

Contextual knowledge co-production and capacity building for sanitation planning: experience from Kerala, India

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ABSTRACT

Small towns in the global South face huge infrastructure deficits in sanitation due to the lack of technical, institutional and financial capacity to establish treatment systems. This knowledge gap and capacity deficit are a socio-ecological challenge that requires knowledge co-production by both science and society. This work focuses on a transdisciplinary initiative on capacity building and knowledge co-production called CANALPY in Alleppey, a town located in the southern state of Kerala, India. The project recognises the need for data and knowledge for developing a fine-grained understanding of the sanitation situation in the town and also raises awareness about canal pollution to arrive at participatory solutions. This study analyses the drivers of co-production of knowledge with its enabling conditions as well as the challenges associated with it. The initiative has been instrumental in creating a space and platform for collaborations, dialogues and discussions on problems of sanitation, water quality and pollution. CANALPY has ensured the dissemination of findings among a larger audience and has inspired new thinking and action. It is also important to take into critical consideration the different practical, socio-political, institutional and competence-related challenges that impede the project's goal of knowledge sharing and capacity building.

Key words: Capacity building, Knowledge co-production, Sanitation, Transdisciplinary research

HIGHLIGHTS

- Capacity deficit in urban local bodies impedes sanitation service delivery, exacerbating environmental challenges.
- The study explores CANALPY, a transdisciplinary initiative to address capacity and knowledge deficit.
- The project led to the creation of a knowledge repository on the town and mechanisms for transferring them to decision makers.
- Understanding enablers and challenges of the CANALPY initiative is critical to adapting the experience to other small towns.

INTRODUCTION

Urban areas all over the globe are facing social and environmental challenges related to climate change, resource scarcity and inequality. Most of the tier two and three cities are already struggling to deliver infrastructure and services due to limited institutional capacities and finances (Brown *et al.*, 2012). Small towns are plagued by sub-standard sanitation infrastructure and services due to governance constraints, paucity of resources and capacity deficit of local governments (Chong *et al.*, 2016) leading to contamination of open wells and consequently shallow aquifers (Bhosale & Kumar, 2002; Quamar *et al.*, 2018) affecting water quality and public health. Though large cities can afford conventional solutions like Sewage Treatment Plants, small towns are faced with huge

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infrastructure deficits due to lack of technical, institutional and financial capacity (Tutusasus & Schwartz, 2018). The limited investments in water and sanitation infrastructure in developing countries including India are ineffective due to the lack of operation and maintenance capacities (Subramanyam, 2020).

Addressing these concerns will require new skills, knowledge and competencies at the levels of household, community and local governments (Sharma *et al.*, 2014). Capacity deficits at the level of local governments have been identified with respect to climate change adaptation in the Philippines (Porio, 2011) and policy formulation and implementation in Delhi (Hughes, 2013). Urban local bodies (ULBs) in India do not have the technical, managerial and financial capacity to undertake water and sanitation-related projects (Rosenqvist *et al.*, 2016; Narayanan *et al.*, 2018b). This crisis of knowledge gap and capacity deficit is a socio-ecological challenge which requires knowledge co-creation and co-production by both science and society (Jagannathan *et al.*, 2020).

Researchers from multiple disciplines need to collaborate with each other as well as stakeholders from the state and civil society to address problems which emerge in real-world scenarios (Rozance *et al.*, 2020; Croese, 2021). Such an approach of integration of knowledge and methods to address challenges at the interface of scientific questions and societal problems is known as trans-disciplinary research (Jahn *et al.*, 2012). This approach is also credited with increasing citizen empowerment and ownership, a lack of which is indicative of a decrease in public trust in new technologies (Fritz & Binder, 2018). However, transdisciplinary research has mainly emerged in the global north where a legitimate and formalised structure is in place so that researchers from universities can engage with the institutionalised stakeholders (van Breda & Swilling, 2019). This is in stark contrast to the situation in the global south where complex, heterogeneous and socially stratified urban systems result in a lack of institutional spaces where formal stakeholders can engage with scientific expertise or state representatives (van Breda & Swilling, 2019). This study focuses on one such transdisciplinary initiative of capacity building and knowledge co-production efforts underway in the town of Alleppey located in the southern state of Kerala in India.

CANALPY¹ deals with knowledge production and transfer between the academic institutions (Indian Institute of Technology (IIT) Bombay), government agency (Kerala Institute of Local Administration, KILA), the local self-government of Alleppey Municipality and the community. The aim of this study is to critically analyse CANALPY to gain a deeper understanding of the enabling conditions or drivers of co-production of knowledge, the challenges and the outcomes. This study is also an attempt at mid-course reflective evaluation to improve the understanding of the team members about the status of the initiative and is expected to carve a roadmap to understand local civic governance challenges related to sanitation faced by small towns.

The next section describes the problems of sanitation and the need for interventions in small towns, followed by the case study site and a description of the activities of CANALPY. After detailing different activities of the initiative, the research methods employed are elaborated. This is followed by the findings of the empirical work detailing various factors which served as enablers and barriers for the initiative. Finally, we discuss the limitations of the work and the conclusion.

Problem of sanitation and the ongoing experiment of the CANALPY initiative

Alleppey, a heritage town in the southern state of Kerala, India (Figures 1 and 2), is renowned for its canals and backwaters. The canals have become progressively polluted over the last few decades due to indiscriminate dumping of solid and liquid wastes (Alappuzha Municipality & Government of Kerala, 2014; Karlaganis & Narayanan, 2014). This is linked to the crisis of sanitation which many of the towns in the global south currently face. In the

¹ Canalpy was initially conceived as a social media campaign; however, over the course of time, the name became synonymous with the whole initiative (<https://canalpy.com/>).

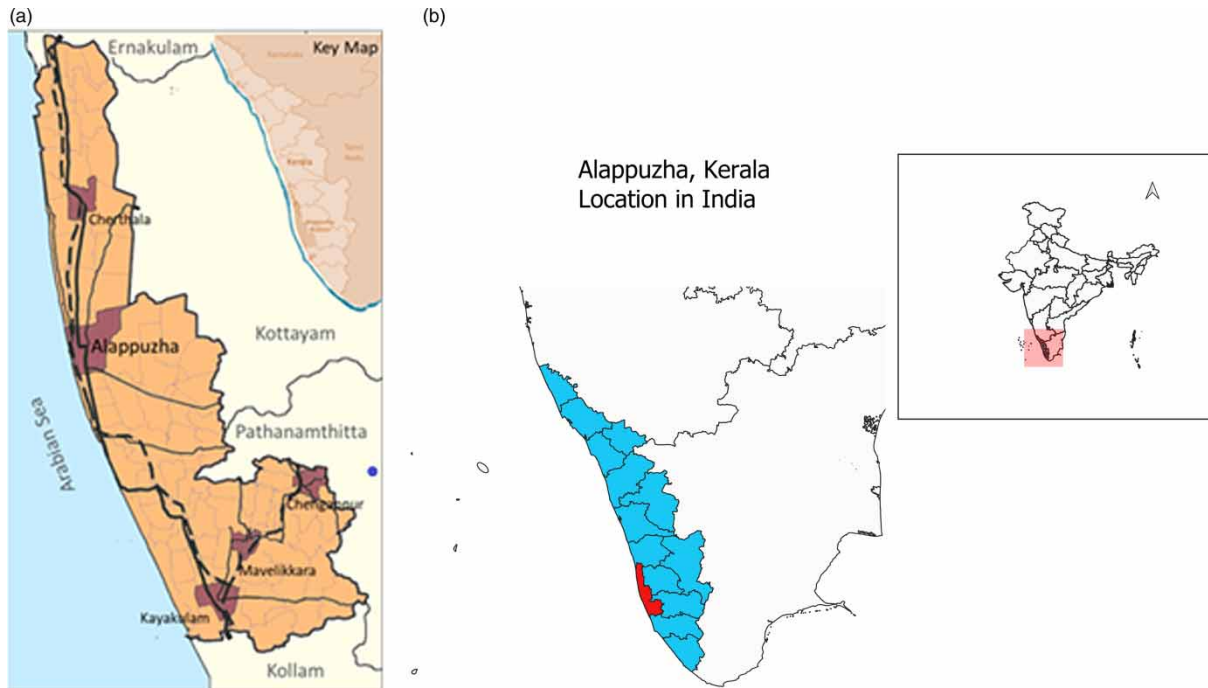


Fig. 1. | (a) Map of Alappuzha District (Source: GOK, 2014). (b) Location of Alappuzha, Kerala (Source: Authors).

face of challenges like the absence of quality data, low budgetary allocations and limited technical capacity, the design of any effective intervention will need a situation analysis of the state of sanitation to explore possible contextual solutions for the town. This was the motivation for the project between the Indian Institute of Technology, Bombay, Kerala Institute of Local Administration (KILA) and Alleppey Municipality.

The aim of the CANALPY initiative was to rejuvenate the heavily polluted canals, and the IIT Bombay team proposed a systematic situational analysis for understanding the baseline condition of the liquid waste management system at the town level. Earlier studies (Narayanan *et al.*, 2018b) proposed a contextual, participatory bottom-up sanitary mapping method which captures the social and spatial arrangements of small towns. The findings of the study demonstrated the need for reliable data for assessing the water and sanitation situation in small towns. Furthermore, the study indicates that government departments lack the capacity and resources to generate fine-grained data (Narayanan *et al.*, 2018b), and it proposed having academic institutions as knowledge producers with students doing data collection and analysis (Narayanan *et al.*, 2018b). The CANALPY initiative sought to replicate the same strategy of engaging the community and academic institutions to develop local capacity.

Researchers from IIT Bombay formed the core research team with the support of the KILA. The initial batch of local volunteers were trained by the team from IIT Bombay and together formed the CANALPY team. The first activity of the CANALPY initiative was a winter school which aimed at conducting a preliminary situational understanding of the sanitation context of the town. After consultations with local youth, civil society organisations like Kerala Shastra Sahitya Parishad (KSSP) and local engineering colleges, a protocol using ODK Collect and OSM Tracker to collect data and track GIS features was developed. Through a set of exercises

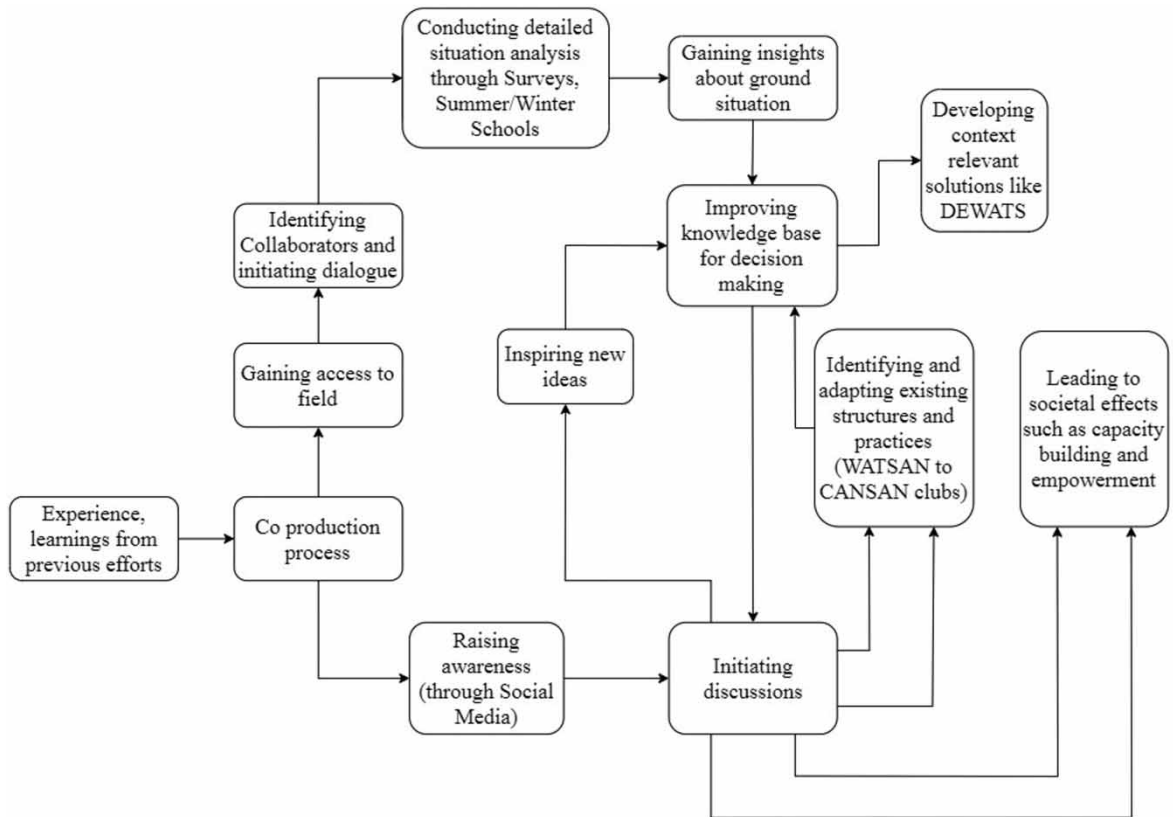


Fig. 2. | Illustration of the knowledge co-production process.

involving participatory drain mapping, water quality assessment and household surveys, the winter school findings conclusively proved the presence of sewage in the canals and prompted the need for a detailed study to understand the sanitation practices of the town (Narayanan *et al.*, 2017a, 2017b).

This was followed by Summer School 2018 which was a scaled-up effort supported by a wide range of participants from both technical and social studies backgrounds who conducted exercises like socio-economic and sanitation practices surveys, willingness to pay surveys, civil surveys of the canals and sub-canals, and studies of bacteriological contamination of water samples. The participants from around the country collected data from 1,500 households and 221 commercial/industrial establishments. The analysis and visualisation of the collected data helped in identifying the major pollution hotspots, polluters and highlighted the disparity in access to services for different socio-economic categories at the ward level.

After analysis of the collected data, canal sheds based on the concept of wastewater sheds (Narayanan *et al.*, 2018b) were made the basic unit of planning and intervention. The data collected during the surveys reflect the social and spatial aspects of pollution and the sanitary practices in the town leading to the demarcation of 'sanitation zones'. Sanitation zones can aid planners in identifying different typologies of sanitation practices and in developing context-specific interventions for each of the localities. The third activity was a winter school in December 2018 which aimed at creating canal shed-specific sanitation plans. The results and insights drawn from each of the studies were shared with the local government, Departments of Irrigation and the Pollution

Control Board along with recommendations for arriving at context-specific interventions for further action. One such context-specific intervention by CANALPY was the decentralised wastewater treatment system (DEWATS) for the most marginalised colony (Municipal Colony) of residents who belonged to the erstwhile manual scavenging occupation in 2019. The operation and maintenance of the DEWATS system was handed over to the members of the Municipal Colony in 2020. Similarly, on the basis of collected data, the Municipality and Kerala State Pollution Control Board conducted meetings with traders and citizen groups like Resident's Associations to encourage them to comply with environmental regulations followed by issuance of notices in case of violations. Timeline, as well as other activities of the initiative, is detailed in [Table 1](#).

[Figure 2](#) explains the nonlinear process flow which is the characteristic of a transdisciplinary action research project. Knowledge production activities are followed by knowledge exchange, like CANSAN, street plays, workshops and Massive Online Open Courses (MOOCs), which leads to the generation of new ideas that then contribute to sharpening original inferences. The ideation process is thus not limited to the researchers at the initial stages but is an iterative process with contributions from many of the collaborators and stakeholders involved in the process.

RESEARCH METHODS

The objective of the CANALPY initiative was to rejuvenate the canals through a participatory process of co-producing knowledge and design action through various activities. This explorative qualitative study deliberates on the drivers and barriers to the knowledge co-production process and attempts to evaluate the impact of the initiative and its allied activities until 2020. This study undertakes a case study approach which entails intensive and detailed analysis of a single case ([Bryman, 2012](#)). The authors were team members involved in the initiative, and the data collection involved multiple processes like key stakeholder interviews, focus group discussions (FGDs) and participant observations.

Table 1 | Timeline of CANALPY activities.

2015–2016	Previous research by team on wastewater sheds and sanitation zones. The team developed an approach to sanitation planning that leverages citizen engagement through participation and local capacities through collaboration with local governments (Narayanan et al., 2018b).
2017	Team approached by Alappuzha Member of Legislative Assembly (MLA) Assembly to clean and rejuvenate the canals. Preliminary visit to town revealed solid and liquid waste pollution due to improper sanitation practices followed by discussions with ULB, MLA First winter school held in December.
2018	Series of surveys and studies conducted on waste and sanitation Summer school was conducted in May. Engagement with community initiated through institution building activities and workshops for local college students. Winter School 2018 for town-wide design of sanitation solutions.
2019	Clean-up organised by youth and community members of the town in one of the canals. CANSAN Campaign – aimed at sensitising school students initiated with the collaboration of education department and local municipality. Awareness building through a series of workshops and classroom sessions. Trained students further tried to build awareness in their communities through street plays.
2020	MOOC on ‘Sustainable and Participatory Sanitation Planning’ – course to replicate the Alleppey experience to other ULBs in Kerala, designed and delivered for elected members and officials of ULBs.

The research process started with key informant interviews who were either in positions of responsibility like elected representatives, officials and particularly those who were actively engaged in the activities of the CANALPY, and this led to an initial list of key informants. During an interview with key informants, they were asked to identify stakeholders not identified in the initial list (snowball sampling). In all, 24 stakeholders were identified and interviewed, and details are synthesised in [Table 2](#). Stakeholders for the FGDs were also identified through purposive and snowball sampling. Two FGDs were held with the women from Municipal Colony.

The interviews followed a semi-structured approach. The questions were on the motivation, challenges encountered and the perceived outcomes of the initiative. FGDs aided in understanding the social dynamics of the community members, specifically the caste, class and gender relations. The interactions mapped the perception of the community members towards CANALPY including their concerns and conflicts related to the activities of the initiative.

Additional data were collected in the form of government reports, documents, publicly available information from the internet and field notes from participant observations in meetings and events. These observations aided in understanding the social relations, information flow and the decision-making process. The collection of data from multiple sources allowed corroboration of findings and identifying similarities and differences between the perceptions of different stakeholders. Data from all these sources were also triangulated to improve the reliability and external validity of the study.

The interview data and FGDs were translated from Malayalam to English and transcribed. While going through the various types of data collected, a constant comparative analysis was done to identify common and divergent themes. The text was then coded in Microsoft Excel according to the identified themes which allowed for categorising and analysing data with respect to the analytical framework identified in the following section.

Analytical framework

The findings from the initial set of activities of the initiative indicate that the problem of polluted canals of Alleppey is complicated by multiple pollution sources, multiple actors, capacity and resource deficit, ineffective monitoring mechanisms, and lack of public demand with the absence of accountability ([Narayanan *et al.*, 2017a, 2017b, 2018a; Chhajed-Picha & Narayanan, 2021](#)). This makes it a multi-actor, multi-scalar, dynamic, uncertain and unclear problem ([Smith & Porter, 2010](#)). Such a multi-causal socially complex problem involving multiple stakeholders is referred to as wicked problems ([Peters, 2015](#)). Local action through the activities of CANALPY has led to a certain amount of knowledge production, transfer and limited capacity building. Though the initiative is local, it is embedded in the broader institutional and societal context. To understand it, an analytical framework adapted from local management action by [Patterson *et al.* \(2013\)](#), as well as the work on collaborative decisions for environmental management by [Margerum \(2008\)](#), is proposed here ([Figure 3](#)).

FINDINGS

The findings section has been organised into two sections, the first examining the drivers for knowledge co-production and the second detailing the barriers and challenges to the co-production process.

Table 2 | Details of interviewees and stakeholder groups.

Stakeholder group	Number of interviewees
Government agencies at the state level	9
Community stakeholders	9
CANALPY team members	6

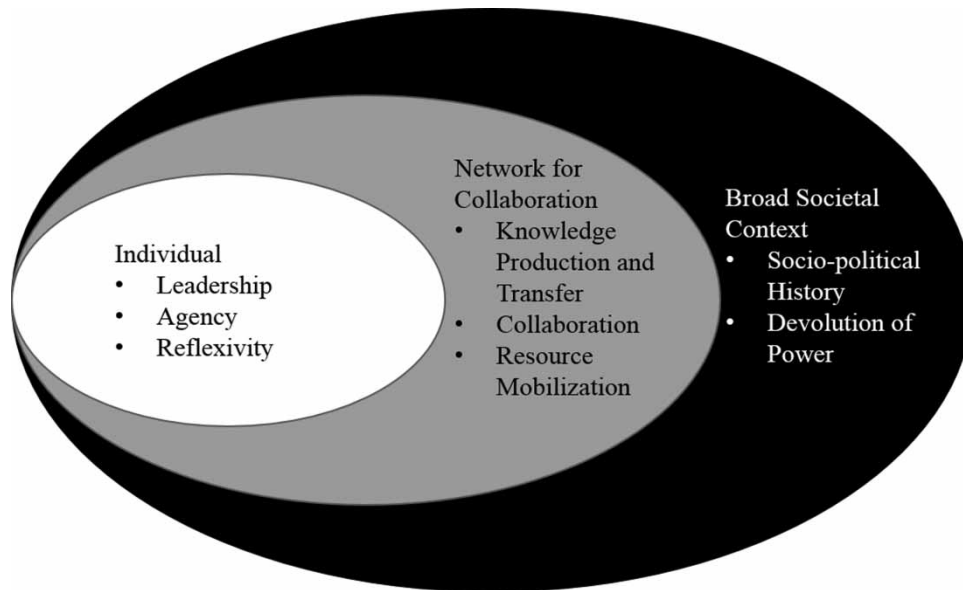


Fig. 3. | Analytical framework for enabling factors which served as drivers for the knowledge co-production process.

Drivers for co-production

Broad societal context

The broad societal context in the framework includes the following aspects: the socio-political history at the sub-national level and the devolution of power by the state government to the local self-government.

Kerala is widely known for its peculiar pattern of development, characterised by high levels of social development. The ‘Kerala Model’ as characterised by sympathisers includes a set of high material quality-of-life indicators coinciding with low per capita incomes, which was brought about by a set of wealth and resource redistribution programmes, investments in human resource development and progressive political participation (Dreze & Sen, 1997). The redistribution of assets by land reforms and the various pro-poor welfare policies were also the result of such politicisation, which led to the development of a welfare state, bringing better living and working conditions to large sections of people (Franke, 2019). The major criticism against the Kerala development experience is the slower rate of growth compared to even the Indian national average (George, 1998), the main reason being the lack of efficiency of the productive sectors of the economy. In addition to these, the environmental damage now faced by the state raises questions on the sustainability of even the limited economic growth achieved so far (Narayanan, 2003).

The 73rd constitutional amendment passed in 1993 in India granted new powers to the local government making them more accountable to the citizens. This was best operationalised in Kerala through the ‘People’s Campaign for Ninth Plan’ from 1996 wherein local governments were given new functions and discretionary budgeting authority over 35–40% of the state’s developmental expenditure (Heller *et al.*, 2007). Examining the socio-political history of the state reveals that democratic decentralisation ably assisted by grassroots democratic organisations has led to the strengthening of local institutions and planning capacity (Heller, 2001). Civil society organisations like the KSSP help mobilise people and their past experience of executing local-level initiatives and planning experiments including environmental accounting initiatives like the resource mapping was adopted by the Kerala State Planning Board (Heller *et al.*, 2007). The historical and political characteristics of Kerala play

a central role in enabling knowledge co-production – the preoccupation with knowledge, education and literacy; broad-based democratisation and social change and concern with sustainability (Shrum & Ramanathaiyer, 2000). It is also important to understand the political and social context of Alleppey with high levels of literacy² and political engagement (Isaac, 1985). There is also a distinct environmental consciousness among the residents, evidenced by the decentralised sanitation campaign in Alleppey from 2012 (Isaac & Gopakumar, 2016). This environmental consciousness was also evident in the interest shown by community members who participated in the activities of CANALPY.

Network for collaboration

At this level, factors that were identified as enablers for the initiative were the process of knowledge co-production and transfer, collaboration between different organisations and resource mobilisation.

Knowledge co-production focuses on engaging with both scientific and societal actors by bridging disciplinary boundaries and solving real-life problems on the ground (Polk, 2014). Similar approaches are given different names such as interactive social research (Talwar *et al.*, 2011), transformative or participatory sustainability science (Lang *et al.*, 2012) and action research or participatory research (Wiek *et al.*, 2014). Some of the features of this type of approach are that (1) they facilitate collaboration among scientists and non-scientific actors, (2) decision makers and the communities strive to generate relevant and context-appropriate knowledge, (3) encourage participants to not only divulge information but engage in deliberation and reflection, (4) keep normative aspects like values central in the research process and finally (5) encourage mutual accountability, ownership and leadership among the participants (Talwar *et al.*, 2011; Lang *et al.*, 2012; Wiek *et al.*, 2014). The aim of this approach is to capture the complexity of societal problems by using knowledge from multiple disciplines and employ a context-specific, collaborative and democratic approach to solve societal problems. Furthermore, this approach creates spaces and opportunities for knowledge exchange and transfer between different stakeholders (Hansson & Polk, 2018).

Another aspect of knowledge co-production is ‘social learning for interdependence’, which refers to bridging the gap between an expert and the people who possess experiential knowledge (Bouwen & Taillieu, 2004). Undocumented knowledge possessed by the community members (about the history of canals, story of progressive pollution, tacit knowledge about canals) does not have the legitimacy accorded to published literature. According to Cash *et al.* (2005), for effective knowledge to take place and for knowledge to cross the boundary between organisations, it is important that negotiation or creation of knowledge is found to be credible, legitimate and salient by all the stakeholders. In this regard, salience describes the relevance and contextual accuracy of the information on which the collaborating stakeholders base their decisions. For example, the appropriate technology solution of DEWATS for the Municipal Colony portrays high salience. Credibility refers to the extent to which scientific outputs and outcomes are perceived as accurate, valid, robust and of high quality by decision makers, while legitimacy describes the extent to which the knowledge producers are considered to be unbiased and trustworthy by decision makers. IIT Bombay is one of the leading academic institutions in the country, and the participation of researchers from the institute provided credibility and legitimacy to the initiative.

Starting with the first winter school in 2017, IIT Bombay and the student participants of summer/winter schools created detailed knowledge about the sanitation practices in Alleppey including knowledge from the experiences and perspectives of non-scientific stakeholders like the residents who were surveyed during the summer/winter schools. This was then converted into different forms – reports, presentations, documentaries

² According to Census 2011, the literacy rate of Alleppey district is 96.24%.

and MOOCs. And different mechanisms were employed for disseminating the knowledge between different stakeholders.

Thus, the generated knowledge was distributed through a knowledge network which exhibited features identified by Luijendijk & Mejia-Velez (2005). First, the knowledge production exercises like summer/winter schools sought to create value by moving beyond information sharing so as to create new knowledge that translated into solution proposals that served as the basis for interventions. Secondly, the activities directly contributed to improving the capacity – through communication and knowledge exchange of the participants – volunteers of CANALPY, school students and interns from academic institutions and officials of line departments. Finally, these activities helped the CANALPY team members in networking with potential stakeholders and in devising strategies for engaging with them as well as other decision makers. These stakeholders became the key collaborators of various activities of the initiative in the field.

CANALPY aimed to leverage the potential for collaboration between different institutions and provided a platform for the same. Since it is difficult to foresee resources and needs for the initiative, collaboration is one of the ways to identify them (Beier *et al.*, 2017). Collaboration between different government agencies was achieved by inviting coordination and support from them. Coordinating with these agencies ensured strategic and nonlinear collaboration which is illustrated in Figure 4. Since the number of collaborating organisations was small, it was manageable and the shared jurisdiction also played a role in the collaboration concluding in local action. This particular characteristic is suggested as one of the contextual features that make a transdisciplinary project

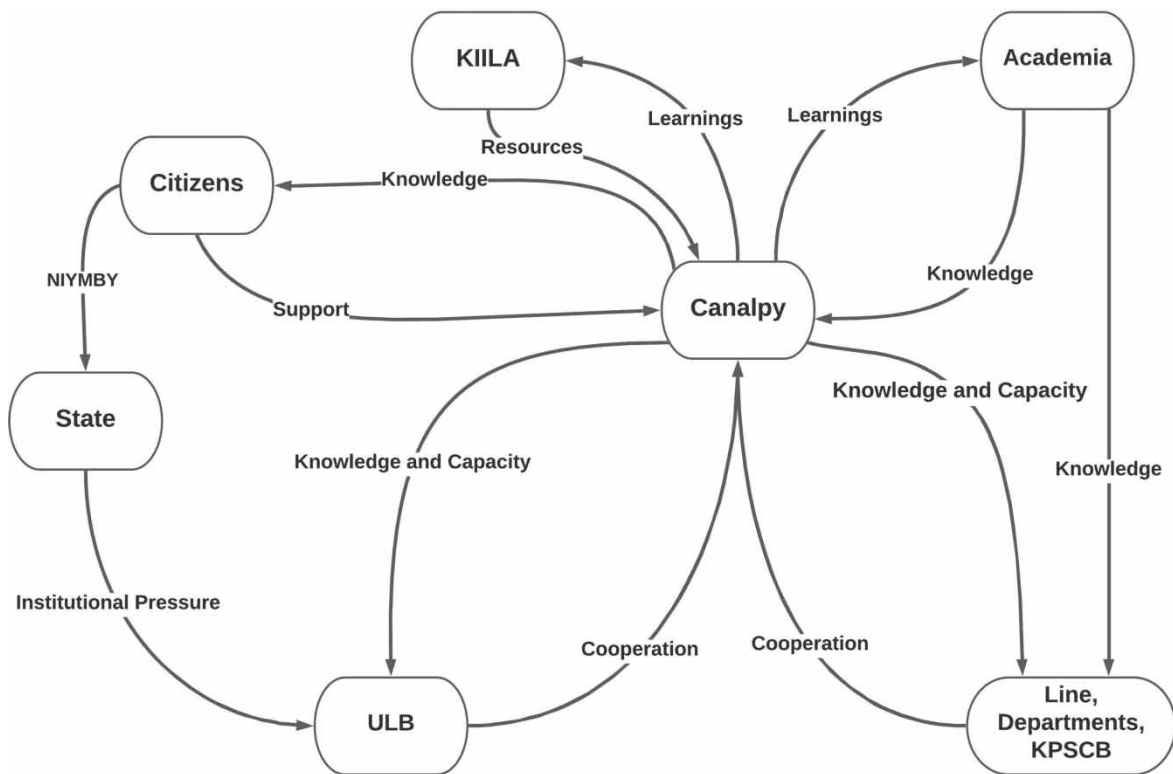


Fig. 4. | Relationships between collaborators in the network.

possible in a field setting (Margerum, 2008). Collaboration was beneficial to researchers involved in the initiative as well, as it enhanced their ‘co-productive capacities’ that are a combination of the scientific resources, cognitive, social and normative capacities to connect knowledge with action (Djenontin & Meadow, 2018). The team from IIT Bombay used the protocols and knowledge generated in Alleppey and leveraged the network of student volunteers to replicate the experiment in the neighbouring region of Kuttanad.

Another important factor that enables transdisciplinary local action projects is the mobilisation of resources. Since collaboration includes parties with various mandates, interests and expertise, it ensures that a complex problem is broken down into simpler questions and solutions are achieved at lower cost and without delays (Beier *et al.*, 2017). This is vital especially in the case of water and sanitation, which is often the responsibility of local governments that normally function with limited staff and financial resources (Crocker *et al.*, 2016). The KILA played an important role as the main funding source for the knowledge production activities and provided the financial and human resources. Furthermore, both formal networks and informal engagement of team members with the residents yielded necessary resources. For example, discussion through the formal network helped in identifying CSR funds for the construction of the DEWATS plant. Furthermore, informal conversations between the CANALPY team, interns and residents were instrumental in the canal clean-up campaign where local residents contributed by participating as volunteers as well as providing tools and food to the volunteers.

Factors at the individual level

At the individual level, leadership, agency and reflection play an important role in facilitating collaboration and knowledge co-production (Patterson *et al.*, 2013). Leadership leverages some aspects of human capital so that individual community members can mobilise resources and influence action by acting as change agents or leaders (Bass 1990 cited in Chaskin, 2001). Leadership includes both formal and informal leaders (Goodman *et al.*, 1998): formal political leadership in the form of support of the local Member of Legislative Assembly (MLA), the Finance Minister of Kerala and one of the strongest enablers of CANALPY. This stems from his conviction as an ex-academic as well as his activities on decentralised solid waste management in the town that is hailed as a model that won national and international acclaim including recognition from UNEP.³ Similarly, the local project coordinator, an elected representative to the Municipal Council leader, could keep CANALPY in touch with the local government. He also leveraged his connections and networks to mobilise local volunteers for surveys and studies. The coordinator and main volunteer is also a dynamic activist who has attributed the success of the activities to their connection with the civil society organisation of KSSP. In the case of multiple collaborating institutions, it becomes important to recognise the power differences and have a neutral role as a facilitator rather than a hierarchical leadership setup (Bouwen & Taillieu, 2004). Thus, the local coordinators fulfilled the leadership duties of providing logistical support, process support as well as agenda-setting, framing and guiding the initiative by engaging in strategic negotiation with the collaborators. Support was provided by certain interested residents who with their agency served as norm setters. To explain this, it is important to explore the ‘agency’ factor.

Transdisciplinary research approaches recognise the importance of human agency in transformational projects attempting to bring about systemic changes (van Breda & Swilling, 2019). Agency is defined as the capacity of people to create, change and live according to their own meaning systems and to have the power and capacity to work towards the community’s own destiny (Bhattacharyya, 2004). Individual agency plays an important role in enhancing community capacity (Chaskin, 2001) and comprises human capital and leadership – skills, knowledge and resources (Chaskin, 2001). In the case of CANALPY, in Municipal Colony, a few key individuals

³ <https://www.unep.org/news-and-stories/story/solid-approach-waste-how-5-cities-are-beating-pollution> (accessed 3 November 2019).

were the main source of agency, who through their leadership, trust-building and willingness to learn new things, triggered learning and action among other residents. This agency was evident from residents of the Municipal Colony reporting violators who throw waste into the canals and from residents volunteering their time, labour and resources for cleaning the canal. Frequent engagement of the team and the researchers with the community through documentary screening, discussions and meetings also led to strengthening community members' ability to assert their agency.

Another factor that has functioned as an enabler at the individual/community level is reflexivity. According to Schwandt (1997, p. 135) (cited in Waghid (2002)), reflexivity is 'the process of critical self-reflection on one's biases, theoretical predispositions, preferences and so on'. Transdisciplinary knowledge is produced by engaging researchers reflexively and pushes universities to shift from being producers of disciplinary knowledge to creatively configure knowledge for tackling increasingly complex problems (Waghid, 2002). In the case of CANALPY, researchers from IIT Bombay and the CANALPY team were constantly motivated to engage in group reflections and discussions regarding the choices and decisions made in the initiative. Further local volunteers and interns have been engaged in multi-loop learning (van Breda & Swilling, 2019) wherein after gathering knowledge and skills through initial training sessions and summer schools, they could reiterate the learning process by delivering the next training session or workshops for students, community members and new interns. This constant engagement made them critically aware of the problems at hand and the consequence of the learning process. This also contributed towards reflexive learning. This commitment to reflexivity by the team and researchers also meant that inferences from the finding of one activity informed the next activity, thus leading to an iterative process of adapting research design and execution.

Barriers to the co-production activities

Practical barriers

Knowledge co-production and transdisciplinary research often face multiple practical and organisational barriers. Practical barriers include lack of time and resources (Polk, 2015). In this initiative, one of the challenges of the summer/winter schools was the lack of local participants. While the expectation from the knowledge production programmes was that young people trained from the summer/winter school would be a part of the awareness campaigns and studies, the proportion of local participants hailing from Alleppey was found to be much less. Many of the interns and volunteers also left after short stints constraining local youth representation. The political leadership in Alleppey expected the CANALPY team members to deliver quick results, and consequently, the team members had to devote a considerable amount of time and energy to managing the expectations. The clash of interests and differences in motivations between the stakeholders as found in literature was clearly observed in the context too. For example, knowledge exchange between researchers, local officials and bureaucrats is difficult when they employ different approaches and have a different vocabulary for framing the problem (Polk, 2015). Also, high expectations of public partners like political representatives may also clash with the production of results on the ground by the project team (Lang *et al.*, 2012). All these come in the way of practical barriers to implement the plans meticulously made through a long process of data collection, iterative analysis, reflection and finalisation.

Socio-political barriers

Varied political interests of the stakeholders can delay or impede consensual decision-making by stakeholders (Ansell & Gash, 2007). In the case of Alleppey Municipality, since the local and state governments belong to adversarial political fronts, it was difficult to develop cooperative alliances for implementation. Inferences from the FGD suggested changing dynamics of local politics. The interest of local government and their

participation was uneven mainly due to external pressure developments in state and local politics, specifically the local elections which took place in 2020. Earlier, the local office bearers of the opposition party wanted the activities of CANALPY to succeed, as it was an initiative of their party leader who was the MLA from that constituency and the Finance Minister of the state. But with impending local body elections and fear of the ruling coalition using CANALPY for electoral gains, the initiative was abandoned by the opposition party. Thus, the same enabling political factors that earlier facilitated the initiative changed into constraints later. Furthermore, the heterogeneous nature of the community affected the participation of the community and in turn the knowledge co-production process. The FGDs conducted clarified that communities are fragmented along gender, caste and class lines. Social hierarchies and stratifications lead to conflicting political agendas, interests and power differentials which were observed as barriers in general (Polk, 2014).

Institutional factors

While the co-production process is a contextualised exercise, it is also important to note that the agencies collaborating on the initiative may not be designed to incorporate the demands of the project on their resources (Polk, 2015). The institutional culture and mindsets may not be suitable for a complex transdisciplinary project, as it entails institutional transaction costs – since various activities of the initiative were taking place outside the confines of their organisations, the stakeholders had to devote time, attention and other resources to the initiative. For academics involved in the initiative, time spent for travelling and attending meetings related to the activities of the initiative may lead to diversion of attention and time from other academic demands (Hoeft *et al.*, 2015). In CANALPY, the main academic partner IIT Bombay is not a proximate stakeholder impeding daily interactions. Due to limitations in motivations and institutional constraints, no local academic institution could take up the role, although attempts were made along those lines. Similarly, since the knowledge co-production and transfer involves multiple organisations, the process is prone to institutional inertia (Campbell, 2004). The local bureaucracy was fragmented along sectoral lines with no clear roles and responsibility definitions to involve in such an unconventional project. Likewise, the opportunity costs for participating stakeholders may be high and often not evident to their academic counterparts. Further logistical factors like lack of resources, financial and time constraints and geographical distance were also important issues faced during various activities of the initiative. These constraints shape the way activities are planned and may ultimately lead to ineffective engagement (Fritz & Binder, 2018).

Competence and knowledge gaps

Apart from practical and institutional constraints, competences of collaborating stakeholders play an important role in the participation and knowledge co-production process (Steelman *et al.*, 2015). Some of the local academic collaborators of CANALPY did not have the requisite skills and competencies to follow up on the various activities or integrate the various types of knowledge generated during the initiative. Academics and other collaborators in the project are trained in specific scientific disciplines and it rarely gives them the skills and competences needed to collaborate with diverse teams (Fritz & Binder, 2018). Many of the activities associated with the initiative could not be followed up due to lack of capacity and skills. This can be attributed to the fundamentals of the academic system which is perceived to be constraining and eager to slot students into disciplinary silos. Most of the disciplinary programmes are limited in providing training which fosters competencies needed for transdisciplinary and participatory research (Rozance *et al.*, 2020). Thus, this lack of skills and experiences may cause some academic researchers to find the whole process stressful and challenging (Cvitanovic *et al.*, 2019).

Apart from institutional factors, another important aspect that affects the transdisciplinary knowledge co-production process is the mindset of the collaborating stakeholders. While [Hansson & Polk \(2018\)](#) contend that high-level administrators with more power tend to be constrained in their thinking, CANALPY found some support from senior administrators of the local government and other agencies like the State Pollution Control Board who welcomed the new ideas and approaches in addressing the problem. However, some of the administrators were unfamiliar with updated knowledge systems, and the team encountered some resistance while trying to pitch alternate ideas to them. Furthermore, during the implementation of the DEWATS system, the team faced an inadvertent delay in bill payments due to hierarchies and red tape which prevented receptivity in organisations and deferred decision-making.

DISCUSSION

This study attempted to identify the drivers, motivations, barriers and challenges to the knowledge production process in the context of the CANALPY initiative in Kerala. One of the first drivers identified was the socio-political history of the state which was instrumental in steering the population towards democratisation, literacy and deepening of local governance. This is in line with findings from other scholars ([O'Connor *et al.*, 2019](#)) who posit that democratisation gives voice to citizens from a broad range of backgrounds thus empowering them to encourage decision makers to be open to all sources of knowledge. Furthermore, our findings also show that the process of decision-making is not only a function of knowledge but dependent on social learning. Experiential knowledge and expert knowledge interacted through collaborative processes to forge long-term relationships between the stakeholders and in building trust.

Our empirical analysis also reinforces findings from previous studies ([Gerger Swartling *et al.*, 2019](#)) that the assignment of an actor with leadership and collaborative skills for the task of facilitating and managing the process is central. This ensured support from the community and trust built with collaborators ensured continuity, especially the engagements with the local government. The findings also demonstrate that collaborating with multiple stakeholders has capacitated the local government and enhanced the co-productive capacities of the researchers. As in the case with other examples of knowledge co-production ([Reyers *et al.*, 2015](#)), the approach of creating platforms for collaboration has resulted in unearthing finer details of waste management practices which has led to the newer and contextual understanding that helped plan subsequent actions.

One of the limitations of the CANALPY initiative is the absence of any analysis of the impact of the activities on the local and other stakeholders. It is still an ongoing exercise, and an external evaluation is currently being explored by the team. This may provide suitable pointers to better design similar transdisciplinary initiatives to bring together academia, local community and local governments.

CONCLUSION

The study assessed CANALPY, a transdisciplinary initiative for knowledge co-production to address the capacity gaps in tackling the sanitation problem in a small town, particularly to rejuvenate its canals. Researchers involved in the initiative worked with local volunteers, citizens, government officials and the ULB for the production and transfer of knowledge to generate context-specific interventions. This study has sought to explore the knowledge co-production process and the various enabling drivers and barriers to the process. Examining the enablers through a multi-level framework helped identify factors that facilitated various activities of the initiative. The process of knowledge co-production is also fraught with risks and limitations mainly due to the socio-political, practical and institutional barriers. In summary, CANALPY has been instrumental in creating a space and platform for collaborations, dialogues and discussions on problems of sanitation, water quality and pollution. Crowdsourcing of data through large academic exercises like summer and winter schools helped generate a

fine-grained analysis of sanitation problems at the town level. By converting the research into different types of knowledge products, CANALPY has ensured that the research findings got disseminated among a larger audience. These knowledge products have inspired new thinking and action, especially innovations like DEWATS in the Municipal Colony that points to the importance of sanitation planning to arrive at priorities for interventions, especially to achieve inclusive sanitation. The MOOCs designed for the elected representatives and officials of ULBs will help scale up the Alleppey experience to the entire state. Although the initiative attempted to bridge the capacity gaps in government agencies, it faced multiple barriers during the process. Another limitation of this study is the role of the authors in the initiative. By being actively involved in the initiative, there is the risk of our objectivity being compromised. However, we have attempted to periodically reflect on our roles as researchers critiquing the initiative as well as our role in the same. Many themes, which have a direct impact on the knowledge co-production and exchange such as the role of leadership, trust and partisan politics, also remain under-explored in this study. Future work has to analyse these along with evaluating the larger implications and outcomes of the initiative.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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