IC-IMPACTS

Networks of Centres of Excellence
Building Healthy Communities in Canada and India

NCE Annual Progress Report
2019 – 2020 Fiscal Year

Images from left to right, top to bottom: (1) IC-IMPACTS and SFU sign Affiliated Network University Agreement (2) Construction of self-healing pavement demonstration project in Chawathil First Nation (3) IC-IMPACTS and DBT Leadership during visit to India (4) Exo-skeletal glove for spinal cord injury survivors (5) IC-IMPACTS office team working remotely during COVID-19 (6) IC-IMPACTS and UVic sign Affiliated Network University Agreement. (7) Research team in the field (8) Construction of HPAS demonstration project in India (9) IC-IMPACTS and DST announcing winners of joint Call for Proposals

Networks of Centres of Excellence
350 Albert Street
Ottawa ON K1A 1H5

Dear Dr. Stewart Fast,

It is with pleasure that we submit to you the 2019-20 Annual Progress Report from IC-IMPACTS Centres of Excellence. This submission, approved by the Board of Directors of IC-IMPACTS, is comprised of the following documents:

1. IC-IMPACTS Annual Progress Report
2. IC-IMPACTS Statistical Tables and Charts
3. IC-IMPACTS NCE Statement of Accounts
4. Report on Conflict of Interest
5. Environmental Review Report

Under a separate cover, you will receive a copy of the IC-IMPACTS independently audited financial statements.

IC-IMPACTS continues to expand its work in the three major areas as described in our mandate: sustainable infrastructure, water management, and public health, with a renewed focus on implementing research outcomes into community contexts. Since 2013, IC-IMPACTS has exceeded all established targets, resulting in a cumulative 1128 publications, 63 bilateral research projects, 24 technology deployments, 350 partnerships, and 30 patents and technology disclosures. These projects have directly resulted in 7 start-ups, hundreds of jobs, and increasing Canada-India business relations in the high-technology market during the overall 2013-20 period. To date, Canada-India partnerships have trained 1059 highly-qualified Canadian and Indian students, most of whom are masters, PhD, and postdoctoral fellows.

The year 2019-20 has seen an expansion in our co-operative projects and joint research with our partners in India and Canada. The University of Victoria and Simon Fraser University have joined our network as Affiliated Partner Universities, and our partnership with India's Department of Biotechnology (DBT) and Department of Science and Technology (DST) continues to grow.

A major focus of the 2018-19 year was the Ganga water project. From there we launched our Call with DBT, *Creating Wealth from Waste*, funding four promising new Canada-India projects and making progress on our long term goal of Ganga River rejuvenation. An additional six Canada-India projects were funded under our joint Call for Proposals with DST: *Cyber Physical Systems to Support Green Buildings in Smart Cities*.

We have also been working to expand our cooperative ventures with Indigenous communities in Canada. Two projects have been selected under our Call: *Innovation in Design and*

Construction of First Nations Housing, and IC-IMPACTS also accomplished a significant milestone this year by deploying a high-tech pavement in an Indigenous community.

Despite setbacks faced in 2020 due to COVID-19, we are pleased to have been granted an extended term with the NCE, and look forward to continuing our work with a renewed optimism. We are thankful to our Theme Leads, Dr. Stewart Aitchison and Dr. Damase Khasa, for their invaluable scientific contributions, to our Board of Directors for their commitments to our strategic planning and mandate, and to our Research Management Committee for their continued evaluation of our research portfolio which is founded on scientific excellence. We would also like to thank our amazing administration team, including our COO Mr. Shapoor Marfatia, for their significant contributions and support.

On behalf of the Board of Directors, we herein advise that IC-IMPACTS Centres of Excellence is in full compliance of the Representations and Warranties as described in Section 12 of the Funding Agreement.

Sincerely,

Mr. Barj Dhahan
Chairman of the Board of Directors,
IC-IMPACTS

Dr. Nemkumar Banthia
CEO & Scientific Director,
IC-IMPACTS

2019 — 2020 IC-IMPACTS NCE Annual Report

YEAR IN REVIEW

Mission and Vision

Since launching in 2013, IC-IMPACTS has been working hand-in-hand with communities in Canada and India to develop community-based solutions to the most urgent needs of each nation: poor water quality, unsafe and unsustainable infrastructure, and health problems arising from water-borne and infectious diseases.

This bilateral research model ensures on-the-ground change in local communities, where tangible results are felt by the people who need it most. IC-IMPACTS research is identified and driven by community need, with outcomes being deployed internationally — from Canada's Indigenous communities to rural villages in India. By addressing these urgent problems, IC-IMPACTS aims to create healthy communities in both nations through improved health and longevity, increased economic prosperity, and positive social change.

IC-IMPACTS is pleased to have been granted an extended term with the NCE, now ending in March 2023. Despite setbacks faced in 2020 due to COVID-19, we are excited to continue our mandate with renewed enthusiasm in the post-COVID climate.

IC-IMPACTS Achievements

FISCAL YEAR 2019 - 20	OVERALL 2013 - 2020 CUMULATIVE
RESEARCH PROJECTS & TECHNOLOGY DEPLOYMENTS	
11 Projects	63 Projects
3 Technology Deployments	24 Technology Deployments
9 Researchers	274 Researchers
OUTPUT: KNOWLEDGE TRANSLATION, HQP AND OTHER OUTCOMES	
41 Partners	352 Partners
158 Publications	1,128 Publications
1 Patents	29 Patents
113 HQP trained	1059 HQP trained
Consolidation phase. No new startups.	7 Startups

New Canada-India Research, Innovation, and Leadership Initiatives

IC-IMPACTS launched multiple Calls for Proposals in 2019 – 2020, and has selected more than ten promising and scalable research and demonstration projects with the potential to transform lives in Canadian and Indian Communities. The following projects were funded during the 2019-20 fiscal year:

IC-IMPACTS and the Department of Biotechnology, Government of India Joint Call for Proposals: Creating Wealth from Waste

This call was launched in response to the increasing agricultural demands to treat waste as a steady source of water and nutrients.

This joint IC-IMPACTS and DBT Call for Proposals was launched in February 2019, and called for biotechnology-driven research-based solutions that can be implemented in cities such as Delhi, Kanpur, and Varanasi, or in locations with similar geographies. The following successful proposals, announced in December 2019, have the potential to be developed as a commercially viable method to extract wealth from waste and be applicable to rejuvenating polluted bodies of water such as the River Ganga.

1. **Biopolymer-based Electrospun Membranes for Recovery of Heavy Metals from Industrial Wastewater**
   — Dr. Xianshe Feng (University of Waterloo) and Dr. Swanpali Hazarika (CSIR-North EastInstitute of Science and Technology)

   This project proposes to use 'electrospinning', a simple and versatile nanofiber production technique, to treat wastewater containing heavy metals before releasing it into the environment. This process would improve public health while dramatically reducing the cost of wastewater treatment for heavy metal recovery.
2. **Optimum Biocell for Tropical Climates**
   — Dr. Patrick Hettiaratchi (University of Calgary) and Dr. Sunil Kumar (CSIR – National Environmental Engineering Research Institute)

   The Optimal Biocell is a novel technology with enhanced energy recovery with cost-effective processes, greenhouse gas emission control, groundwater contamination control, and resource and space recovery as direct and indirect benefits. This project aims to build an optimum biocell in Thane using a mixture of municipal solid waste and sewage sludge as feedstock to generate renewable fuels like CNG.
3. **Biovalorization of Lignin**
   — Dr. Vikramaditya G. Yadav (University of British Columbia) and Dr. Syed S. Yazdani (International Centre for Genetic Engineering and Biotechnology)

This project proposes to develop a family of biocatalytic processes that convert lignin to pharmaceutical building blocks, flavouring agents, and drug delivery platforms. Biocatalytic processes are greener, emit less carbon dioxide and are more energy efficient than other alternatives.

4. **Development and scale-up of technology for microbial extraction of xylose from agro-waste materials and subsequent conversion into xylitol. Subtitle: Conversion of hydrolysed lignocellulosic residues into biopolymers for applications in composites**
   — Dr. Tatjana Stevanovic (Université Laval) and Dr. Baljinder Kuar (Punjabi University).

   This innovative project will establish a microbial biotransformation, consisting of xylose extraction by acid hydrolysis of agro-waste and its conversion into xylitol, using recombinant microbial strain to develop high-value food and pharmaceutical building blocks from lignin waste, which in most cases is currently burned.

IC-IMPACTS and the Department of Science and Technology, Government of India Joint Call for Proposals: Cyber Physical Systems to Support Green Buildings in Smart Cities

This joint IC-IMPACTS and DST Call for Proposals was launched in March 2019 to address the energy use, CO2 emissions, raw materials use, waste output, water consumption, and corresponding impacts on human health that come with living in urban areas. A UN report indicates that 54% of the world's population lives in urban areas, which is expected to increase to 66% by 2050, with most of the increase concentrated in Asia and Africa[1].

As a result, the need to build "green buildings" in conjunction with Smart Cities will minimize the impact on human health and the environment as well as reduce life cycle costs. Six proposals were chosen for funding in December 2019:

1. **Large Area Microbolometer Uncooled Focal Plane Arrays for Thermal Imaging**
   — Dr. Ghassan Jabbour (University of Ottawa) and Dr. Madhusudan Singh (IIT Delhi).

   As a result of rapidly growing populations in urban cities and gaps in safety code enforcement, utilities like electricity and gas pose serious risks in high-rise buildings. This research will develop low-cost thermographic imaging for reliable real-time temperature monitoring of potential risk areas (e.g. utilities) to detect potential disasters in advance.

[1] https://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html

2. **Carbon neutrality through combined CO2 capture and novel H2 technology with production of non-conventional fuels for smart cities**
   — Dr. Ibrahim Dincer (The University of Ontario Institute of Technology) and Dr. Subrata Borgohain Gogoi (Dibrugarh University Assam).

   In response to the acidification of oceans and rivers, as well as climate change, this project aims to develop a holistic strategy towards mitigating the environmental impact of global warming with alternative, synthetic, and environmentally-friendly fuels.
3. **Metawall: Metamaterial based lightweight panel wall for enhanced building acoustic and seismic resistance**
   — Dr. Sreekanta Das (University of Windsor) and Dr. Arnab Banerjee (IIT-Delhi).

   Light-weight wall panels are a popular option for thermal insulation, acoustic privacy, and reduced seismic demand; however, acoustic performance of these panels is very poor, and seismic performance varies. This project will provide a pathway to design a novel panel wall using metamaterials for both acoustic and seismic purposes.
4. **Metamaterial walls for improved acoustic performance in green building**
   — Dr. Umberto Berardi (Ryerson University) and Dr. Arpan Gupta (IIT Mandi).

   This project will develop a natural metamaterial, made of naturally available or recyclable material, to improve the acoustic environment in green buildings.
5. **Improving building energy demand predictions in Smart Cities through sensor observations and considerations of landscape characteristics**
   — Dr.Fitsum Tariku (British Columbia Institute of Technology) and Dr. Prasad Avinash Pathak (FLAME University).

   Energy consumption of buildings is a major challenge to the sustainability goals of cities. This project aims to improve Building Energy Models (BEM) to more accurately estimate a building's energy demand. This model will combine information from high-resolution satellite data and sensors for a more accurate and accessible reading.
6. **Harnessing the potential of renewable energy (Solar / Wind) for sustainable building energy management through Compressed Air Energy Storage**
   — Dr. Fariborz Haghighat (Concordia University) and Dr. V Gayathri (Vellore Institute of Technology).

   This project is focused on a novel concept of utilizing waste while meeting the thermal demands of the building, enhancing the overall roundtrip of efficiency of the storage system. This kind of system paves the way for the concept of 'net zero' buildings, where the proposed system with proper sizing and controls meets both thermal and electrical demands of building.

Call for Proposals: Innovation in Design and Construction of First Nations Housing
Housing challenges have plagued Canada's Indigenous communities, who are faced with poor construction, risks from mold, forest fires, extreme weather, seismic activities, and more. This call was launched after consultation with the Assembly of First Nations (AFN) and the development of the IC-IMPACTS First Nations Working Group, consisting of five members with significant and relevant construction experience in on-reserve communities. This call is dedicated to the design and construction of low-cost, resilient, energy efficient, and safe housing for Indigenous communities, an area of immediate and high priority for IC-IMPACTS.

1. **Wildfire House**
   — John Bass (University of British Columbia)

   Using a community health survey to establish a baseline of indoor air quality-related health concerns, the findings of this research will be integrated into viable building code and construction advancements and capacity-building programs developing local skills and locally sourced materials into a community-funded prototype house.
2. **Development of cost-effective, energy-efficient, and resilient housing technologies for First Nations communities**
   — Dr. Ashutosh Bagchi (Concordia University)

   This research focuses on developing a self-sufficient, resilient, solar-powered housing in Indigenous and remote communities. The self-sufficient solar-powered community will take advantage of renewable energy resources and address the issue of the extensive use of diesel fuel, which is not only costly, not sustainable, but also introduces health and fire hazards as many of those systems are not well-maintained.

Demonstrating advanced technologies in communities

With a primary aim of social transformation through research, IC-IMPACTS continues to focus on research projects that produce deployable technologies, approaches, and interventions for the benefit of target communities. With this aim in mind, IC-IMPACTS has a unique ongoing Call for Innovative Technology Demonstration projects open and accepting proposals throughout the year. Below are a few examples of current technology deployments:

Advanced Pavement Installation at Chawathil First Nation
Dr. Nemy Banthia, University of British Columbia, Canada

This internally cured concrete pavement was developed utilizing scrap tire fibers, cellulose fibers, and other recycled materials, giving it the ability to "self-heal", requiring less maintenance and lasting much longer than traditional concrete pavements. IC-IMPACTS successfully deployed this technology in Chawathil First Nation (near Hope, British Columbia)

in 2019.

In addition to improving the longevity of concrete, adding these fibers reduces landfill waste through the re-use of scrap tires and other recycled materials. In order to monitor the performance of the pavement, the team has embedded 30 solar-powered sensors that transmit data over the internet to IC-IMPACTS researchers. These health-monitoring sensors provide 24/7 data that will enable efficient future designs and improvements in the self-healing pavement technology. A similar version of this technology was installed in the community of Thondebhavi, India, in 2014.

Smart App-Based Rapid Multiplex Screening of HIV Associated Co-Infections of at Risk Populations at the Point-of-Care: A Demonstration Study in India
Dr. Nitika Pant Pai, McGill University, Canada

An estimated 300 million people worldwide are living with undiagnosed HIV and related co-infections. Lack of awareness, rampant social stigma, and discrimination impedes early screening, resulting in disease progression and serious reproductive issues in both men and women. Available screening methods take up time and money, usually entailing multiple visits which discourage individuals in rural communities from seeking help. This project, the *AideSmart! app based rapid point-of-care multiplexed co-infection screening strategy,* attempts to simplify this process by:

- Integrating any rapid point-of-care screening device for STIs
- Engaging and counselling patients
- Communicating test results
- Geotracking and rapidly linking participants to the nearest provider or facility.

This project aims to improve the knowledge and skill sets of frontline health professionals, offer them certification and proficiency training in point-of-care technologies, create a cadre of skilled, trained, and certified frontline lab technicians and counsellors.

PERFORMANCE AGAINST PROGRAM REVIEW CRITERIA AND NETWORK OBJECTIVES

Excellence of the Research Program

The following examples from each of IC-IMPACTS three themes demonstrate the relevance of the Canada-India bilateral research and application model:

Theme 1 – Safe and Sustainable Infrastructure

WildFire House Prototype
John Bass, University of British Columbia, Canada

Indigenous communities in Interior British Columbia are suffering at the intersection of two crises: housing and climate change. In addition to wildfires, which increase in size and intensity each year, problems of mold, overcrowding, and improper ventilation plague existing housing in the Yunesit'in community. Using a community health survey to establish a baseline of indoor air quality-related health concerns, the findings of this research will be integrated into viable building code and construction advancements and capacity-building programs developing local skills and locally sourced materials into a community-funded prototype house.

As with all of IC-IMPACTS' engagements with Indigenous communities, this demonstration project was born out of collaboration and equal partnership between the Yunesit'in Government and the research institutions involved.

Mobile App for Improving Survival in Fires through Efficient Egress: The Role of Impromptu Indoor WiFi Localization and Georeferenced Building Maps
Dr. Raja Sengupta, McGill University, Canada
Dr. Ashwin Srinivasan, BITS Pilani Goa Campus, India

This project will develop a Mobile App to assist in emergency evacuations from public buildings, made possible through the convergence of three new technologies. The first is *WiFi-based Indoor Localization*, which will accurately locate users indoors through WiFi, where traditional GPS receivers would not work. The second is *georeferenced buildings combined with 3D topology*, allowing buildings and their exit routes to be precisely mapped out. The third is wayfinding using shortest path algorithms on the 3D topology, which when combined with visual and oral guidance, identifies the quickest and easiest way to exit the building. This app will also be able to estimate the number of people using each pathway, and re-route individuals to alternate exits to avoid stampede conditions.

This technology will be tested in partnership with the Indigenous community of Wemindji.

Theme 2 – Integrated Water Management

Testing and Upscaling Phytoremediation Technology in Real-World Conditions
Dr. Damase Khasa, Université Laval, Canada
Dr. Manzoor Shah, University of Kashmir, India

This demonstration project has tested the potential of the 'hydrophytoremediation' technique as a low-input phytotechnology to remove heavy metals from contaminated aquatic ecosystems. It will be the first demo project of its kind to conduct real-world in situ testing of this innovative model for bioremediation byphytobial filtration (plants and microbes) of

chemically and biologically contaminated aquatic ecosystems. Field work for this project has been postponed to summer 2021 due to COVID-19.

Biovalorization of Lignin
Dr. Vikramaditya G. Yadav, The University of British Columbia, Canada
Dr. Syed S. Yazdani, International Centre for Genetic Engineering & Biotechnology (ICGEB), India

'Biorefining' is defined as the separation, isolation and conversion of cellulose, hemicellulose and lignin from lignocellulosic biomass into fuels, chemicals, materials and energy.

While a number of processes have been developed over the years to produce valuable products from cellulose and hemicellulose, very few processes utilizing lignin have been achieved, largely owing to the severe unruliness of lignin. Our inability to utilize lignin is a lost opportunity for the green economy, as it is abundant and can provide a myriad of chemicals that could be used as building blocks for life-saving pharmaceuticals or even as flavours and food ingredients.

Theme 3 – Public Health

A Portable Fever Kit for Dengue and Chikungunya
Dr. J. Stewart Aitchison, University of Toronto, Canada
Dr. Manoj Verma, IISc Bangalore, India

Dengue and Chikungunya, both viral infections carried by mosquitoes, have very similar symptoms despite being different diseases. Both are prevalent in India, but because of an overlap in symptoms, it is often difficult to know which infection is present and what treatment is required.

This project aims to develop a portable fever kit that can differentiate between the viral infections of dengue and chikungunya. The result will be a cartridge-based test that will operate using a single finger stick capillary blood sample, and be as easy to operate as a conventional blood sugar meter. This will quickly determine the cause of symptoms, simplifying the diagnostic process and making treatment faster and more accurate.

Researchers have successfully developed a proof of concept test which can simultaneously detect the presence of the NS1 protein for Dengue (an early stage marker) and the IgG response of the body (a late stage marker).

Citizen-lead Evaluation of the Public Health Response to COVID-19 in India: Harnessing Information and Communications Technology (ICT) to Promote Real-Time learning, Human Rights and Good Governance
Dr. Mira Johri, Université de Montréal, Canada
Dr. Aaditeshwar Seth, IIT Delhi, India

Mobile Vaani (MV) is a federated network of voice-based community media platforms running in several Indian districts and used by rural and low-income populations. The participative, voice-based nature of the platform has proven to be very relevant for people with fewer technology or literary skills.

This project will deploy MV technology and volunteer networks to support communities and governments in India in responding to the COVID-19 emergency. It's key activities are:

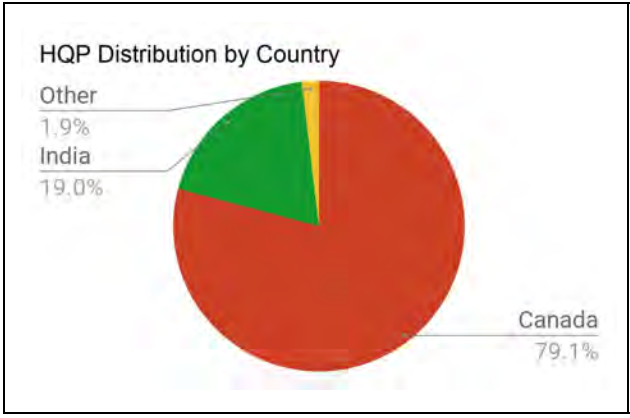
- Issues raised by callers to the MV network will be tagged and mapped in real time, to provide a dynamic portrait of COVID-19 cases, and the socio-economic dimensions of the disease and related control measures.
- Ground-level volunteer network will be mobilized to connect people in need of help with organizations and authorities who can be of assistance to them.

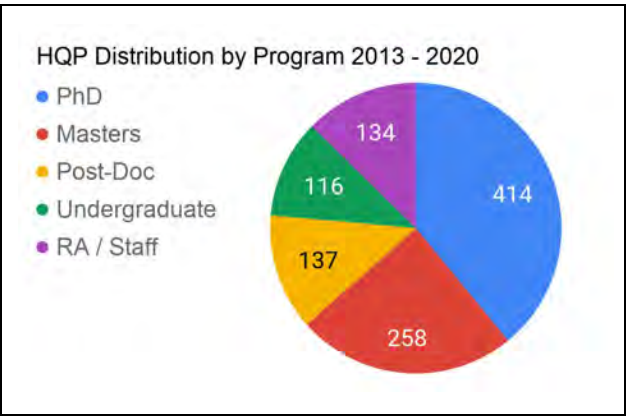
Development of Highly Qualified Personnel

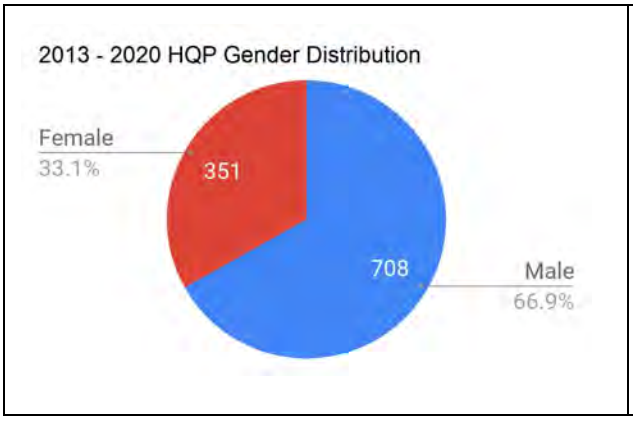
HQP Stats

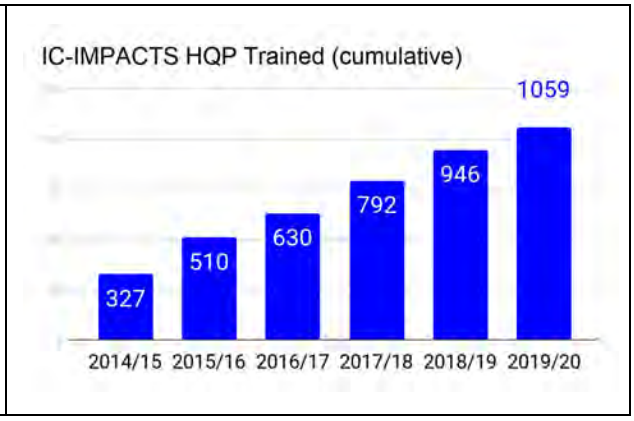
Since 2013, IC-IMPACTS has trained a total of 1059 HQP. 838 (79%) are Canadian and 221 (21%) are international, with 201 (19%) HQP from India and 20 (2%) from other countries. IC-IMPACTS HQP is made up of 13% Postdoctorals, 39% PhD students, 24% Masters, 11% Undergraduate and 13% others.

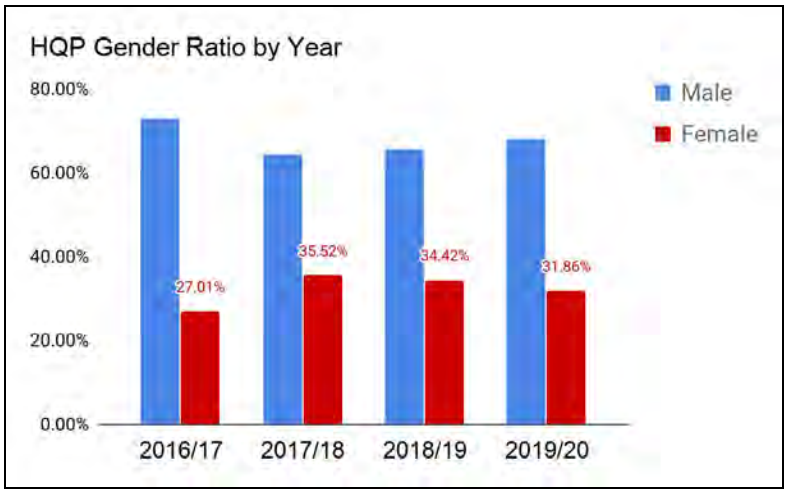
In 2019-20, IC-IMPACTS continued to exceed our goals with 113 HQP trained through ongoing research and technology deployments











Female participation among HQP has been trending upward. Current female participation for 2019-20 is at 32%, comparing favourably with the engineering industry, which has markedly low female representation. UBC reports that women make up 26% of its engineering students.[2]

HQP Jobs and Start-ups

HQP Alumni have a 90% success rate in finding employment within their chosen field. Some of our HQP have also launched start-up companies, which are directly responsible for the creation of approximately 37 jobs (and growing).

Below is a list of featured start-up companies based on IC-IMPACTS research:

Company	HQP / Student(s)	University	Province	# of Employees
Buyuanxiar Inc.	Si Pan	McMaster University	ON	2
Tricca Inc.	Sheetal Rimal, Uzma Zehri	Université Laval	QC	2
HRG Infrastructure	Harsh Rathod	University of Victoria	BC	5

[2] https://apsc.ubc.ca/about/facts-and-figures#gender

INpact	Dylan Verburg	University of Windsor	ON	2
Boost Environmental Systems Inc.	Indre Tunile, Dylan Purdue, Rony Das	University of British Columbia	BC	2 - 4
Mithra Sustainable Solutions	Negar Roghanian	University of British Columbia	BC	3
ChipCare	James Dou, Srishti Garg	University of Toronto	ON	20
Total				**36 - 38**

HQP Leadership Awards

The HQP Leadership Awards are dedicated to supporting university students in achieving their strategic goals by giving students the opportunity to design, manage, and lead workshops, short conferences, or projects related to their research program and aligned with one of IC-IMPACTS thematic areas. In light of the continued impacts of COVID-19, IC-IMPACTS has offered an online version of this award, encouraging students to maintain social distance and host online events. The following HQP Leadership Awards were awarded in 2019-2020:

1. **Water and Environment Student Talks (WEST 2019)** led by HQP Abhishek Dutta, University of British Columbia, June 2019
2. **Workshop on Detecting Electrically Charged Biomolecules (DECBio'2019)** led by HQP Amanpreet Singh, L'Université de Sherbrooke, June 2019.
3. **Citizen Science, Open Data, and Water Monitoring Workshop** in Bangalore, India, led by HQP Shyam Thomas, Ryerson University, July 2019.

IC-IMPACTS Student Engagement Committee (SEC)

The Student Engagement Committee is an active student body that connects with IC-IMPACTS students and alumni, both in Canada and India. The chair of the committee has a seat on the IC-IMPACTS Board of Directors. In response to COVID-19, the SEC compiled a list of resources for Indian students in Canada, with information on visa renewals and instructions to register with India's Consular Services.

HQP Training

All HQP participate in bilateral research teams, where they experience different research approaches, perspectives, and processes. IC-IMPACTS projects provide HQP with direct training in the applied aspects of research, where they can observe the impact of the project and interact with end-user communities. IC-IMPACTS' community-based research provides a

unique opportunity for students to participate in transforming ideas from the lab to communities around the world.

These practical skills taught and relationships built help IC-IMPACTS HQP achieve their goals, with alumni data indicating that 40% find employment in industry, another 40% find employment in academia, and 20% end up in other areas. Over 90% of IC-IMPACTS HQP alumni are employed in their chosen field.

Networking and Partnership

IC-IMPACTS Network Expansion – New Partnerships

IC-IMPACTS is expanding its network by creating new partnerships with contributing universities, NGOs, industry leaders, and community organizations with a renewed focus on demonstrating technologies in communities.

University Partners

Network Partnership Agreements

The University of Victoria and Simon Fraser University have both signed affiliated network agreements with IC-IMPACTS, marking new partnerships to advance student and faculty collaborations between Canada and India.

IC-IMPACTS will work with both universities in promoting student-led leadership workshops, summer institutes, and technology demonstration projects in India and Canada. University partnerships give university students and faculty members the opportunity to attend events with Indian educational institutes, interact with Indian industry leaders, and create student internship and HQP entrepreneurial training opportunities

New Network Members 2019-2020

The following universities have joined the IC-IMPACTS network as members this fiscal year:

- Ryerson University
- University of Waterloo
- University of Ottawa
- University of Ontario Institute of Technology
- British Columbia Institute of Technology

International Partners

The Centre's unique partnership with the Department of Science and Technology (DST) and the Department of Biotechnology (DBT) have been critically important in providing an Indian perspective, setting the direction of Calls for Proposals, and financially supporting Indian academic participation in the IC-IMPACTS research program. The relationship with DST and DBT has expanded and enhanced the strategic networks and partnerships in Canada

and India to build capacity and improve the international reputation of both Canada andIndia.

In February 2020, IC-IMPACTS Leadership visited the Visvesvaraya National Institute of Technology (VNIT) campus in Nagpur, India, where he met with Director Padole, Dr. Peshwe & Mr. Acharya for a discussion on future research collaboration. Mr. Dhahan also met with Dr. Sarbjot Singh Behl, Dean of Academic Affairs & Student Welfare at Guru Nanak Dev University in Amritsar, Punjab, to discuss bilateral Canada-India research and student mobilization.

Featured Partners

IC-IMPACTS is grateful to our NGO partners who contributed by providing financial support to the Centre. IC-IMPACTS partnered with Praxis Spinal Cord Institute (formerly the Rick Hansen Institute) and Indian Spinal Cord Injuries Centre (ISIC) to fund multiple bilateral projects related to spinal cord injury. In December 2019, the three organizations co-hosted the second Design Thinking Workshop, an Indo-Canadian Workshop in New Delhi to Augment Treatment Approaches for Spinal Cord Injury Patients.

IC-IMPACTS is also grateful to the Canada-India Education Society (CIES) for their financial contributions and support. CIES is not-for-profit organization supporting education, health care, and job creation to transform communities in Canada and India and has been supportive of IC-IMPACTS' mission and vision, with the shared goal of community transformation in Canada and India.

IC-IMPACTS has established a number of partnerships in India as well. To preserve and strengthen these relationships, IC-IMPACTS has taken initiatives such as the Annual India Week, to meet with our Indian partners in-person for a week and provide an opportunity for our Canadian PIs to interact as well.

Notable Events

- IC-IMPACTS Annual Research Conference – June 20 and 21, 2019 – Vancouver, Canada
- IC-IMPACTS in Collaboration with IIT Alumni Association of BC: Cracking the Code: Entrepreneurship tn Canada – September 28, 2019 – Vancouver, Canada
- IC-IMPACTS Science and Technology Innovation Dialogue – December 9, 2019 – New Delhi, India
- IC-IMPACTS Design Thinking Workshop – December 10, 2019 – New Delhi, India
- IC-IMPACTS SEC - Commercialization of Technologies in India and Canada Workshop – December 13, 2019 – Ahmedabad, India
- IC-IMPACTS in Collaboration with the IIT Alumni Association of BC: A Saga of Inclusive, Sustainable and Frugal Innovations from and for Grassroots: Lessons from the Honey Bee Network – March 10, 2020 – Vancouver, Canada

Knowledge and Technology Exchange and Exploitation

IC-IMPACTS PIs have published a vast amount of works, including 158 in the last year alone. Since 2013, IC-IMPACTS research has generated 1128 scholarly publications. Our PIs have a large number of technology disclosures, some of which are in the patenting process in collaboration with their respective universities.

Several of IC-IMPACTS' funded projects have involved workshops and training for the local community. Dr. Bruno Lee and Dr. K. Srinivas Reddy held two workshops to dissimilate the research and findings of their project: *Solar Energy Powered Net-Zero Energy Smart Buildings*. The *Design Integration towards NZEB Workshop* was held in June 2019 and attracted over 45 participants, with speakers including both PIs and Co-PIs from Canada and India. The *Heat Pump Integration in High-Performance Buildings Workshop,* held in August 2019, focused on work with IC-IMPACTS and Canadian application of this technology, and was attended by more than 100 international participants.

Dr. Mira Johri's project, *Dialled In: Tapping Community Voice To Improve Child Immunization Services In India*, involves the training of over 50 community members who originate from the rural areas served. These team members are learning computer usage for communication, presentations, data entry, and knowledge retrieval.

Management of the Network

Supporting the success of IC-IMPACTS is a team of highly skilled professionals who facilitate national and international communication and provide a platform to collaborate, exchange ideas, and build connections between Canada and India.

Having a multi-cultural understanding and knowledge of multiple country regulations, this team is skilled in managing and problem solving the complexities of Canada-India projects. IC-IMPACTS' Vancouver-based team interfaces with over 60 principal investigators and 50 HQP in Canada, and an equal number of people working on over 40 bilateral projects at any given time.

At an early stage of the COVID-19 outbreak, we took immediate steps to protect the health and safety of our people, mobilizing our work-from-home plan. We not only safeguarded our staff, but also provided support and direction to a large number of HQP, researchers, and international partners during an extremely uncertain time. More information on our COVID-19 response is detailed in Section C. An overview of our organizational structure and brief profiles of the team is attached in Annexure II.

TRENDS AND JUSTIFICATIONS

Impact of COVID-19 Pandemic

As IC-IMPACTS research takes place across Canada as well as across international borders, COVID-19 has had a significant effect on our work. India entered an extended lockdown period in response to the virus, temporarily putting a halt to our collaborative ventures. Cross-Canadian collaboration has also been made difficult, as researchers face varied circumstances in different provinces. As of June 2020, research and deployments have mostly come to a halt, but after our recent NCE extension, we are hopeful for a quick recovery.

In response to the COVID-19 Pandemic, IC-IMPACTS has utilized its unique role as a Canada-India Research Centre to solicit proposals based out of collaboration between both countries. The bilateral nature of IC-IMPACTS research offers a unique perspective on the global impacts of this crisis. Our ongoing Call for Innovative Demonstration Initiatives has been re-purposed to seek COVID-related proposals; we have received several inventive high-quality proposals, which we look forward to watching grow over the next year. Both DST and DBT have reached out to IC-IMPACTS and expressed serious interest in new collaborations directly related to COVID-19.

IC-IMPACTS has reached out to international students to offer resources and support during this time. We have encouraged students to participate in weekly online seminars, both as speakers and attendees. We have additionally launched a dedicated Online HQP Leadership Award, similar to the standard HQP Leadership Award but moved online to encourage continued physical distancing. The Centre has been working in a completely online mode ever since the gravity of the pandemic was made clear. All staff have been working from home to ensure their safety and the safety of the larger public.

NETWORK-LEVEL PERFORMANCE

Commitment to Equity, Diversity, and Inclusion

As an international research Centre, IC-IMPACTS is acutely aware of the benefits brought to innovation through diversity; having a wide range of knowledge and perspectives is invaluable when it comes to research and deployment in a community setting. We are also aware of the current lack of diversity in science and engineering, and the barriers that continue to prevent underrepresented groups from full participation. IC-IMPACTS aims to eliminate these barriers and create an equitable environment of support and respect.

Our commitment to equity, diversity, and inclusion is built into all IC-IMPACTS steering committees as a key responsibility, and these principles are considered carefully during the review process. We are fortunate to have multiculturalism built into our foundation as a

Canada-India Research Centre, and the majority of IC-IMPACTS researchers belong to at least one of the four federally designated groups.

IC-IMPACTS is headquartered in Vancouver and hosted by the University of British Columbia on the traditional, ancestral, and unceded territory of the Musqueam people. The inclusion of Canada's Indigenous communities in research and innovation is a major priority for IC-IMPACTS, exemplified by our Call for Proposals and multiple projects with an Indigenous focus.

Top Achievements and Progress on Targets

Our identified targets from our 2018-19 Annual Report were as follows:

1. **Continue to make progress on our core goal of working as a facilitator of Canada-India collaboration**.
   10 new collaborative Canada-India projects have been funded in 2019-20 in areas that are beneficial to both countries. We look forward to continuing collaboration with India's DBT and DST to launch additional bilateral calls in the years to come.
2. **Continue to deepen our engagement with Canada's First Nations communities.**
   This year has seen a new technology deployment within an Indigenous community, and two new projects funded under our Call for Proposals: Innovation in Design and Construction of First Nations Housing.
3. **Supporting HQP innovations and ideas through the HQP Leadership Awards and Webinars.**
   IC-IMPACTS maintains an open call to fund HQP initiatives to encourage students in achieving strategic goals, such as developing a research or industry partnership or running a university-level course. In view of COVID-19, we have transitioned to a fully online webinar series managed by students.
4. **Launch strategic initiatives to promote workshops, conferences, and collaborations that will lead to commercialization of IC-IMPACTS technology.**
   The IC-IMPACTS Students Engagement Committee held the first *Commercialization of Technologies in India and Canada Workshop* this past fiscal year in Indian Institute of Management, Ahmedabad, India. IC-IMPACTS has continued to work online and supported canadian and indian entrepreneurs with contacts, advice, deployments and webinars to bring together people to people connections in both Canada and India.

Closing Remarks: Looking forward to a gradual recovery from COVID-19 in 2020-21

As is evident from the preceding pages, IC-IMPACTS' bilateral model has proven to be very successful since its inception in 2013, and has consistently exceeded its established targets.

We are now thankful to receive an extension to March 31, 2023 to compensate for the delays created by the COVID-19 pandemic. Our targets for the next year are as follows:

1. In the post-COVID-19 era, India will emerge as one of the fastest-growing markets, our largest research partner, and a reliable diplomatic and trade ally of Canada. We at IC-IMPACTS are committed to facilitating Canada-India collaboration by launching new Calls for Proposals with the Department of Biotechnology (DBT) and the Department of Science and Technology (DST), both premier Indian government funding agencies. In particular, for the remaining part of our mandate, we'll focus entirely on technology deployment and commercialization. Towards this end we have already launched a Call, "*Ideas to Prototyping and Commercialization (I2PC)*", and both DST and DBT have agreed to support these Calls with matching funds. If any higher TRL research is needed before a potential demonstration of technology can occur, we remain committed to supporting it.
2. We will further strengthen our engagements with Canada's Indigenous communities by following up on our successes. In particular, an advanced self-healing pavement installed in Chawathil First Nation, BC, is now providing IC-IMPACTS researchers with 24/7 live data through sensors embedded in the concrete using solar-powered internet connectivity. Leading by example, we are now in consultation with three other First Nations communities to demonstrate advanced technologies in waste-water treatment, green-house construction, fishery infrastructure, and 3D printed homes. These deployments will open up co-learning opportunities for IC-IMPACTS researchers and HQP, and directly benefit our Indigenous communities.
3. In the coming years, we'll devote significant efforts to creating models that ensure our sustainability beyond March 31, 2023. We have already started discussions with Canadian companies (some of our own startups) and various national and international agencies (including DBT, DST) towards building a sustainable future research program in areas such as food security, robotics, ICT, public health, water, and civil infrastructure.
4. We will continue to support innovations and ideas by facilitating HQP-led entrepreneurship, workshops, café-scientifique, round-tables, and seminars in an online working environment.
5. We'll continue to prioritize equity, diversity, and inclusion throughout all aspects of our work.
6. IC-IMPACTS has transitioned to an online mode of work and collaboration in recent months. We will continue to reach out to all our stakeholders, including partner universities, students, pan-Canadian researchers, colleagues in India, funding agencies, industry partners, and not-for-profit organizations through online media. Our office has established online working protocols, and we will continue to strengthen innovations to meet future challenges.

We recognize the difficulties and uncertainties COVID-19 has created, and remain committed to all our stakeholders and especially our students. We continue to work with optimism and excel in collaborative international research, deploy research outcomes in Indigenous communities, and continue to focus on training of IC-IMPACTS HQP.

ANNEXURE I: Photo Gallery

EVENTS




IC-IMPACTS Annual Vancouver Research Conference, June 2019


IC-IMPACTS Science and Technology Innovation Dialogue, December, 2019, New Delhi

The 'Design Thinking Workshop', hosted by the Indian Spinal Injuries Centre in collaboration with IC-IMPACTS and Praxis Spinal Cord Institute, December 2019, New Delhi

HIGHLY QUALIFIED PERSONNEL

SEC-hosted Commercialization of Technologies in India and Canada Workshop, December 2019 in Ahmedabad, India

HQP-Led Workshop on Detecting Electrically Charged Biomolecules (DECBio'2019) at L'Université de Sherbrooke

NETWORKING AND PARTNERSHIP

Dr. Nemy Banthia and Mr. Barj Dhahan with DBT Leadership on a visit to India, February 2020

IC-IMPACTS and DST announcing winners of joint Call for Proposals, Cyber-Physical Systems to Support Green Buildings in Smart Cities, December 2019

Dr. Banthia with Dr. Joy Johnson, Vice-President, Research and International, Simon Fraser University at the signing of the SFU Network Partnership Agreement

Dr. Banthia with Professor Jamie Cassels , President and Vice-Chancellor, University of Victoria at the signing of the UVic Network Partnership Agreement

Dr. Banthia with Dr. A. K. Mukherjee, Director General of ISIC (left) and Mr. Bill Barrable, CEO of Praxis Spinal Institute (right), December 2019

Dr. Banthia (middle) with senior leadership of Visvesvaraya National Institute Of Technology, January 2020

PROJECT HIGHLIGHTS

Smart Infrastructure with High Fracture Toughness, Durable Concrete Employing Large Amounts of Industrial Waste
Dr. Nemy Banthia, University of British Columbia, Canada

Construction of the parking lot demonstration site in Chawathil First Nation, Hope, BC.

Sensors embedded in the pavement

Completed and painted parking lot

A High Performance Advanced Septic (HPAS) System for Villages and Roadside Restaurants

Dr. Edward McBean, University of Guelph, Canada

Dr. Y. Ramji Satyaji Rao - National Institute of Hydrology, India

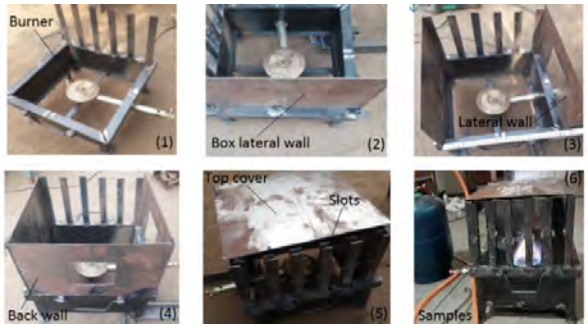
PI, Co-PI, and students in front of signage at the deployment site

Workshop on High Performance Septic System (HPAS) for Villages and Roadside Restaurants

Construction of the HPAS

HPAS before final soil layer placement

Improving Fire Safety of Structures Through the Development of Fire Retardant Laminated Glass Glazing
Dr. Maged Youssef, Western University
Dr. Ajitanshu Vedrtnam, Invertis University



Components of the fire testing setup

Passive Fire Testing Setup

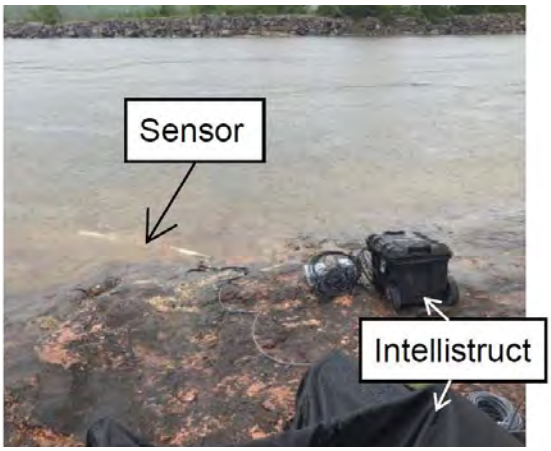
Solar Energy Powered Net-Zero Energy Smart Buildings
Canadian Lead: Dr. Bruno Lee, Concordia University
Indian Lead: Dr. K. Srinivas Reddy, IIT Madras

Design Integration towards NZEB Workshop, held June 25, 2019. The speakers of the workshop included Canadian PI and co-PI, and Indian PI, Dr. Reddy from IIT-Madras.

Heat Pump Integration in High-Performance Buildings Workshop held on August 24, 2019. The workshop attracted more than 100 international participants.

Scour Monitoring of an Overwater Bridge in Manitoba using Dissolved Oxygen (DO) probes
Dr. Fae Azhari, University of Toronto, Canada

Research team at the deployment site



Setup of scour monitoring sensor

On-site preparation

Prototype of the sensor

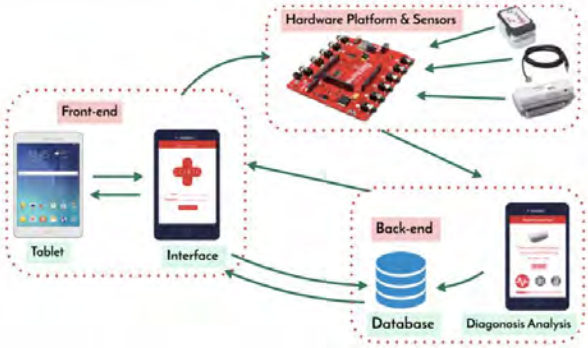
Contaminated land reclamation using hybrid absorbable landscape and native plant species with real time monitoring to improve public health in Punjab

Dr. Rishi Gupta, University of Victoria, Canada

Dr. Neeta Raj Sharma, Lovely Professional University, India

Workshop at the University of Victoria, BC,

Workshop at Lovely Professional University,

Canada	Phagwara, India
 Genetically modified poplar plants	 Carwash Demonstration Site at LPU
A Portable Fever Kit for Dengue and Chikungunya Dr. J. Stewart Aitchison, University of Toronto, Canada Dr. Manoj Verma, IISc Bangalore, India	
 Clinic in a box next to the Chipcare prototype with test cartridges	 Schematic showing the components for the clinic in a box, including the tablet based front end, hardware sensors and backend machine learning module

ANNEXURE II: Project List

THEME 1: Safe and Sustainable Infrastructure **List of Projects**
Sustainable Infrastructure Using Smart FRPs Canadian Lead: Dr. Shamim Sheikh, University of Toronto *This project will develop more durable and life-extending techniques for concrete infrastructure using a technique for the upgrade of concrete columns that reduces and even eliminates the rate and risk of corrosion.*
Conservation Of Heritage Masonry Structures Within Cauvery Basin Waterworks Canadian Lead: Dr. Vivek Bindiganavile, University of Alberta *This project will develop new techniques to repair and rehabilitate heritage masonry, for which modern building materials and binders are inadequate in preserving the integrity of their heritage value.*
Modelling And Assessment Of Deficient And Repaired Structures Canadian Lead: Dr. Frank Vecchio, University of Toronto *This project presents a new focus for developing state-of-the-art analysis tools for concrete structures so that an assessment can be undertaken to determine if a structure is deteriorating to the point where rehabilitation or strengthening is required.*
Characterization And Use Of Industrial Fly Ash Canadian Lead: Dr. Daman Panesar, University of Toronto *This study examines various aspects in order to effectively increase the use of fly ash in infrastructure and construction. Worldwide, the cement industry is under pressure to reduce greenhouse gas emissions and energy consumption and a number of initiatives have been taken to address these concerns. Industrial by-products (ex. fly ash, slag) have been used as supplementary cementing materials resulting in several benefits, including lowering the environmental impact of concrete.*
Structural Health Monitoring Of Tall Buildings Using Vibration-Based Techniques Canadian Lead: Dr. Lucia Tirca, Concordia University *This research project aims to develop an efficient instrumentation strategy for SHM for tall and mid-rise buildings to monitor their static and dynamic behaviour and assess the structural conditions.*
Evaluating The Integrity Of Railways Infrastructure In India And Canada With An Emphasis On Bridges And Tracks Canadian Lead: Dr. Mustafa Gul, University of Alberta *Aging and deteriorating civil infrastructure systems are among the most significant challenges faced by our modern societies in Indian and Canada. This project will use structural health*

monitoring techniques to evaluate the current condition and anticipated remaining lifespan of railway bridges and tracks in Canada and India.

Full Field Non-Contact Shm Protocols For Long Span Railway Bridges And Heritage Structures
Canadian Lead: Dr. Rishi Gupta, University of Victoria
This research project will synthesize the state-of-art technologies available for SHM of civil structures, efficiently incorporate UAVs and contemporary electronic systems, with particular focus on inspecting transportation structures like bridges.

Application Of Precast Products Made Using Bottom Ash And Fly Ash For Rural Pavements And Other Infrastructure In India
Canadian Lead: Dr. Rishi Gupta, University of Victoria
This project will focus on developing mixes that utilizes bottom ash for producing both cement-less concrete and also as fine aggregate in concrete. A Geopolymer mix will be developed exclusively for the precast industry. The focus of this project will be on implementation of this material as a low-cost alternative for rural pavements in India. Pavers constructed using theism aerial will be used in the Canadian environment to create permeable landscapes in urban environments.

High Fracture Toughness, Durable Concrete with Minimized Carbon Footprint Employing Large Amounts of Industrial Wastes
Canadian Lead: Dr. Nemkumar Banthia, University of British Columbia
This research program aims to contribute to the development of innovative pavements, enhance detection of corrosion in reinforced concrete bridges, undertake research in seismic strengthening for BC schools, and improve durability and performance of innovative materials.

Urban Heat Island effect and building energy demand: linkages explained using a dense, low cost sensor network
Canadian Lead: Dr. Raja Sengupta, McGill University
Indian Lead: Dr. Prasad A. Pathak, Shiv Nadar University
The research aims to understand the relationship between Urban Heat Island (UHI) intensity and building energy demands using real world quantitative data. Using open source hardware-software platforms, the research team will build and deploy a low-cost sensor network for UHI mapping and indoor temperature-humidity mapping. The data will be used together with information on conditions external to the building to develop a model linking UHI intensity and urban morphology.

Smart Sensor Deployment in Buildings: Evacuation Planning and Energy Management
Canadian Lead: Dr. Mark S. Fox, University of Toronto
Indian Lead: Dr. Krithi Ramamritham, IIT Bombay
The project will instrument two office buildings and several homes to gather detailed usage data and inform the researchers on peak usage capping, demand response and emergency evacuation. The end product of the research will be a family of algorithms, ontologies and

prototypes that will provide better building energy management and building evacuation.
India-Canada Initiative for Resilient Global Urban Shelter Canadian Lead: Dr. Constantin Christopoulos, University of Toronto Indian Lead: Dr. Ravi Sinha, IIT Bombay *The primary objective of this project is to develop new cost-effective seismic isolation platform (SIP) concepts that can be mass implemented for the most commonly designed buildings in urban settings in India.*
Solar Energy Powered Net-Zero Energy Smart Buildings Canadian Lead: Dr. Bruno Lee, Concordia University Indian Lead: Dr. K. Srinivas Reddy, IIT Madras *The research project aims to identify optimal configurations of building technologies that are suitable for the local climatic conditions and construction practices to achieve the aggressive design goal of net-zero energy buildings (NZEB) in which locally produced energy from renewable energy sources is at least equal to the energy consumer over an average year.*
Energy and Water Disaggregation for Non-Intrusive Load Monitoring in Buildings Canadian Lead: Dr. Ivan Bajic, Simon Fraser University Indian Lead: Dr. Angshul Majumdar, Indraprastha Institute of Information Technology - Delhi *The research proposes to improve sustainability in water and energy through improved non-intrusive load monitoring (NILM). Specifically, the project aims to improve disaggregation techniques and propose a new area of cross domain disaggregation.*
Mobile App for Improving Survival in Fires through Efficient Egress: The Role of Impromptu Indoor WiFi Localization and Georeferenced Building Maps Dr. Raja Sengupta, McGill University, Canada Dr. Ashwin Srinivasan, BITS Pilani Goa Campus, India *This project will develop a Mobile App to assist in emergency evacuations from public buildings, made possible through the convergence of three new technologies.*
Improving Fire Safety of Structures Through the Development of Fire Retardant Laminated Glass Glazing Canadian Lead: Dr. Maged Youssef, Western University Indian Lead: Dr. Ajitanshu Vedrtnam, Invertis University *This project aims at developing fire-resistant laminated glass that has improved post-breakage performance during fires. The developed glass will contain the fire, and, thus, improve the safety of high-rise buildings.*
Fire Performance of Aged Reinforced Concrete Structures Canadian Lead: Dr. Mark F. Green, Queen's University Indian Lead: Dr. Umesh Kumar Sharma, IIT Roorkee *This project will design new reinforced concrete structures for better fire performance and to develop suitable fire-resistant repair strategies for corroded and aged existing structures.*

Assessment of Fire Performance of Structural Elements and Structural Systems Through Conventional Fire Tests and Hybrid Fire Simulation Canadian Lead: Dr. Oh-Sung Kwon, University of Toronto Indian Lead: Dr. Dipti Ranjan Sahoo, IIT Delhi *This project aims to deploy full-scale and multi-site hybrid fire simulation in the national fire laboratories of Canada (National Research Council) and India (Central Building Research Institute.*
Development of cost-effective, energy efficient, and resilient housing technologies for First Nations communities Canadian Lead: Dr. Ashutosh Bagchi, Concordia University *This research focuses on developing a self-sufficient, resilient, solar-powered housing in Indigenous and remote communities. The self-sufficient solar-powered community will take advantage of renewable energy resources and address the issue of the extensive use of diesel fuel, which is not only costly, not sustainable, but also introduces health and fire hazards as many of those systems are not well-maintained.*
Innovative Field Demonstration of Sustainable Infrastructure Canadian Lead: Dr. Shamim Sheikh, University of Toronto *This project aimed to rehabilitate corroded columns in a chemical plant in Gujarat, India using three different techniques. One of these techniques involves the use of FRP without removing contaminated concrete or steel while making the structure water and air tight. This technique has been tested and validated on structures in Toronto.*
Large Area Microbolometer Uncooled Focal Plane Arrays for Thermal Imaging Canadian Lead: Dr. Ghassan Jabbour, University of Ottawa Indian Lead: Dr. Madhusudan Singh, IIT Delhi *As a result of rapidly growing populations in urban cities and gaps in safety code enforcement, utilities like electricity and gas pose serious risks in high-rise buildings. This research will develop low-cost thermographic imaging for reliable real-time temperature monitoring of potential risk areas (e.g. utilities) to detect potential disasters in advance.*
Carbon neutrality through combined CO2 capture and novel H2 technology with production of non-conventional fuels for smart cities Canadian Lead: Dr. Ibrahim Dincer, The University of Ontario Institute of Technology Indian Lead: Dr. Subrata Borgohain Gogoi, Dibrugarh University Assam *In response to the acidification of oceans and rivers, as well as climate change, this project aims to develop a holistic strategy towards mitigating the environmental impact of global warming with alternative, synthetic, and environmentally-friendly fuels.*
Metawall: Metamaterial based lightweight panel wall for enhanced building acoustic and seismic resistance Canadian Lead: Dr. Sreekanta Das, University of Windsor

Indian Lead: Dr. Arnab Banerjee, IIT-Delhi *Light-weight wall panels are a popular option for thermal insulation, acoustic privacy, and reduced seismic demand; however, acoustic performance of these panels is very poor, and seismic performance varies. This project will provide a pathway to design a novel panel wall using metamaterials for both acoustic and seismic purposes.*
Metamaterial walls for improved acoustic performance in green building Canadian Lead: Dr. Umberto Berardi, Ryerson University Indian Lead: Dr. Arpan Gupta, IIT Mandi *This project will develop a natural metamaterial, made of naturally available or recyclable material, to improve the acoustic environment in green buildings.*
Improving building energy demand predictions in Smart Cities through sensor observations and considerations of landscape characteristics Canadian Lead: Dr. Fitsum Tariku, British Columbia Institute of Technology Indian Lead: Dr. Prasad Avinash Pathak, FLAME University *Energy consumption of buildings is a major challenge to the sustainability goals of cities. This project aims to improve Building Energy Models (BEM) to more accurately estimate a building's energy demand. This model will combine information from high-resolution satellite data and sensors for a more accurate and accessible reading.*
Harnessing the potential of renewable energy (Solar / Wind) for sustainable building energy management through Compressed Air Energy Storage Canadian Lead: Dr. Fariborz Haghighat, Concordia University Indian Lead: Dr. V Gayathri, Vellore Institute Of Technology *This project is focused on a novel concept of utilizing waste while meeting the thermal demands of the building, enhancing the overall roundtrip of efficiency of the storage system. This kind of system paves the way for the concept of 'net zero' buildings, where the proposed system with proper sizing and controls meets both thermal and electrical demands of building.*
WildFire House Prototype Canadian Lead: John Bass, University of British Columbia, Canada *Using a community health survey to establish a baseline of indoor air quality-related health concerns, the findings of this research will be integrated into viable building code and construction advancements and capacity-building programs developing local skills and locally sourced materials into a community-funded prototype house.*

THEME 2: Integrated Water Management
List of Projects

Biomonitoring Of Water Quality In Relation To Human Health Using Biosensors And Improvements Through Nanoparticle Based Purification Systems Canadian Lead: Dr. Damase P. Khasa, Université Laval Indian Lead: Dr. Manzoor Shah, University of Kashmir *This project strives to identify some of the key waterborne pathogens in Indian and Canadian water bodies, and to deploy a novel nanoparticle-based water treatment system to eliminate toxins and microorganisms from water. The research further aims to develop a better understanding of the role of invasive aquatic plants and the overall relationship between water quality and human health index.*
Development Of An ICT Platform For Water Quality Monitoring Canadian Lead: Dr. Clarence de Silva, The University of British Columbia Indian Lead: Dr. Sandhya Shrivastava, Bhavan's Research Centre, Mumbai University *The research program is designed to develop an ICT (information and communication technologies) platform for monitoring and assessment of drinking water.*
High Quality Potable Water For Small/Remote Communities In Canada And India Canadian Lead: Dr. Pierre Bérubé, The University of British Columbia Indian Lead: Dr. Anand Krishnamurthy, GE India *The research program uses a living laboratory approach to develop novel drinking water treatment systems for small and rural communities in Canada and India.*
Quantum Dot Solar Panels For Water Treatment In Remote Settings Canadian Lead: Dr. Edward Sargent, University of Toronto *This research project seeks to develop innovative solar energy to support water treatment in remote and low resource settings.*
A Nanotechnology Enabled Device For The Detection Of Harmful Bacteria In Drinking Water Canadian Lead: Dr. Michael Serpe, University of Alberta Indian Lead: Dr. Soumyo Mukherji, IIT Bombay *This project is aiming to bring cleaner water to communities through the creation of an easy-to-use device to detect harmful bacteria. The device uses colour differentiation to communicate safety of water.*
Handheld P-Laps Pathogen Detector Canadian Lead: Dr. Thomas Thundat, University of Alberta Indian Lead: Dr. Bhaskaran Muralidharan, IIT Bombay *This project will develop a handheld device to detect E-Coli in water and help communities understand when drinking water is contaminated.*
Microfabricated, Low-Cost, High-Sensitivity Chlorine And Ph Sensor Systems For Water Quality Monitoring Canadian Lead: Dr. Jamal Deen, McMaster University

This project will develop a low cost sensor that can easily determine the effect of chlorine as a disinfection strategy for highly contaminated water.
Direct Cryptosporidium Detection For Developed And Developing Nations Canadian PI: Dr. Mina Hoorfar, University of British Columbia Indian PI: Dr. Krishna Khairnar, CSIR - NEERI *This project strives to develop a rapid and robust sensor technology to identify Cryptosporidium, a pathogen found in water in Canada and India.*
Compact High-Rate Water Treatment Systems For Small Communities Canadian Lead: Dr. Ramin Farnood, University of Toronto Indian Lead: Dr. Vivek Kumar, IIT Roorkee *This project aims to develop new cost-effective technologies to better protect remote communities from potential contamination in water resources and maintain healthy environments and ecosystems.*
Development Of A Low-Cost Water Monitoring Kit For Multiplex Heavy Metal Detection Based On Aptamer Sensors Canadian Lead: Dr. David Juncker, McGill University Indian Lead: Dr. Rohit Srivastava, IIT Bombay *This project aims to develop a novel detection technology that is suitable for routine monitoring at a low-resource setting. The project will focus on characterization of structure-switching properties of aptamers and development of analyte detection mechanisms together with the creation of visual signal detectors, combined into a user-friendly detection kit.*
An Innovative Sustainable Biotechnology For Resource Recovery From Wastewater Streams Using Microwave Enhanced Advanced Oxidation With Algae Canadian Lead: Dr. Victor Lo, The University of British Columbia Indian Lead: Dr. Pradeep Kumar, IIT Roorkee *This research program seeks to develop an economically viable, technologically feasible process to improve and enhance resources and energy recovery from municipal wastewater and biosolids.*
An Innovative Green Technology For Treating Municipal And Industrial Wastewater Entering Rivers And Streams Canadian Lead: Dr. Shiv Prasher, McGill University Indian Lead: Prof. Rameshwar Kanwar, Lovely Professional University *This research project seeks to bring together biomass based biochars and hydrochars from rice husk waste products to remove heavy metals and other contaminants from industrial and domestic wastewater that makes its way untreated or only partially treated into rivers and streams.*
Development Of Capacitive Deionization Technology For Point-Of-Use Water Purification

Canadian Lead: Dr. Madjid Mohseni, The University of British Columbia Indian Lead: Dr. Sathish Kumar, Eureka Forbes Ltd. *This research project seeks to develop a new CDI (Capacitive Deionization Technology) water purification system for point-of-use applications and replace the widely used, but very inefficient Reverse Osmosis units.*
A Study Of Technology And Financial Appropriateness Of Water And Wastewater Infrastructure In Selected Cities Of India Canadian Lead: Dr. Govind Gopakumar, Concordia University Indian Lead: Dr. N.C. Narayanan, IIT Bombay *This project aims to study the type and appropriateness of water and wastewater technologies available to cities and towns in India and to improve decision making within governments through technical education development of future planners and practitioners.*
Sewage Contaminated Lake Water Quality Restoration through Aeration and Floating Wetland Plants Canadian Lead: Dr. Rajesh Seth, University of Windsor Indian Lead: Dr. Rakesh Kumar, CSIR-NEERI *Organics and nutrient pollution of surface water bodies is a serious and widespread problem. Managing the wastewater at the source is not always possible, so solutions need to be developed to deal with polluted water before it reaches surface water bodies used for drinking. The objective of this initiative was to enhance the assimilative capacity of the existing natural or man-made water bodies for in-situ bioremediation of organic and nutrient pollution.*
Thondebhavi water quality assessment Canadian Lead: Dr. Pierre Bérubé, University of British Columbia *A pilot-scale passive membrane system for drinking water treatment in small and remote communities was developed and ready for deployment. Analysis was conducted on water for the town of Thondebhavi in preparation for piloting water the water treatment system.*
Thorsby water quality assessment Canadian Lead: Dr. Michael J. Serpe, University of Alberta *This technology deployment was in response to an uncharacteristic smell in the treated water distributed to households in Thorsby Village, Alberta. The town of 1000 residents receive tre ated water from the Saskatchewan River. Through a full water sample collection and frequency analysis, researchers examined the health of the water distribution system to determine if any action was required.*
A Floating Treatment Wetland System for Removing Contaminants from Rivers and Streams using a Biomimicry Approach Canadian Lead: Dr. Shiv Prasher, McGill University Indian Lead: Dr. Ramesh Kanwar, Lovely Professional University

This project aims to inspire stakeholders to adopt simple, sustainable and effective technologies for wastewater treatment and to promote safe use of wastewater for agriculture.
Application of Emerging Biotechnology for Non-point Source Pollution Control of River Ganga, India Canadian Lead: Dr. Onita Basu, Carleton University Indian Lead: Dr. Anirban Gupta, IIEST Shibpur *Investigating the potential application of immobilised EKW bacterial cultures in stable polymeric beads for non point sources water pollution control of River Ganga in India and for development of polymeric beads, the most feasible technique is investigated*
Passive UF Membrane Demonstration Canadian Lead: Dr. Pierre Bérubé, University of British Columbia *The proposed research focuses on an immediate and significant need both in Canada and India: the provision of high quality drinking water to residents of small and rural communities. The main project outcome will be the development of novel drinking water treatment systems which will be commercialized in partnership with the industrial collaborators. Residents of the partner communities, as well as other small/rural communities in Canada and India, will be the main benefactors as the novel systems will provide them with high quality drinking water.*
Sensors 4 people / 3 Drops Canadian Leads: Dr. Michael Serpe & Dr. Gaspard Durieux, University of Alberta *This project aims to solve a major challenge across India: access to dependably safe drinking water. Using new quality-sensing technology, researchers are developing and implementing a framework for collaborative monitoring and mapping of water quality.*
Testing and upscaling phytoremediation technology in real-world conditions Canadian Lead: Dr. Damase Khasa, Université Laval Indian Lead: Dr. Manzoor Shah, University of Kashmir *This technology deployment will establish and evaluate phytoremediation technology and explore the social acceptability of this technology by local communities. Four sites have been targeted for this demonstration, two in Canada and two in India. This project will be tested in real-world conditions and demonstrates the balance between discovery and application-based research to solve the problem of water contamination in both countries.*
Biopolymer-based Electrospun Membranes for Recovery of Heavy Metals from Industrial Wastewater Canadian Lead: Dr. Xianshe Feng, University of Waterloo Indian Lead: Dr. Swanpali Hazarika, CSIR-North EastInstitute of Science and Technology *This project proposes to use 'electrospinning', a simple and versatile nanofiber production technique, to treat wastewater containing heavy metals before releasing it into the environment. This process would improve public health while dramatically reducing the cost of wastewater treatment for heavy metal recovery.*

Optimum Biocell for Tropical Climates
Canadian Lead: Dr. Patrick Hettiaratchi, University of Calgary
Indian Lead: Dr. Sunil Kumar, CSIR – National Environmental Engineering Research Institute
The Optimal Biocell is a novel technology with enhanced energy recovery with cost-effective processes, greenhouse gas emission control, groundwater contamination control, and resource and space recovery as direct and indirect benefits. This project aims to build an optimum biocell in Thane using a mixture of municipal solid waste and sewage sludge as feedstock to generate renewable fuels like CNG.

Biovalorization of Lignin
Dr. Vikramaditya G. Yadav, University of British Columbia
Dr. Syed S. Yazdani, International Centre for Genetic Engineering and Biotechnology
This project proposes to develop a family of biocatalytic processes that convert lignin to pharmaceutical building blocks, flavouring agents, and drug delivery platforms. Biocatalytic processes are greener, emit less carbon dioxide and are more energy efficient than other alternatives.

Development and scale-up of technology for microbial extraction of xylose from agro-waste materials and subsequent conversion into xylitol. Subtitle: Conversion of hydrolysed lignocellulosic residues into biopolymers for applications in composites
Dr. Tatjana Stevanovic, Université Laval
Dr. Baljinder Kuar, Punjabi University
This innovative project will establish a microbial biotransformation, consisting of xylose extraction by acid hydrolysis of agro-waste and its conversion into xylitol, using recombinant microbial strain to develop high-value food and pharmaceutical building blocks from lignin waste, which in most cases is currently burned.

THEME 3: Public Health
List of Projects

Next Generation Molecular Diagnostics For Emerging Viral Diseases
Canadian Lead: Dr. Francois Jean, The University of British Columbia
Indian Lead: Dr. Santanu Chattopadhyay, Nationwide the Family Doctors
This project seeks to develop a non-invasive and rapid diagnostic test for West Nile and Dengue Viruses in blood samples.

Engaging Community Pharmacists In India To Enhance Early Detection Of Tuberculosis
Canadian Lead: Dr. Madhukar Pai, McGill University
Indian Lead: Dr. Nita Jha, World Health Partners

This project engages community pharmacists in India in order to improve early detection of and provide effective treatment for tuberculosis. This pilot intervention engages community-based pharmacists and utilizes e-health technology to achieve early TB case detection.

A High Quality Serotype Discriminating Dengue Virus Diagnostic Test Adapted For Field Investigation
Canadian Lead: Dr. Sachdev Sidhu, University of Toronto
Indian Lead: Dr. Amitabha Chaudhuri, SciGenom Labs
This project seeks to develop a sensitive and specific diagnostic test for dengue virus that will allow medical personnel to monitor patient infections more accurately. It will benefit both Canada, where screening technology is needed to monitor mobile populations coming from high-dish countries, and India where dengue infection is prevalent. It will also provide training and collaboration opportunities for researchers in both countries.

Identification Of High Affinity Ligands Against Dengue Virus NS1 For The Development Of An Affordable Point-Of-Care Diagnostic Kit
Canadian Lead: Dr. Tom Hobman, University of Alberta
Indian Lead: Dr. Easwaran Sreekumar, Rajiv Gandhi Centre for Biotechnology
This project will develop pan- and serotype-specific, high-affinity small molecules targeting the NS1 protein for accurate diagnosis of dengue infection. These small molecule ligands will be more stable, affordable and efficient for detecting dengue infection compared to current antibody-based diagnostic kits.

Development Of A Portable Device For Early Detection Of Eye Infection And Dry Eye Disease
Canadian Lead: Dr. James Feng, The University of British Columbia
Indian Lead: Dr. Ashutosh Richhariya, L.V. Prasad Eye Institute
This project will develop a portable diagnostic tool that detects the premature breakup of the tear film and the loss of the mucous layer on the cornea as indicators of dry eye and impending eye infection. As an alternative to current methods, detecting premature breakup and other abnormalities in the tear film is much faster and relatively inexpensive, and holds promise for a new technique that can be used in the field for early diagnosis for people at risk of eye infection.

A point-of-care device for malaria diagnosis and drug resistance genotyping
Canadian Lead: Dr. Stephanie Yanow, University of Alberta
Indian Lead: Dr. Aparup Das, National Institute of Malaria Research
The research proposes to further refine the Accutas System (a system designed by the research team) for use in India to test patients for malaria, a parasitic infection that is deadly if left undiagnosed. We will expand the testing to discriminate different forms of malaria and identify infections that are resistant to certain drugs. Specifically, we wish to develop a multiplex assay that can detect the two widely prevalent malaria parasites, Plasmodium (P.) falciparum and P. vivax in a single infection.

Development of a Hand Held Molecular Point-Of-Care Test Device for Infectious Diseases Canadian Lead: Dr. James Mahony, McMaster University Indian Lead: Professor Daman Saluja, University of Delhi *The project aims to develop a novel, single use, hand-held point-of-care test (POCT) device that addresses the program of lag in result turn-around times typically faced by remote facilities.*
Surface modulation of CuS quantum dots using biginelli compounds for construction of a portable fluorescence sensor for bacteria Canadian Lead: Dr. Jan J. Dubowski, Université de Sherbrooke Indian Lead: Dr. Narinder Singh, Indian Institute of Technology Ropar *The project proposes to develop a fluorescent quantum dots (QDs) based biosensor for detection bacteria, which represents a next generation in the field of bacteria detection. Bacterial strains of Salmonella, E. coli, L. pneumophila, Shigella, and Staphylococcus which are responsible for gastrointestinal or enteric diseases will be investigated. Modified (biginelli derivatives/Ab) QDs will be deposited on screen printed electrodes*
Development of Portable Spine MEG Scanner for Real Time Spinal Functional Evaluation and Data Acquisition Canadian Lead: Dr.Teresa Cheung, Simon Fraser University Indian Lead: Dr. Rohit Sharma, Indian Institute of Technology, Ropar *This is a low-cost system using optically pumped magnetometers (OPM) technology optimized for detection of spinal cord function with real-time acquisition. Current technologies to monitor spinal cord function are highly invasive with limited accuracy. Recent developments in OPM offer a portable and inexpensive solution that may provide access to this important imaging technology to smaller hospitals and research centers.*
Wearable Technology to Monitor Sitting Posture and Reduce the Pressure Injury Risk Canadian Leads: Dr. Hossein Rouhani, University of Alberta, Dr. Chester Ho, University of Alberta *This project aims to improve sitting posture and provide a user-friendly and economical means to empower persons with SCI to reduce the risk of pressure injury in the community, and improve their quality of life in Canada and India.*
COPE: Community-health Outcomes and Personalized Education/Exercise for Spinal Cord Injured Individuals Canadian Lead: Andrei Krassioukov, University of British Columbia Indian Lead: Dr. Nishu Tyagi, Indian Spinal Injuries Centre *This technology will encourage community inclusion for spinal cord injured (SCI) individuals by delivering comprehensive healthy living skills and video-image based training on the necessary topics after discharge. The COPE web-portal shall provide community guidance where there is none and improves the quality of care where there is some.*

Design2Impact: Uniting Researchers, Makers, and Spinal Cord Injury Survivors through Open-Source Technology Canadian Leads: Dr. Aaron Yurkewich (University of Toronto, Canada) and Stewart Russell, Makers Making Change at Neil Squire Society *This project aims to develop a knowledge translation and mobilization gateway accessible to researchers, makers, and spinal cord injury survivors, and enable international rehabilitation researchers to translate their technologies to SCI survivors.*
Development of Wearable Artificial Muscle for a Tetraplegic Hand Indian Lead: Dr. Harvinder Chhabra, Indian Spinal Injuries Centre *Patients with traumatic spinal cord injury (SCI) often lose the ability to complete activities of daily living (ADLs) requiring basic hand dexterity. Dr. H.S. Chhabra, Medical Director & Chief Of Spine Services at the Indian Spinal Injuries Centre and his team of investigators are in the process of developing a wearable artificial muscle for a tetraplegic hand. This innovative exoskeletal glove simulates muscle movement, enabling the wearer to live a more independent life.*
Smart app-based rapid multiplex screening of HIV associated co-infections of at-risk populations at the point-of-care: A demonstration study in India Canadian Lead: Dr. Nitika Pant Pai, McGill University Indian Lead: Dr. Suma Nair, Manipal Academy of Higher Education *This project will provide evidence to scale a connected multiplexed strategy that screens for multiple co-infections with point-of-care tests, facilitated by an app. It will be operationalized at the point of clinical care by health care professionals*
Dialled In: Tapping Community Voice To Improve Child Immunization Services In India Canadian Lead: Dr. Mira Johri, Universite de Montreal, Canada *In India, childhood immunisation is a priority health strategy with suboptimal uptake. This project developed a mobile phone e-health application to support a social, behavioural, and community engagement (SBCE) intervention to improve immunization and child health outcomes among underserved rural Indian populations. Researchers developed the Tika Vaani ("vaccine voice" in Hindi) model to educate beneficiaries about immunisation and basic child health themes, as well as dispel misinformation and empower households to better care for their children and themselves.*
A Portable Fever Kit for Dengue and Chikungunya Canadian Lead: Dr. J. Stewart Aitchison, University of Toronto, Canada Indian Lead: Dr. Manoj Verma, IISc Bangalore, India *This project aims to develop a portable fever kit that can differentiate between the viral infections of dengue and chikungunya. The result will be a cartridge-based test that will operate using a single finger stick capillary blood sample, and be as easy to operate as a conventional blood sugar meter. This will quickly determine the cause of symptoms, simplifying the diagnostic process and making treatment faster and more accurate.*

Demonstration Projects
Sewage Contaminated Lake Water Quality Restoration through Aeration and Floating Wetland Plants Canadian Lead: Dr. Rajesh Seth, University of Windsor Indian Lead: Dr. Rakesh Kumar, CSIR-NEERI, India
Innovative Field Demonstration of Sustainable Infrastructure Canadian Lead: Dr. Shamim Sheikh, University of Toronto
Thondebhavi water quality Assessment Canadian Lead: Dr. Pierre Bérubé, University of British Columbia
A Floating Treatment Wetland System for Removing Contaminants from Rivers and Streams using a Biomimicry Approach Canadian Lead: Dr. Shiv Prasher, McGill University
Application of Emerging Biotechnology for Non-point Source Pollution Control of River Ganga, India Canadian Lead: Dr. Onita Basu, Carlton University
Passive UF Membrane Demonstration Canadian Lead: Dr. Pierre Bérubé, University of British Columbia
Sensors 4 People / 3 Drops Canadian Lead: Dr. Michael Serpe, University of Alberta
Contaminated Land Reclamation Using Hybrid Absorbable Landscape and Native Plant Species with Real-Time Monitoring to Improve Public Health in Punjab Canadian Lead: Dr. Rishi Gupta, University of Victoria *This project uses a Low Impact Development (LID) technique that involves planting genetically modified poplar trees to remediate heavily contaminated soil in formerly industrial areas.*
A High Performance Advanced Septic (HPAS) System for Villages and Roadside Restaurants Canadian Lead: Dr. Edward A. McBean, University of Guelph *This project involves the deployment of a High-Performance Advanced Septic System (HPAS) technology designed to treat wastewater from villages, household clusters, and roadside restaurants. This system is currently treating a substantial percentage of the wastewater from Jawaharlal Nehru Technological University, Kakinada (JNTUK).*
Scour Monitoring of an Overwater Bridge in Manitoba using Dissolved Oxygen (DO) Probes Canadian Lead: Dr. Faezeh Azhari, University of Toronto

Thorsby Water Quality Assessment
Canadian Lead: Dr. Michael J. Serpe, University of Alberta