

Revitalizing the Yamuna River: Social Entrepreneurship Approaches

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Abstract—New Delhi, India’s capital city, with a population of almost twenty-two million faces a daunting challenge: Its sacred river, the Yamuna, is one of the most polluted in the world. In fact, within the city limits, the Yamuna is primarily constituted by treated and untreated sewage and other toxic effluents. The water is rendered “dead” with zero oxygen, thus posing serious health hazards to the citizens of New Delhi. Might there be a way to cleanup and revitalize the river plain using social entrepreneurial approaches? In this paper, we propose to study the key ingredients required for creating and nurturing a social entrepreneurship and innovation based ecosystem in the region. The methodology employed is qualitative in nature and draws on evidence based on interpretative interviews as well as direct and indirect observations. Using case examples of five socially driven ventures in the region, we examine how they they impact the local community in a manner that opens up new frontiers for positive social change. In doing so, these social entrepreneurs create value by introducing technology innovations that solve problems, while creating new opportunities for organizations and communities involved with the Yamuna river cleanup efforts.

I. INTRODUCTION

The focus of this paper is on exploring social entrepreneurship and innovation ecosystems in the Yamuna River Plain. The Yamuna River, which flows through New Delhi, is what environmental experts call a “dead river” -- its oxygen-carrying capacity suffocated by thousands of gallons of sewage being pumped into the waterway 24 hours a day. In fact, environmental activists say many rivers in India have become dirtier as the economy has developed, with city sewage, farming pesticides and industrial effluents freely flowing into waterways despite laws against polluting. According to The Central Pollution Control Board (CPCB) 2015 report, around 37,000 million liters per day (MLD) of untreated sewage water flows into the rivers across the country. As per the report, as many as 302 river stretches on 275 rivers across the country have, over the years, got polluted due to both municipal and industrial wastewater discharge.

Could there be an opportunity to transform the Yamuna river bank into someplace residents could visit and enjoy? Could this create new economic and social connections, and growth? Indeed, it has been the objective of many activists, environmentalists and politicians, including Prime Minister Narendra Modi. The goal is to revamp the river plain into a waterway lined with parks and public spaces. However, despite decades of planning and investment the river has over the years become even more polluted. The National Green Tribunal

(NGT), as part of a January 13, 2017 order, asked the various stakeholders to implement the Maili se Nirmal Yamuna Revitalization Project 2017 to clean up the river. Further, the local government through the Delhi Jal Board had also committed to clean the river and build a sewage treatment plant. In fact, they had signed a 5-year agreement with the University of Virginia (UVA) to collaborate in planning the river’s restoration [1]. In March 2017, UVA hosted an exhibit in Delhi – to demonstrate to people how a whole new Yamuna could transform their city. Officials in charge of the project say the initiative would help restore the ecological value of the Yamuna and attract visitors to the riverfront. The goal of the exhibit was to engage the efforts of government agencies, experts and activists, in India and internationally, in an ongoing research addressing the multidimensional challenges for the recovery of the relation between Delhi and its sacred river Yamuna [2]. The initiative of Delhi Jal Board was one of the most ambitious projects in the National Capital and was believed to be a huge step forward towards the transformation of Delhi’s natural water resources [3]

The paper is structured as follows. First, we provide an overview of the Yamuna river plain in the greater New Delhi area of India, which is the research venue for this study. We will then present the social entrepreneurship framework and discuss the relevant literature. After this, we will present the research methodology employed. We will then provide descriptive mini case studies of five social entrepreneurial initiatives poised to have impact on the region. Following this, we will provide an analysis and discussion on the potential for a social entrepreneurship and innovation ecosystem in the region. Finally, we will present our conclusions and key recommendations for the region.

II. YAMUNA RIVER PLAIN: AN OVERVIEW

The Yamuna is the longest and the second largest tributary river of the Ganges (Ganga) in northern India. Originating from the Yamunotri Glacier at a height of 6,387 meters on the south western slopes of Banderpooch peaks in the uppermost region of the Lower Himalaya in Uttarakhand, it travels a total length of 1,376 kilometers (855 mi) and has a drainage system of 366,223 square kilometers (141,399 sq. mi), 40.2% of the entire Ganges Basin, before merging with the Ganges at Triveni Sangam in Allahabad. It is the longest river in India which does not directly flow to the sea [4].

The Yamuna crosses the Indian states of Uttar Pradesh, Uttarakhand, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and Delhi. Just like the Ganges, the Yamuna too is highly venerated in Hinduism and worshipped as goddess Yamuna, throughout its course. In Hindu mythology, she is the daughter of Sun God, Surya, and sister of Yama, the God of Death, hence also known as Yami and according to popular legends, bathing in its sacred waters frees one from the torments of death [5]. As of March 2017, the Ganges become the first non-human entity in India to be granted the same legal rights as people. A court in the northern Indian state of Uttarakhand ordered on Monday that the Ganges and its main tributary, the Yamuna, be accorded the status of living human entities [6]. The decision, which was welcomed by environmentalists, means that polluting or damaging the rivers will be legally equivalent to harming a person.

The Yamuna runs through the heart of Delhi – India’s second largest city, with a population around 19 million people. In this area, the river is tainted with sewage and industrial pollution. In some places, the river has stagnated to the point that it no longer supports life [7]. The river enters Delhi near Palla and traverses a distance of about 48km. The 22-km stretch from Wazirabad to Okhla is only 2% of the river’s length, but 70% of the total pollution gets loaded here. Around 22 drains flow directly into the river. Of these, four main drains–Najafgarh, Najafgarh supplementary, Shahdara and Barapullah, are the key contributors to pollution [8]. Water from the Yamuna is treated chemically before being supplied to Delhi’s residents as drinking water. In some areas however, the pollution is so bad that nothing can live in the Yamuna, and the city has essentially turned its back on the waterway. Today, the river is choked with as much as 58 percent of New Delhi’s waste [9].

III. LITERATURE OVERVIEW AND FRAMEWORK

From various research perspectives, social entrepreneurship has been enforced to provide change [10] to meet unfilled social needs [11] and accomplish societal transformation [12]. It is a form of entrepreneurship that is proposed to spur development [13] in the form of poverty alleviation [14] [15] and sustainability [16] [17] [18]. Social entrepreneurship is thus all about ‘explicitly aspiring to solve a major societal problem with professional management and business efforts and, indeed, enable the creation of widespread social change [19]. Turning to the “social innovation school”, social entrepreneurship is also conceived to be more about outcomes and social impact, than incomes [20].

Grimes et al. have suggested that the better we understand how social innovations arise, the better we will understand how particular forms of social entrepreneurship opportunities are grasped [21]. Social innovation can thus be conceived as a sub-concept that partake in the formation of the social entrepreneurship conglomerate [22]. Social entrepreneurship is formed through extended possibilities for co-creation that recombines elements of social innovation, where we do not only have economic or technological logics for recombination

at play, but social logics. Quoting Mumford’s [23] definition of social innovation as “the generation and implementation of new ideas about social relationships and social organization”, Maclean et al [24] emphasize that “social settings, relations and self-organization” is central to these processes.

In order to contextualize and study these social settings and relations, we adopt the holistic approach proposed by Tripl [25] and employ the Regional Innovation Systems (RIS) framework. RIS could be described as “a set of interacting private and public interests, formal institutions and other organizations that function according to organisational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge [in the region]” [26]. We define entrepreneurship as “a context-dependent social process through which individuals and teams create wealth by bringing together unique packages of resources to exploit marketplace opportunities” [27].

The core concepts of regional innovation systems are rooted in the theory of innovation and, in particular, in the theories of economist Joseph Schumpeter. His views on innovation-related technological changes and entrepreneurship as drivers for economic growth became the basics for innovation policy in many regions [28]. Schumpeter also saw a special role for entrepreneurs since entrepreneurial activity that drove innovations resulted not necessarily from linear or rational thinking, but from creative pioneering processes [29]. Thus, entrepreneurial efforts are necessary to bring innovations into market. A vast array of theories and concepts has been employed to explore the entrepreneurship phenomenon [30]. Some studies have focused on several units of analysis, theoretical perspectives, and methodologies [31]. In addition to studying new firm development [32], exploration and exploitation of opportunities [33] [34] and entrepreneurial behavior of existing firms [35] [36], entrepreneurship research also examines institutional approaches [37] [38]. At the same time, researchers evaluate the differences in innovation systems in different territories, with the conclusion that every country and region has its own innovation system that reflects the particular institutional elements [39] [40]. For example, according to North [41] innovation development is related to “adaptive efficiency”, the rate at which institutions are able to change.

According to Hansen [42] there is a general lack of knowledge regarding efficient policies for implementation of these innovation systems. Very few of the recent studies in this area deal with creation of common knowledge and innovation spaces. Lundquist and Tripl [43] identify the following stages of cross-border RIS development: asymmetric cost-driven systems, emerging knowledge-driven systems and symmetric innovation driven systems. They also consider different types of barriers and suggest policy measures on how to overcome these barriers. Hansen [42] in turn, suggests that effect of elimination of different kind of barriers in cross-border collaboration is “more or less a black box”. In particular, according to him, it is difficult to predict if the elimination of the barrier would have a long term result. Hanson also sees both opportunities and challenges presented by cultural,

technological, institutional, and other variations of different parts in cross-border regions. He proposed that investment in physical infrastructure does not necessarily lead to a higher level of cross-border integration in scientific collaboration and knowledge flows.

We apply the regional innovation system framework to the Yamuna river plain by analyzing information from the interviewees in the context of RIS subsystems and crucial dimensions, which were proposed by Tripl [25]. RIS framework is considered to be appropriate to study innovation and knowledge flows in regions [42][43][44]. Guided by the study of Tripl [25], we suggest studying entrepreneurial activities in RIS through five major sub-systems: Knowledge generation and diffusion subsystem, Knowledge application and exploitation subsystem, Regional policy subsystem, as well as through local interactions and socio-institutional factors. The theoretical framework that we applied in our study is presented in the figure below:

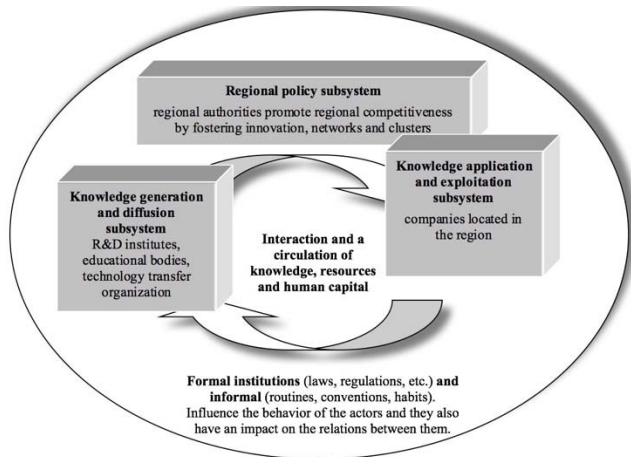


Figure 1: regional innovation system and its subsystem (source adapted from tripl [25])

Knowledge generation and diffusion subsystem is associated with public research institutions, technology mediating organizations, educational bodies and workforce mediating organizations. **Knowledge application and exploitation subsystem** is connected with activities of the companies, clients, suppliers and competitors and industrial cooperation. **Regional policy subsystem** includes regional authorities and public authorities, development agencies. The efficiency of innovation development is connected with **local interactions** between subsystems and regional innovation system as a whole is influenced by **socio-institutional factors**, including laws, regulations, values, practices, routines and others.

In the next section, we provide details on the methodology employed for studying ventures that could potentially impact the innovation and entrepreneurship ecosystem in the region.

IV. METHODOLOGY

The research approach used for this paper is qualitative in nature. The qualitative method is expected to give us a rich and deep interpretation of the organization being studied [45] [46].

The inductive approach builds on existing concepts in research on social entrepreneurship while exploring for new strategies, processes and relationships. Qualitative researchers view themselves as the primary instrument for collecting data. They rely partly or entirely on their feelings, impressions and judgments in collecting data [47]. In choosing an interpretive paradigm [48], we aimed to gain a deeper understanding of a phenomenon through understanding the interpretations of that phenomenon from those experiencing it [49].

In meeting the criticisms of case study research in the field of social entrepreneurship, certain scholars have already demonstrated the potential of case studies as inspiration for new ideas [50]. Using the case-study methodology [51], our research is designed to follow the development of a potential social entrepreneurship and innovation ecosystem in the general Yamuna river plain. Following the work of other scholars [52] [53] [54], we carried out the case study research in close interaction with practitioners who deal closely with the organizations under study. Following case-study methodology [51], we deployed ethnographic methods for studying the organizations and its various socially motivated projects. Accordingly, we drew upon first-hand rich materials such as personal, extensive interviews with venture founders and employees both in person (in the US) and via skype, questionnaires, and direct observations at formal and informal settings [55]. Additionally, we also performed extensive primary and secondary historical research and analysis. We accessed primary and secondary archival sources such as news reports and industry reports issued, as well as social media coverage.

TABLE 1: ORGANIZATIONS STUDIED

Name of Organization	Area of Innovation
HelpUsGreen	Used and leftover flower waste management
Mrida Group	Business models for Sustainable and Holistic development
DeTect Technologies	Prediction and detection of oil and gas leakages
Ayala Water & Ecology	Environmental sustainability through phytoremediation
Omnipresent Robot Tech	Robotics, industrial UAV/drone and video analytics

The data collection was done over a 3-month period from June 2017 through August 2017 and helped provide knowledge and insights into the recent growth and development of a few socially driven organization in the river plain. At the core of the various organization's social engagement there are several projects, aiming to solve different social issues, ranging from pollution control to job creation. The authors conducted 8 personal interviews with key stakeholders as well as employees at the various organizations. The interviews were semi-structured in nature.

Following the qualitative interview research methodology, we used a hybrid model of specific and open-ended questions during our interviews. As the interview progressed, as per the qualitative research methodology, we were also very attentive

to the variety of meanings that emerged as the interview progressed and the direction in which the interviewee was possibly leading me. This open stance meant being alert to developing meanings that, in some cases, rendered previously designed questions irrelevant in the light of the changing contexts of meaning. Insights and understandings were produced by several iterations, where new data gathered from interviews and observations was compared in gradual stages with data collected previously [56]. The longest interview lasted about an hour and 45 minutes and the shortest lasted 15 minutes, with the average length being approximately 30 minutes. Most of the interviews were audio recorded and then transcribed into complete manuscripts within a week of the interview.

V. MINI CASE STUDIES

A. HelpUsGreen

“When we began in May 2015, everyone thought we were mad. No-one had seen anything come out of flower waste before and they were like ‘Oh, you really think you’re going to do something with that?’”

- Ankit Agarwal, Co- Founder, HelpUsGreen

“Everyone cares about the Ganges and the Yamuna rivers but do nothing because they believe ‘we can do only little’. We want to change this. Our raw material – temple-flowers is free and its potential has not been tapped for centuries. We want to change how India handles the monumental temple-waste problem.”

- Karan Rastogi, Co-Founder, HelpUsGreen

Showering flowers (8 million tonnes annually) at temples and mosques is a religious ritual in India. These flowers are a symbol of devotion and thus believed that the flowers should be discarded into River Ganges to respect their sanctity. Sadly, these sacred flowers rot (16% of the total river pollutant) and create havoc in the fragile ecosphere of the river and leach in the groundwater. Toxic arsenic, lead and cadmium from the harmful farm-runoff, pesticides, insecticides (>1000ppm) used to grow flowers mixes with the river water making it highly poisonous (PH 6-8.5) and has been linked with contracting cholera, hepatitis and severe diarrhoea -- the leading cause (86.7%) of child mortality across India & Bangladesh.

The monumental temple-flower disposal and the deep-rooted religious significance is overriding Ganges and the Yamuna’s biophysical stability and slowly killing it. With over more than 420 million people who rely on the rivers for food, water, agriculture and the millions pilgrims who venture into India’s holiest river to bathe and worship.

The Solution

HelpUsGreen has developed the concept of ‘flowercycling®’ and is the world’s first profitable and lean solution to the monumental “temple-waste” problem. HelpUsGreen® has gained interest across Southeast Asia and

has received interest from across India, Nepal and Bangladesh. They collect floral waste from temples and mosques in Kanpur, Uttar Pradesh, India. The waste is then hand-processed by women manually in self-help group to produce the following products:

- Florafoam® (biodegradable substitute to Styrofoam)
- Plant fertilizer – Mitti®
- Charcoal free Incense Sticks – Sticks & Stones®
- Bathing bars – Yet to be launched

All of the products are EcoCert organic certified with 6 in the pipeline. The production process provided dignity and disease-free livelihoods for the manual scavenger women. India’s 1.6 million manual scavengers collect human excreta from dry latrines and sewers on a daily basis (FSG 2016) and carry it away with their heads for disposal at the outskirts of cities. HelpUsGreen had been featured over 160 international articles & case studies including Fortune and Fast Company. The organization was revolutionizing the way India handled the “million ton flower waste disposal problem” and brought hope to revive the lifeline of over 420 million people – The Ganges and the Yamuna rivers.

B. Mrida Group

“At Mrida, we are excited about the opportunity to bring to bear, the rigor and the financial discipline of the corporate world into the development sector. Through a combination of passion, commitment and leveraging of our past experience, we see immense potential to develop innovative business models that uplift lives at the Base of the Pyramid, and create deep, sustainable and scalable impact”

- Arun Nagpal, Co-founder and Managing Director

Incorporated in 2014, Mrida (Sanskrit for ‘Soil’) was a New Delhi based social enterprise that sought to uplift rural communities by creating socially driven interventions in areas such as energy and agriculture. Focused primarily on the underserved communities that inhabited the Yamuna river plain area that covered the states of Uttar Pradesh and Uttarakhand, Mrida had empowered local people with energy access and agricultural initiatives. As an example, Mrida had set up solar micro grids in villages near the river plain not connected to the electricity grid, had replaced kerosene lamps with energy efficient LED bulbs and had brought mobile charging and digital connectivity. Further, the Mrida team worked with the local community leaders to advocate effective use of energy.

Mrida also facilitated effective agricultural practices by encouraging small and marginal farmers from the region to cultivate high value plants, crops and herbs. To help the farmers, Mrida had created an end-to-end supply chain covering collection of produce, storage, processing, branding and market access for a range of health and wellness related products and services, including traditional Indian remedies. The organizations aim was to provide income generation opportunities and remunerative prices to rural farmers while at the same time offering fresh and healthy produce to the consumers. Central to Mrida’s agricultural initiatives was a

fully equipped herbal extraction facility showcasing the best of equipment and technology, good manufacturing practices, and a comprehensive testing laboratory. Mrida had partnered with leading businesses such as IL&FS Ltd, Mahindra & Mahindra Ltd., Reliance Industries Ltd. And the Rio Tinto Group for integrated CSR/philanthropic initiatives. Further, Mrida had created Earthspired, a consumer brand to establish linkages between farmers and rural artisans from the river plain, and the urban consumer. The product line ranged from millet and amaranth based flour mixes to cookies and salted snacks that were prepared by the villagers and sold in cities.

C. DeTect Technologies

“With our patented technologies we aim to predict and detect oil and gas leakages that have been the cause of life, property damage and pollution in cities and rivers worldwide.”

- Meenu Choudhary, Head of Business Development,
DeTect Technologies

Inspired by the loss of human life and property in gas and oil leakages, detect technologies was committed to provide solutions for predicting these leakages and also detecting them if they occur. Founded by Indian Institute of Technology - Madras alumni and faculty, it was chosen as the 2017 best startup in to have emerged from an Indian college campus. With patents filed in the US and India, the firm's flagship product was the Guided Ultrasonic Monitoring of Pipe Systems (GUMPS), a one of a kind intelligent sensor indispensable to any industry that required pipeline health and integrity monitoring to prevent potentially hazardous leaks. It was projected that such a sensor could be used to predict and detect oil and gas leakages from oil pipelines which run on the river bed of the Ganga River and its tributaries such as the Yamuna. The Ganges, often called India's lifeline, was the country's national river and had significant economic, environmental and cultural value attached to it.

GUMPS was a fully automated continuous condition monitoring system for pipelines that could operate at extreme temperatures. This system was capable of monitoring pipelines of lengths of up to 60 meters from a fixed point. It also transmitted the data to any location using the Cloud. The data was analyzed using intelligent algorithms and provided information on the state of the pipe line including early detection of defects being formed and their growth rates.

Another key product being developed was a drone named Noctua which was used for inspections. The drone promised faster, easier inspection of boilers, stacks and towers. Research and development was underway to provide high quality semi-autonomous visual inspection of difficult to access or hazardous regions.

By continuously monitoring a huge network of pipelines and alerting the plant for any impending leaks, GUMPS and Noctua were positioned to prevent loss of marine life and pollution due to oil leakages. It was also the first continuous real-time pipe monitoring technology for rivers in India. Apart from the energy sector, Detect technologies were also seeing adoption in the chemical, fertilizer, power and nuclear

industries. Major Indian companies such as Reliance, Tata, Bharat Petroleum Corporation Limited and Hindustan Petroleum Corporation Limited were among their clients.

According to the founders, the biggest challenge had been the transition their products from the research and development phase to a commercially viable industry-certified stage. This was crucial as the oil and gas refineries had stringent certification requirements due to the risk of accidents.

D. Ayala Water & Ecology

Ayala Water & Ecology Ltd, was an Israeli based company of sustainability experts with 26 years of experience in the field of phytoremediation. The company aimed to use natural, energy free, tools to restore balance to the environment and had developed the “Natural Biological System”, a sustainable natural technology for treating sewage and waste streams, rehabilitating affected water bodies and rebalancing watersheds.

From headquarters at an organic farm owned by Ayala's founder and CEO Eli Cohen in Zipori, Israel, and through worldwide partners, Ayala had designed and implemented NBS™ as a tailored solution that integrated into the social and environmental fabric, providing an economical and aesthetic side of waste treatment that has never been known before. The company used shrubs and constructed wetlands to destroy contaminants in a natural way.

Ranging in scope from acid mine drainage remediation in Chile to urban sewage treatment in India, the NBS™ was changing the global water-energy equation, reducing dependence on energy and maintenance, freeing up valuable water resources for on-site usage, and most of all, restoring nature's ability to preserve and protect itself.

In early 2017, the Delhi government had established a partnership with Ayala to clean up, through ecological methods, an eight-kilometer stretch of one of the most polluting drains that emptied into the highly-polluted Yamuna river [57]. The government had chosen the supplementary drain to begin with and plan to expand the project further. The firm had been tasked with preparing a detailed project report on cleaning up the Bhalswa to Surghat stretch of the supplementary drain. The drain was among the four big canals that join the Yamuna in Delhi where it traverses a distance of about 46 kilometers [58]. The rest were the Barapula, Shahadara and Najafgarh drains. The company was already working on three other projects in India i.e. the Ganga rejuvenation project in Rishikesh, and on two lakes in Hyderabad and Bengaluru.

E. Omnipresent Robot Tech

“We wanted to contribute back to India and also saw the emerging market here in robotics and their potential for autonomous continuous cleaning of great Indian rivers such as the Yamuna and Ganga”

- Aakash Sinha, CEO and Founder

Omnipresent Robot Tech was a robotics, industrial UAV/drone and video analytics solutions provider. The company build robots for industrial inspections and defense,

and the software that drives them. Using computer vision, machine learning and virtual reality, they provide clients with visual analytics and actionable insights. Founded in 2010 and based in New Delhi the firm had developed state of the art unmanned aerial vehicles and river cleaning robots. One of the company's flagship product was an unmanned water surface vehicle called "Ro-Boat" that was capable of detecting and collecting all kinds of trash including chemical effluents and floating debris from the surface of water [59]

"A large part of why the Yamuna isn't getting any better is that it can't self-purify anymore. And it's all this trash that prevents it from flowing like a river. Our estimate is that with a device like the Ro-boat, we'll be able to clean up around 200 tonnes of the river's waste in one year."

- Ravish Rawal, Ro-Boat design team

Equipped with GPS and sensors, Ro-Boat had cameras and video analysis capability to detect pollutants like plastic, chemicals and heavy metals in water. It could also suck out water and filter it. The device had been recognized among the top 20 innovations by Massachusetts Institute of Technology (MIT) and had been identified as a possible technological intervention for the mammoth task of cleaning the Ganges and the Yamuna rivers under the Union Water and Resources Ministry's Ganga Action Plan (GAP). In fact, The Union Science and Technology Ministry had recommended it for the use, terming it as a potential technology for cleaning garbage or dirt from the river or water bodies.

Following this, the company had piloted and successfully tested in the Yamuna and Ganga Rivers. The founders had proposed that it would be possible to clean a river in a particular state in a six-month time span [60]. Equipped with solar panel batteries and a twin propeller engine, the Ro-Boat had the unique ability to completely submerge in the river and pull out pollutants settled on the river bed.

VI. ANALYSIS AND DISCUSSION

Knowledge generation and diffusion

Access to startup networks and incubators such as the Indian Institute of Technology – Madras incubation cell seems to have been a key factor for the launch and development of the initiatives described above. Several of the founders were western-educated and had returned to India and desired to create an impact within their local constituencies and lead meaningful lives in their own communities. The Delhi ecosystem had several entities that played key roles such as the R&D laboratories and centers of excellence. It was interesting to note that many students in the region had a hidden capacity to compete and become entrepreneurs. Therefore, an important task for regional leaders and university management is to recognize and help realize this student potential.

There appears to be a trend towards increasing number of innovation that are not related to just natural science, but related to social sciences. Such innovations are not always associated with new technological findings, but rather with its effective

dissemination [61], which requires new solutions from social science such as business strategies and policy measures.

Knowledge application and exploitation

It was clear from the interviews that the entrepreneurs involved had deep tacit knowledge of the Delhi and the surrounding ecosystem. They understood the local constituencies and ways to interact with them. It was suggested that the entrepreneurs would benefit from more alliance and concrete strategies for collaboration between mature industries and multi-national corporations in the region. For instance, it was suggested that big companies could establish a fund to help local social entrepreneurs help clean up the Yamuna through technological intervention to a point where they could possibly buy it. Further, a local business advisory could help translate sustainability needs of the local companies to a concrete demand, which could then be met by social entrepreneurs.

Triple helix collaboration and cluster initiatives are seen as fairly effective by some of the interviewees for the development of an innovation cluster in the region.

Regional policy

The role of the government through the Delhi Jal Board to create a comprehensive plan to clean the Yamuna river and restore its ecological value and was critical for the support of local entrepreneurial initiatives. In particular, the Delhi Jal board and the regional business hubs seem to be important actors as they can provide the vision and network required for the development of an innovation ecosystem for the Yamuna cleanup efforts.

The plan to clean the drains flowing into the river as well as restoring the ecological value of the river by building biodiversity parks and ecological landscapes like treatment wetlands, catchment wetlands, mosaic of grasslands, floodplain forests, terrestrial forest communities and new habitats was bound to attract the attention of social entrepreneurs seeking to strike public-private partnerships and create mission-driven organizations.

Local Interactions

The potential for the development of social innovations is associated with the collaboration between academia, industry and the regional authorities. Based on the interviews, explicit scientific talent was considered to be one of the most valuable assets for developing an innovation ecosystem in the Yamuna river plain [61]. Local entrepreneurs mentioned that they would benefit from more formal and informal networks and modes for communication with other entrepreneur and innovation leaders working in the same area. Nevertheless, some of the regional networking initiatives did not seem to be very promising anymore and the level of awareness about these initiatives were not as high as they could be. Further, there appeared to be a lack of a business tradition and understanding for the challenges and opportunities for a startup culture. Therefore, it is important that the Delhi Jal Board through its partnerships with local and international universities and think tanks help create and nurture an entrepreneurial culture in the area. By supporting social and

technical interaction among developers and implementers, including open communication, questioning new ideas and understanding different perspectives, creativity and innovation can be promoted [62]

Socio-institutional factors

Social entrepreneurs are able to direct their efforts to creating new value by introducing innovations that solve problems and bring new opportunities to organizations and communities [63] [64]. Based on our observations, it was apparent that the local entrepreneurs did not see their efforts as such a profit-driven entities, but more as an empowering tool to actively influence their immediate environment. Their organic and bottom-up approach in enlisting participation and support for their projects was striking. Successful innovation performance in entrepreneurial firms relies on building greater employee involvement in small firms' innovation activities [65] [66], and innovation is often recognized as an act of creative collaboration [67]. It can be argued that having a strong social purpose tied to their work provides an impetus for regional authorities and entrepreneurs to continuously innovate and improve their problem-solving skills. As with any new ecosystem, it can be mentioned that trust based economic cooperation between the various stakeholders in an innovation ecosystem could take time.

Some of the most prominent achievements so far are related to creation of an innovation ecosystem in the area is the favourable legislations for the Yamuna cleanup efforts, employment opportunities as well as economic and society benefits that result from a cleaner and healthier immediate environment. For challenges as big as cleaning up the Najjaffgarh Drain and others, an integrated, ambitious and well-coordinated effort between the government and the private sector is required.

VII. CONCLUSIONS AND RECOMMENDATIONS

In this paper we explored social entrepreneurship and innovation oriented initiatives in the general Yamuna river plain and attempted to gain an understanding of the local innovation ecosystem. It was evident that social entrepreneurs are able to direct their efforts to creating new value by introducing technology innovations that solve problems and bring new opportunities to organizations and communities [63] [64]. We evaluated the role of five socially driven innovations using the RIS framework. Following the approach of Trippel [25], the process was categorized as knowledge generation, dissemination, application and exploitation.

We also analyzed the regional policy subsystems, interactions of these subsystems and socio-institutional factors. After studying these processes, we conclude that socially minded entrepreneurs and their innovations are critical for the growth and development for the RIS surrounding the Yamuna river plain. It needs to be emphasized that social innovations are not purely technology-driven but are rather driven by effective policies. It is apparent that the social entrepreneurs in the region do not see their initiatives as just a profit-making entity, but more as an empowering tool to actively influence their

immediate environment. Their organic and bottom-up approach in enlisting participation and support for their projects is impressive. The further development of an innovation ecosystem in the region could contribute to the processes of commercialization and dissemination of innovations focused on the Yamuna cleanup efforts. More interregional networks, triple-helix collaboration, issue awareness campaigns and specific policy-measures and incentives would further help in the creation of a robust ecosystem. Some of these measures could include the redirection of public funds towards socially-oriented innovations, their dissemination and implementation, development of transformative 'sociotechnical' innovations [68] [61]; promotion of cooperation of social entrepreneurs and startups with bigger corporations and finding new opportunities for social innovations to "tap into existing infrastructure" [61]. It must also be mentioned that qualitative methods in the form of personal interviews provided rich data, which would have been impossible to obtain using only content analysis and quantitative research. New knowledge was not always developed as a result of the interviews, but it was rather "weaved" by both the parties in a process of conversation. Interviewees covered different issues during the conversation – some of them primarily described how their organizations were interacting and institutions were functioning, whereas others mentioned more about specific functions and role of their organizations.

Based on the lessons learned from the various socially driven initiatives described here, the Delhi Jal Board could garner important insights into areas such as concept mapping and effective brainstorming practices for improving the process and procedures of their own Yamuna cleanup efforts. For example, by supporting these social entrepreneurs enabling further interaction among developers and implementers, including open communication, questioning new ideas and understanding different perspectives, creativity and innovation can be promoted [62]. This includes refining a deliberate, methodical process in which the Delhi Jal Board members work to identify problems, incubate ideas and generate ideas in an iterative process [69]. Further, with the help of these venture, the government could seek to inspire its own constituencies, NGOs, other companies, and customers in the region to shape the social environment of which they are a part. In doing so, this opens up new frontiers for positive social change.

The five social ventures described shares principal features with Bower and Christensen's [70] disruptive-innovations model and aims to surpass the status quo of existing business models by establishing new ways for creating social value. Through this process, the ventures cultivate a new type of citizen who take the lead in solving social problems and utilize their skills and knowledge in an impact-oriented manner. Even small actions such as signing the National Yamuna River Rights petition and sharing it with others, and volunteering with local cleanup efforts in the community, could be very powerful. Ventures such as HelpUsGreen inspire and teach citizens to not simply throw used flowers and other objects from pujas (devotional prayer) into rivers but instead to put them in composting piles that can be recycled in effective ways later.

This change in mindset blurs the line between business and the overall community's self-governance.

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