the MST GMANOVA model, hence we can employ the Expectation Maximization (EM) algorithm for deriving the estimators for the model parameters.
***Step 5*:** Construct the Likelihood Ratio Test (LRT) for comparing the means across the different groups. ***Step 6*:** Conduct extensive Monte Carlo (MC) simulations to assess the empirical performances of the estimator and the test, under different scenarios.
***Step 7*:** Finally, a real-data on insurance risks or any other financial returns data, during the time of catastrophe, will be modelled using the newly developed MST GMANOVA model.

7. **Thematic areas covered under SDGs** – **NA**

8. **Budget Details –** Total = 14 lakhs

Year 1		Year 2	
Budget head	Amount	Budget head	Amount
Research Personnel (SRF)	5,80,000	Research Personnel (SRF)	5,80,000
Consumables	50,000	Consumables	50,000
Contingency	20,000	Contingency	20,000
Travel (Conference & Collaboration)	50,000	Travel (Conference & Collaboration)	50,000

9. **Social Impact (*Qualitative and Quantitative*)** –Simple modelling of financial data using normal distribution not only ignores the skewed and volatile character of certain financial data, such as asset pricing or property-liability insurance claims at the firm level, but also the temporal nature of such financial variables. As a matter of fact, temporal nature of financial data has motivated development of several well-known time series models. However, we seldom encounter applications of skew normal or skew *t* distributions for financial time series data. Therefore, models incorporating skewness, volatility and time dependency are essential and the need of the hour for effective and improved decision making, especially for multivariate financial data. Financial and actuarial data being time- dependent, can be easily modelled using GMANOVA models, which also allows comparison across firms, while accounting for temporal correlation, dependency and ordering. The proposed MST

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1. **Title of the Project** – 3D printing flexible and conductive ionogels

2. **PI details with Dept and Designation** – Dr. Alan Ranjit Jacob, Assistant Professor, Department of Chemical Engineering

3. **Origin /Background Problem** – Routine and systematic vitals monitoring is a significant part of the healthcare and well-being industry. There is a significant interest in developing flexible wearable electronics but very little emphasis has been placed on developing materials that are electrically conductive as well as printable on demand. The Soft Matter group at IITH is capable of designing and developing such unique and functional soft materials that is expected to have significant implications in the health care industry.

4. **Aim and Objectives** – This problem will tackle two major objectives i) development of conductive materials that are "flexible" and can be on demand 3D printable ii) intelligent and optimally design based 3D printing for improved flexibility and maximum conductivity of the material.

5. **Proposed Work** – The proposed work will be focussed on developing ionogels that undergo sol gel transition and can sustain large deformation loads as well as many cycles of deformation. The work will include a systematic of study of sol-gel transition of ionogels. Conductive additives like colloids and emulsions is expected to provide enhanced mechanical strength, structure and conductivity which will also be considered in developing the most appropriate ionogel formulation. These formulations will be extruded from the 3D printer in different design configurations and tested for sustained performance quality at large deformation range.

6. **Thematic areas covered under SDGs** –UN SDG # 3 – Good Health and Well Being, SDG # 9 – Industry, Innovation and Infrastructure

7. Budget Details (Please do not include any overheads. Overheads will be added as per institute CSR norms. Bifurcations within the budget may be provided. However, this can also be provided later. Please include the year wise budget with a max of 3 years.

Year 1	**Equipment: 3D printer, Rs 15,00,000**
	Consumables: Rs 2,50,000
Year 2	**Consumables: Rs 2,50,000**
Total	**Rs 20,00,00**

8. **Social Impact (*Qualitative and Quantitative*)** – Flexible electronics market is worth nearly $22billion in 2023 and is expected to quadruple to $80 billion by the end of this decade. It is very much essential to develop market ready materials that can revolutionise this industry and be at the

forefront to improve quality of life. This proposal is also expected to align with Make in India initiate of Government of India.

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PROPOSAL

1. **Title of the Project** – Pilot-Scale Production of Essential Oil Blended Nanofiber-Based Sanitary Napkins: Menstrual Hygiene Management

2. **PI details with Dept and Designation** – Prof. Chandra Shekhar Sharma, Department of Chemical Engineering. Email: cssharma@che.iith.ac.in

3. **Origin /Background Problem** – Menstruation is a natural process experienced by women worldwide and the use of sanitary napkins has become an integral part of managing menstrual hygiene, and has greatly improved the quality of life for women. However, concerns have been raised regarding the potential health risks associated with the superabsorbent polymers (SAPs) used in these products. Studies have indicated that although these polymers are capable of absorbing large amounts of liquid, transforming it into a gel-like substance to prevent leakage, prolonged exposure to SAPs in sanitary napkins can lead to skin irritation, allergic reactions, vaginal discomfort, disrupting the natural pH balance of the vagina, potentially leading to infections and other gynaecological complications.

   Nanofiber technology offers a promising alternative to achieve high absorbency sanitary napkins and therefore can be used as an alternative to SAPs in sanitary napkins. Nanofibers are ultra-fine fibers with diameters range of a few nanometers to several micrometers, possessing a high surface area-to-volume ratio, enabling superior absorbency and fluid management capabilities. Furthermore, essential oils are recognized for their ability to control odour, prevent skin irritation, and promote relaxation and stress relief. Therefore, essential oils blended nanofibers can potentially replace SAPs, providing enhanced absorbency, comfort, and overall performance in menstrual hygiene products.

4. **Aim and Objectives** – This research proposal aims to (i) analyse and improve the quality, performance, and assessment of economic viability of (ii) pilot 1000 samples essential oil blended nanofiber-based sanitary napkins. It will also include process optimisation, refining of materials based on user's feedback. Furthermore, fostering collaborations with industry partners will enable us to tackle market challenges and bridge the gap between research and commercialization, leading to revolutionize female hygiene in India by providing safer, eco-friendly, more comfortable, and affordable menstrual products. The project aims to enhance women's health, confidence, and quality of life through nanofiber technology and menstrual hygiene management.

5. **Current Status of your work (including TRL)** – The current status of our work is at Technology Readiness Level (TRL)-6, where we have successfully demonstrated the technology of manufacturing sanitary napkins from nanofibers. The fabricated protype have been tested in terms of efficacy compared to SAPs based products. Also, at lab-scale, we have successfully developed the manufacturing process and optimized the formulation to

incorporate essential oils into the nanofibers, to impart antimicrobial properties. These samples will undergo rigorous testing and evaluation to assess their effectiveness in providing relief from skin irritation, preventing bad odour, and protecting against infections.

6. **Proposed Work** – The proposed work entails the pilot-scale production of 1000 samples of essential oil blended nanofiber-based sanitary napkins. This project aims to commercialise nanofibers for sanitary napkins production and based on feedback, changes (minor) will be made in the final product. This proposal also includes optimisation of manufacturing process and evaluation of the feasibility and performance of essential oil blended nanofiber based sanitary napkins.

7. **Thematic areas covered under SDGs** – Our essential oil blended nanofiber-based sanitary napkins align with the Sustainable Development Goals (SDGs), particularly SDG 3 (good health and well-being) and SDG 5 (gender equality). By addressing gender-specific hygiene needs and promoting women's health, our product contributes to empowering women and achieving gender equality (SDG 5). Additionally, the use of essential oils and advanced nanofiber technology supports SDG 3's aim of ensuring healthy lives and well-being for all.

8. **Duration & Budget Details-**

   Proposed Duration: 1 year

   Proposed Budget (INR): 16.5 lakh (Research personnel: 3.0 L, Consumables: 3.0 L, Customization of Electrospinning: 6.0 Lakh, Travel: 2.0 Lakh, Contingency 1.0 Lakh, Overheads 5%, Project Management Fee: 5%)

9. **Social Impact (Qualitative and Quantitative)** - The scale up of essential oil blended nanofiber-based sanitary napkins will bring significant social impact. Qualitatively, these innovative products will address skin irritation, bad odours, infections, and taboos surrounding menstruation, thereby empowering women and improving their well-being. By incorporating therapeutic essential oils, the napkins provide relief and promote feminine hygiene. Quantitatively, user trials and feedback will refine the product, potentially leading to widespread adoption. The proposed research aligns with government initiatives like "Beti Bachao, Beti Padhao" and "Swachh Bharat Abhiyan," offering an opportunity for further integration of our product with these initiatives.