

Collective Infrastructural Speculations

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ABSTRACT

Community Networks (CNs) offer a means for high-quality communication infrastructure growth, especially in rural areas providing benefits to social and economic development; CNs hold potential to be community-owned infrastructure fostering community resilience. Towards realizing this potential of CNs, we explored two research questions: What does resilience mean for the communities who build, maintain, and use a CN; and what are community-based visions for fostering resilience and sustainability of their CNs? We carried out four speculative design workshops with different stakeholders at two CNs: Ocean View Community's CN in South Africa and the Channapatna Health Library's CN in India. We report our findings as two design fictions that emerged as collaborative articulation of our collective visions, acting as 'Infrastructural Speculations' nuancing our understanding of resilience in CNs. We offer insights into how speculative design could become a part of ongoing, situated participatory design and infrastructuring work.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods; Participatory design.

KEYWORDS

Participatory Speculative Design, Community Networks, Infrastructural Speculations, Global South

ACM Reference Format:

Siddhant Shinde, Naveen Bagalkot, Nervo Verdezoto, Ganief Manuel, Muni Ramakka, Ndinelao Iitumba, Deysi Ortega, Dinesh Tb, and Melissa Densmore. 2024. Collective Infrastructural Speculations. In *Participatory Design Conference 2024 (PDC '24 Vol. 1)*, August 11–16, 2024, Sibul, Malaysia. ACM, New York, NY, USA, 14 pages. <https://doi.org/10.1145/3666094.3666111>

1 INTRODUCTION

The COVID-19 pandemic brought forward a range of iniquities at many levels across the globe; the Internet and the knowledge it offers was one of the many infrastructures whose unequal and inequitable distribution came to the fore [1, 37]. Especially in rural areas, Community Networks (CNs) are organizations or movements formed to offer high-quality communication infrastructure growth to provide free, subsidized, or low-cost access to the internet via wireless means by and for the communities [2, 17, 31, 34, 39, 61, 72]. CNs are recognized as enablers of sustainable development offering employment and business opportunities, educational and healthcare support, and are positioned as resilient infrastructures that enable marginalized communities to become more resilient in crises [27, 29, 30, 38].

Designing, building, and maintaining a CN is a collaborative effort, which invariably draws upon the underlying resilience of the community, that is, the ability of the community to adapt to change, being frugal while coming together to pool their resources towards strengthening themselves and their neighbors. As a community-owned and maintained infrastructure, a CN also needs to be resilient to respond and continuously adapt to existing and future socio-technical community challenges [15, 20, 28, 38, 47, 61]. However, there is a need to understand the interrelationships between resilient communities and resilient CNs. For, a CN is not only an infrastructure that bypasses mainstream Internet Service Providers (ISPs) to offer affordable access to high-speed Internet but also holds the potential to strengthen a community through fostering local knowledge and content, as well as offer relevant and meaningful services and digital skills development for the community, by the community [14, 27, 28, 44–46, 53, 57, 63, 77, 78].



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PDC '24 Vol. 1, August 11–16, 2024, Sibul, Malaysia
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ACM ISBN 979-8-4007-0808-4/24/08
<https://doi.org/10.1145/3666094.3666111>

A CN holds the potential to be a core community-owned infrastructure that fosters community resilience. Towards realizing this potential of a CN, we ask the following research questions:

- What does resilience mean for the communities who build, maintain and use a CN?
- What are community-based visions and requirements for ensuring and fostering resilience and sustainability of their CNs?

We are an informal coalition of academic researchers, co-designers, Free Libre and Open-Source Software (FLOSS) activists, engineers, and community experts, learning from our respective ongoing work of collaboratively designing, implementing, and maintaining three CNs in South Africa and India: The Ocean View Community (OV), South Africa; Devrayanadurga Hills (DD Hills), India; and The Channapatna Health Library (CHL), India. In South Africa, we have been working with the OV community to build a CN since 2015, co-designing and deploying tools supporting content and services¹ on the mesh wireless network. At DD Hills² and CHL³, we have been involved in the design, implementation, and maintenance of two CNs, through situated participatory action research and design. Leveraging our ongoing work, and exploring answers to our research questions, we carried out a series of speculative design workshops with various stakeholders at the OV's CN and the CHL's CN, respectively.

In this paper, we report the findings from the workshops in the form of two design fictions that emerged as collaborative articulation of our collective visions [4, 8, 19, 24, 65]. The design fictions act as 'Infrastructural Speculations' [84] nuancing our understanding of resilience in CNs. Through this work we understand that resilience is not dependent on one monolithic infrastructure development but on how multiple entanglements of human and non-human actors help build collective ownership and maintenance of the network and facilitate local content creation, curation, and engagement with and through the community infrastructure. Through this paper we contribute to the emerging discourse of participatory speculative design [22, 85], highlighting possibilities for bringing together diverse researcher-activist-community stakeholders in a long-term situated, sustained, and participatory practice of infrastructuring towards collectively realizing resilient community networks.

2 RELATED WORK

2.1 Resilient Communities & Resilient Community Networks.

Low-resource communities have developed their strategies for resilience to fight back against unfavorable and challenging circumstances [13, 25, 41, 66, 67, 81, 82, 86, 92, 93]. CSCW, HCI, and PD research has studied resilience in various contexts and different complex situations [11, 49, 80-83, 87] highlighting the important role of cultural expectations and human capacity in a dynamic evolving process situated in people's everyday environments [81]. One of the major focus areas is on how technology is used and adopted during an emergency or disaster, for example, during war

¹<https://www.inethi.org.za/>

²<https://open.janastu.org/projects/cowmesh>

³<https://llncolab.notion.site/Channapatna-Health-Library-4b72a31fea8241b79c2f75a6b9d302b6>

times [58, 59]. Resilience is also understood as the need for a better understanding of the wide range of consequences of adapting for community well-being [25], while suggesting a socio-technical approach to design for community resilience [9]. In the last decade, there has also been a call to move away from the above conceptualization of resilience towards a deeper understanding of what is being maintained for whom and by whom, through the discourse of resilience [26]. In the Global South and especially across African communities the idea of being resilient also comes from the idea of *jugaad*⁴ [54, 68] and repair cultures [5, 6, 43, 45], where innovation, creativity, and collaborations are happening in the community due to a lack of resources and the need to adapt to uncertain circumstances [42, 91-94, 98].

Our study focuses on understanding the community-based visions of resilience and sustainability in the context of CNs among socioeconomically diverse stakeholders in India and South Africa. CNs for the last two decades have shown capabilities of supporting and connecting people who are most often neglected in both rural and urban settings to provide affordable telecommunication access [7, 61]. According to the Internet Governance Forum's Declaration of Community Connectivity of 2017, a CN must be owned by the community that deploys it, it should have transparency in its operation, and it should operate democratically, and actively include community members on the ground in design, development and management. Initially, CNs were set up by tech enthusiasts and activists to explore and experiment with alternative communication, knowledge, information systems, and structures to the Internet [7, 20, 36, 48, 62, 73, 75]. In the case of fewer resources and rural and lower-income communities, there are instances of university groups setting up the network infrastructure with the local governing bodies of the area [44, 63]. There are also cases of activists, technologists, and researchers in not-for-profit organizations helping and teaching rural communities to set up, operate, maintain, and manage the CNs [7, 60]. Nicola Bidwell [15] highlights how CNs provide academics, researchers, activists, and technologists a chance to explore and test concepts and ideas 'in the wild', beyond predictable research and development settings. Resilience emerges in the joining of local awareness and knowledge highlighting the embedded and situated nature of resilience rather than external expert intervention by specialists in resilience [15-18]. Building on such an understanding of resilience and CNs, we focus on understanding the idea of situated resilience and sustainability through communities' perspective and their visions of community network infrastructures.

2.2 Participatory Speculative Design.

There has been a growing exploration of combining speculative design with participatory methodology and co-design methods for futuring, through the emergence of participatory speculative design (PSD) [22, 23, 35, 65, 74, 88-90, 96]. A combination of the concerns within PD on sustaining the relationships with participants and their contexts beyond workshops, and the concerns within the Speculative Design regarding whose visions are represented in process and outcomes of futuring is driving this emerging discourse

⁴Jugaad is a name for ad-hoc creative resolution of problems by the people in resource-constrained settings.

[35]. A recent work [22] has argued for considering PSD as a more integrative approach to achieving embedded and ethical political actions while using situated participatory speculations to address potential tensions when working collaboratively with different communities toward socio-technical alternatives.

We are particularly interested in facilitating collective speculations to elicit and articulate community-based visions of resilience and sustainability of the CNs and the associated socio-technical infrastructures situated as part of the everyday life of the community members. Work [21] highlights the thinking about the CNs as sites of bottom-up infrastructuring by emphasizing the situated emerging dynamics of participation in the building and maintenance of grassroots wireless community networks. They illustrate this by describing the antennas not just as functional technical devices but as active “non-human agents” and thus considering the wireless antennas as “infra-structuring objects” [21]. Along the same lines of conceptualization of participatory ‘design in the wild’ as an ‘embedded, ongoing, and multi-relational activity’ [50] adapted the notion of ‘artful infrastructuring’, borrowing from Suchman’s notion of ‘artful integration’ [76] by addressing the topic of design and development by “non-designers”.

2.3 Infrastructural Speculations.

Infrastructuring over the years has advanced the understanding and the importance of long-term situated engagements and the impact of PD work that continues beyond the researchers’ and designers’ actions in different social, cultural, economic, and political settings [23, 51]. Some PD researchers and practitioners have moved away from the explicit focus on design methods and workshops towards theorizing PD as less of a fixed design process and more about the complex entanglement with the “collectives of humans and non-humans”, through which “matters of concern” are handled [12]. The works highlight the politics of care in participatory practices to explore the ethical commitments of designing [56], and critique PD workshops as research practices with the limited time that privilege and prioritize certain immediate actions while overlooking the local understanding of design [69], which hold potential harms to further marginalize and ultimately undermine the participation of certain individuals [40].

Drawing from works of community-based infrastructuring [3, 51, 52] in our work, we consider infrastructuring as a mode of practice that is embedded, located, and emergent and helps to develop and maintain long-term engagements with the communities. The speculative design workshops were not a set of one-off ‘research events’, but a part of ongoing research-practice engagement with the two CNs. We draw from the work on ‘Infrastructural Speculations’ [84] that calls for speculative design efforts to go beyond the utopia-dystopia binaries and explore ways to integrate and weave the complex everyday infrastructures and settings as part of fictional accounts of alternatives and futures. The two design fictions we present in this paper, are particular ‘infrastructural speculations’ that center, and are simultaneously situated in the complex and long-lived relationships between community members and technology with the respectively evolving CNs.

3 RESEARCH CONTEXT: THE COMMUNITY NETWORKS.

We carried out the participatory speculative design workshops with members of two community networks: The Ocean View (OV) community, Cape Town, South Africa, and the Channapatna Health Library (CHL), Karnataka State, India.

The OV community is a peri-urban township 40km outside the Central Business District (CBD) of The City of Cape Town, South Africa. Through a collaboration between iNethi⁵ and Black Equations since 2015, the OV community has fibre internet to the schools and library, and residents can purchase internet through mobile service providers or wireless ISPs. FOCUS, the community wireless network is maintained by Black Equations, which is a company led by Ganief Manuel, one of the OV community members.

Channapatna is a town located 80 km southwest of Bangalore. MAYA⁶ is a non-profit organization that has trained and supported about 100 women community Health Navigators (HNs) to offer door-to-door services of monitoring and management of chronic conditions within their communities, out of which 25 are based in and around Channapatna town; their work coordinated by Muni Ramakka. At the time of the speculative design workshops, the community of the HNs did not have a community wireless network deployed on the ground. However, we had begun the work of imagining the Channapatna Health Library (CHL)⁷ as a form of CN and deploying its components through a collaboration between the HNs, members of Design Beku⁸ [10], and Janastu⁹.

4 METHOD.

Between January 2022 and July 2022, we conducted a series of four Speculative Design workshops in South Africa and India. The first set of workshops at both the sites (S1 and S3), focused on envisioning the futures of CNs as community-owned infrastructures, drawing from participatory speculative world-building methods [24, 71, 84]. The second set of workshops (S2 and S4) explored the idea of resilience in CNs in the context of ongoing design and development of network infrastructures at the respective sites.

Researchers and local collaborators across both sites, met weekly online for a month before the workshops to discuss the ongoing works on the ground. As a part of the larger ongoing research project the workshops aimed to understand the community-based visions and requirements for ensuring and fostering resilience and sustainability in situated CNs. The speculative design workshops were informed by stakeholders’ interviews and co-design workshops of network management interfaces [101]. The project aimed to recognize the crucial roles of community members, not just as users and managers of the CNs but as experts in local socio-cultural context and content [15–17]. The speculative design techniques were used to foster creative articulation of community members’

⁵<https://www.inethi.org.za/>

⁶www.mayahealth.net

⁷<https://designbeku.in/Channapatna-Health-Library-dc06f345f869428ca9cb9f78b456f04d>

⁸www.designbeku.in; Since April 2024, the CHL and related CN infrastructuring work moved with the key members from Design Beku under the responsibility of Aruvu Collaboratory at aruvu.org.

⁹<https://janastu.org/>

Table 1: Participant and Activity details for each of the four speculative design workshops

Sessions	Location	Activities	Duration	Participants	Participants code
S1	Ocean View	Narratives of Futures in Response to Premises	4 hours	15 (5 Groups)	S1G1 - S1G5
S2	Ocean View	Keyword Prompts	4 hours	5	S2P1 - S2P5
S3	Channapatna	Narratives of Futures in Response to Premises	4 hours	10 HNs (3 Groups) + 1 FC	S3G1P1-S3G1P3, S3G2P1-S3G1P3, S3G3P1-S3G3P4
S4	Channapatna	Collective Mapping of Mesh-Mash Network	2 hours	10 HNs (3 Groups) + 1 FC	S4G2P1-S4G2P3, S4G3P1-S4G3P4

visions of community-owned infrastructures for current and future CNs.

Methodologically, we aimed to understand how speculative design, particularly informed by infrastructural speculations [84], could take on a community-based participatory approach situated in the ongoing practices of the community members, to elicit community-based visions for the future, while enmeshed with the socio-technical realities of their struggles and challenges from the past and present.

The project got ethics clearance from the Institutional Review Board at the University of Cape Town in South Africa. The Indian authors, during the time of the study, were not affiliated with institutional review frameworks and hence, we relied on community-based discussion and formats for recording informed consent and data protection for the Indian workshops.

4.1 Participant Recruitment.

With the help of the Ganief Manual, a member of the OV community and coordinator of Black Equations, we recruited 15 participants from OV through Facebook and WhatsApp groups. Only 2 participants out of 15 had some prior knowledge about the FOCUS network. For the second workshop, 5 participants out of 15 were invited due to budget constraints and limitations. We engaged with the group of 10 HNs and the Field Coordinator (FC) - Muni Ramakka in Channapatna, with whom we have been collaboratively building the Channapatna Health Library. Table 1 offers the details of the participants and activities across both the sites. Figure 1 shows the participations in the four sessions in action.

4.2 S1 & S3: Narratives of Futures in Response to Premises¹⁰.

Informed by interviews with CN managers and maintainers [101] we designed two activities. The first activity was to sketch a 'day-in-a-life' followed by sharing a 'highlight-of-your-day'. The first activity provided us with scenarios of the participants' lives, which helped us to build three premises for alternative futures of their CNs. In the second activity, participants were presented with these premises to speculate visions and possibilities for their CNs in the specific socio-cultural, political, and economic contexts of their current operations.

The premises for the second activity in South Africa:

- Imagine an alternative world, where the iNethi network has around 300 access points in the Ocean View community and it has covered the entire area with an Internet network. How would you then interact with the network and what are the challenges you think the network would come across?
- It is the year 2025 and COVID-19 is back with a new variant, lockdown is back, and you're in a new pandemic situation. How would you then interact with the network?
- The people responsible for the development and maintenance of the network are no longer living in Ocean View. Would you keep the network alive? If yes, then how?

The premises for the second activity in India:

1. Imagine an alternative world, where the Channapatna Health Library is all built with well-curated and annotated audio-video content. How do you see yourself using all this information and resources in your work?

bullet· There is a new wave of COVID-25, and the lockdown is happening again, how would you use the Health Library?

bullet· The ASHA workers (public community health workers) through technology may challenge your work. How would you engage with the concerns of ASHA workers and other Public Health officials?

4.3 S2: Keyword Prompts to Situate Future CN Infrastructures in Practice in SA.

After the early analysis of the first Speculative Design workshop in South Africa, we created a list of 20-25 keywords that were repeated by the participants during the conversations. For the second speculative design workshop, we provided the participants with these keywords and asked if they could relate to any keywords and, if yes, then how. The first activity was to sketch/write different ways any of the above keywords played a role in their life and daily practices. The second activity was to speculate and articulate an alternative world that could emerge when the participants acted upon the keywords in everyday situations. The idea was to encourage them to imagine for themselves how their everyday practices are situated in the context of the CNs while articulating their ideas of resilience.

¹⁰For more details on the premises and the full design fictions, please refer the supplementary material



Figure 1: A composition of images from each of the four workshops. From top, participants in SA (S1) and India (S3) articulating alternative worlds in response to the three premises. Bottom Right: Participants in SA responding to keyword prompts (S2). Bottom left: Participants in India collaboratively mapping network infrastructure near their homes (S4).

4.4 S4: Collective Mapping of Mesh-Mash Network to Situate Future CN Infrastructure in Practice in India

S4 was designed to facilitate the HNs to anticipate and speculate the challenges, struggles, threats, and benefits of deploying the physical infrastructure with and for the HNs within and around their homes and localities, and through such speculation, understand their visions of the resilience of the network and its usage and maintenance.

For this session, we used ISP design center software and Commotion Construction Kit (CCK)¹¹ to speculate the deployment of the

physical infrastructure underlying CHL with the HNs and FC, Muni Ramakka. We organized the HNs into three groups, two groups with three members, and one with four members, based on the proximity of their homes mapped previously. For the activity, the HNs were asked to map the following concerning the network infrastructure setup on the Channapatna map using the CCK toolkits: a) Approximate location of all the HN's houses in the group, b) Public institutions around their respective houses (Public Health Center and Government Schools), and c) Try mapping the tallest building around their house for setting the antenna.

¹¹<https://commotionwireless.net/docs/cck/>

4.5 Data Synthesis into Design Fictions.

All four sessions were audio-recorded with informed consent, to capture the discussions prompted by the premises and the activities. We also took images of the creative materials produced by the participants. After every workshop, the research team, which included representatives from the respective CNs met online for a quick synthesis of emerging themes of visions and concerns through performing an Affinity Mapping activity [97] using an online collaborative whiteboard platform (MIRO). The focus of this activity was on modifying and fine-tuning the next workshop.

At the end of the workshop series, the entire team met in Bangalore for a data synthesis workshop. The audio recordings were transcribed and translated into English (from Kannada and Dakkhani). In the synthesis workshop, we coded the transcripts of the workshop discussions to highlight patterns of past and present challenges, barriers, concerns, solutions, and workarounds, as well as aspirations for futures stated by the participants. For the scope of this paper, we decided to restrict our reporting to the themes situated in the respective communities rather than attempt a cross-community synthesis. With this focus, subsequently, two researchers synthesized the patterns into two creative design fictions¹² [4, 19, 24, 65]. As part of further iterations, post the workshop series, we shared these fictions with the representatives of the CNs part of the research team, who annotated and modified the fictions to bring them closer to the specific discussions that happened during the workshop. The design fictions carry fictional names for characters drawn from the specific lived experiences shared by the participants and from the researchers' ongoing engagement with the respective CNs.

5 DESIGN FICTIONS: COLLECTIVE INFRASTRUCTURAL SPECULATIONS.

We present two design fictions as collective visions of resilient CNs. The narratives of these fictions are embedded into the situated socio-technical infrastructures of the respective community networks and community practices and their locations. We further elaborate the fiction through analysis supported by the participants' quotes and / or excerpts of the discussions during workshops highlighting challenges, struggles, threats, and benefits envisioned by the participants while imagining alternative worlds.

5.1 DF 1 – Building Capacity with and through the CN Infrastructure.

"It's getting difficult and harder each day to manage and sustain the network alone," Hussain thinks to himself while fixing the server which has been down for the last 2 days. Joshua as always hanging around after the school asks, "What's the problem with the network this time, sir? Is it again the backhaul or it's the server? Can I help with anything?" Joshua being an aspiring gamer has been curiously learning about servers in his free time on YouTube. During the conversation, Hussain, feeling Joshua's enthusiasm, asks him if he wants to learn the basics of server and network management

and join the team. Joshua instantly says, "Yes!!" Hussain always intended to build a local community members' team of maintainers.

Unable to compensate Joshua for his time because of limited funding they decided to extend the mesh network and set up a node at Joshua's home, so he could have direct access to the local server and avail the lucrative data packages. Hussain being a learning fellow at "School of CNs", plans to design a course for Joshua in the local language specific to OV infrastructure.

The next day when Hussain arrives at Joshua's house for the site visit and elevation mapping, he shares with concern, "Last month when we set up an antenna in this area, the gang members stole the cables and vandalized the antenna. It has been difficult to set up a network in and around flats housing". He continues "At other flats across the few streets we have people who know the gang members, so they don't vandalize our setup, here we need to build trust with the gang or find other ways to set up the network."

The above fiction narrates the communities' visions of resilience through building capacity with and for the community through the network infrastructure. The fiction also highlights a desire for the network infrastructure to be adaptable, as a way of being resilient, in use that is situated in the specific cultural, geographic, and socio-economic realities of their communities. Following are the themes that are reflected in the narratives.

5.1.1 Self-maintenance and Management of the Network Infrastructures. The ability to self-maintain and manage the network was the most repeated strategy discussed by the participants while speculating the scenarios to sustain the network. The participants expressed their desire to learn the basics of networking, particularly through short-term courses or workshops. The participants (S1G5) also mentioned that community members with technical interests should equip themselves with the necessary skills to maintain the network, via YouTube tutorials or short IT courses, "Each one of us can independently, we can teach ourselves, and we can go through the necessary processes to equip ourselves to teach ourselves what they (network operators) know. We can equip ourselves with the necessary skills to maintain the network, but how? Everything is on YouTube, a YouTube tutorial and then you can quickly fix the network, this sounds perfect, but it can happen. Short IT courses, you can go through that."

The participants also expressed the need for community members to volunteer to teach each other to be more efficient and independent. The desire to self-learn and have ad-hoc strategies to quickly fix the infrastructure was persistent throughout the discussions. Group 5 members (S1G5) said, "Let's say you have some IT experience. You now know how to manage the network, but that is just you yourself. You know, to manage the network, what you can do is to teach the work, pass it on, is to teach others too. Yes, what this workshop is for, but you can teach others out too in this way, you train others to be even more and more efficient than what you were."

Along with desires to learn, train, and upskill they also mentioned methods and tools to do so, such as weekly or monthly workshops, creating video tutorials in the local language, and community engagement events in the township. A participant referred to the ongoing SD workshop as a fun project and asked for such curated workshops for engaging and training the next generation of network maintainers from the community. Participants (S1G4)

¹²We have produced three fictions. Due to limitations of space, we have included only two fictions here, and report the three as part of supplementary materials.

commented, *“Start workshops like this one. I mean, Friday, we were working on how to manage the network system, do more workshops like that, I think having such fun projects within the community to make them aware of iNethi or how to use the network. They can have workshops like this one again, that workshops they can have programs and stuff to educate the next generation maintainers.”* This need for volunteering, mutual aid, and helping each other to overcome the challenges of maintaining and sustaining network infrastructures reflects their desire for capacity building in the community with and through the network.

5.1.2 Fostering and Supporting Local Economy. The vision to build a network that the OV community could maintain and sustain was also reflected in desires to build and improve the economic situation of the community members with and through the network. The ability of the infrastructures to sponsor the community and keep the money circulating in the local economy by creating jobs for younger people was mentioned by Group 3 members in S1 (S1G3): *“Also creating a job and especially for the younger people who want to study IT. And all of that, we can train new ones, it’s a good factor. And then also in doing that now we’re actually keeping the money in the community rather than giving it to Vodacom, that’s taking it out and sponsoring other communities. We can sponsor our own community, we can build and contribute towards uplifting our own community.”* The group also discussed and speculated strategies to make the network more affordable and accessible. They mentioned that if the network is run by community members who are skilled technicians, then they do not have to depend on any other outside companies and pay them for the job. The vision to be resilient is reflected by being independent of any outside agencies while building the local economy and sustaining the network ground up. *“If it’s all about the affordability and accessibility then if it’s run by the community, then you don’t need to still stress about somebody that needs to come in from outside to come and serve as a deal. Because we’ve got skilled technicians in our own community”*-(S1G3).

5.1.3 Adapting and Adjusting to Ongoing Conflicts. Vandalism and theft of property were a few challenges that emerged during the discussions in S2. A participant (S2P4) elaborated on his past experiences of gang culture occupying the territory in the OV township. The participant commented: *“In OV, over here with gangsterism comes territory, with gangs comes territory. So, they take over, they take a space. And if we say, within that space, there are a few hot spots. Now they are like, this is mine, this is my space.”* (S2P4). During the activity he speculated and sketched a scenario in his alternative world in which the iNethi network experiences destruction, damage, and theft of the routers and the cables: *“Imagine in vandalism, in that marking the territory, maybe they damage a piece of iNethi equipment.”* Another participant (S2P3), who was a part of a gang a few years back, talked about how the gang targets people and if they see you installing a network in the rival gang’s area, they might think you are spying or snitching on them, and they wouldn’t let you do any business in their area.

In S1, unique solutions were speculated by the participants such as placing the antenna and routers on taller poles making it difficult for gang members to climb and putting up fences and dogs at the access points to scare them. They also suggested other immediate possible strategies of creating security groups and focused

WhatsApp groups to prevent theft and vandalism. Group 1 (S1G1) mentioned, *“[creating] Security around like the routers, so the stuff won’t get vandalized,”* Group 2 (S1G2) extended this into an idea for a *“group chat and a security group team to help to try and prevent cable theft, and vandalism after the towers and connectivity points.”* Such solutions and strategies to the ongoing conflicts due to the prevalence of gang culture and associated phenomena provided by the various groups reflect their visions of collectively organizing as a means of resilience.

5.1.4 Building Local Platforms to Enable Affordability. The benefits of affordable data packages by the iNethi network were most repeatedly mentioned by the groups in S1 and S2. With high rates of unemployment in the community, the participants expressed the desire to have a range of options to buy small data packets and vouchers for a day or two at a low price rather than per month at high prices. A participant (S2P3) with a hotspot installed in his house mentioned that affordability is an important factor for him because he doesn’t have a steady income but enough irregular income or pocket money that he can afford a data package for 10Rands. He said, *“With me personally, I’m unemployed, I do get, I get little money, I get enough money but a 10R and is what I always have. So, affordability is a big thing for me and because I have a hotspot myself.”*

The participant (S2P5) who was a social media influencer with the most followers on Instagram in the OV township shared strategies to save data, particularly highlighting ideas for monitoring and management platforms to have control over individual data usage. Group 3 (S1G3) expressed their desire for a *“Local platform where we can see the data usage and remaining data to track it. . . a time limit on a voucher so that if you were online before load shedding and during load shedding, you must not lose the data. When you go online again, you are monitoring the data usage, you won’t lose it. When you stop, it stops there until you connect back.”* Group 1 (S1G1), highlighted the need to build services and tools on a local server that is independent of the World Wide Web and can be accessed without the Internet, *“So for people who want to know and understand more about the network, maybe you can make a platform where they don’t need internet connections for its access.”* The participants envision the network infrastructure as decentralized and independent of the global network to adapt and overcome the socially situated challenges such as high data costs and to maximize data usage while not extending their financial resources.

5.2 DF 2: Appropriating Infrastructures to Suit Situated Community Healthcare Practices.

Listening to an audio recording received by Anita’s client¹³, on the WhatsApp group, she responds, *“this is not real information, Akka! Vaccines are important to prevent Covid; people with Diabetes and Hypertension should take it.”* It has been more than a year since the Indian government introduced Covid vaccines. This incident instigated Anita to seek and record patterns of vaccine hesitancy and misinformation/disinformation in the locality, uploading on CHL.

¹³The Health Navigators (HNs) term the community members they serve as clients.

At the weekly meeting with the groups of HNs Anita plays the recording on the editing studio suite. Ramakka after listening to the audio says, "We have curated narratives of vaccination using Pickle in the editing studio, use them for awareness." Jabeen Taj intervenes, "but Ramakka, some clients don't listen to the audio more than once, so I suggest we start making illustrated magazines, story books, and educational content for clients using Pickle."

"Also, not all of my clients have mobile phones or internet connections to listen and share audios," says Anita with concern while suggesting, "But if we set up a computer, with a network node at my house, I can invite people to my house and share this information." Listening to this suggestion, HNs anticipated they could increase the client base by setting up nodes at their respective houses; people could approach them directly, and they could share the collection. Ramakka wraps up the day's discussion with an action plan, "The Primary Health Center (PHC) is closer to Anita's house, and I know the nurse of the PHC in the locality. Let's extend the network connection to PHC and set up a node there as well for people to listen and watch synthesized and curated stories of the communities' experiences while waiting."

The visions of resilient e network infrastructure in the above fiction emerge through HNs' imagination of the distribution of network infrastructure in their locality through adapting and appropriating it for the community members. The fiction also illustrates the HNs' visions of being resilient by building and curating the local library to address and tackle the on-ground health issues of their clients. Being creative with the archive to keep the community members engaged reflects sustainability in the context.

5.2.1 Curating and Expanding the Digital Library of Local Lived Experiences. During the SD workshops, the HNs were in the process of collectively building the digital health knowledge infrastructure, to enable "Channapatna Health Library" (CHL), the collection of the local lived experience of health. The participated HNs collectively expressed during S3 that they see value in building and creating the "CHL" for the community and themselves. The HNs highlighted different scenarios of the digital library in use, situated in their daily community healthcare practices. A HN (S3G2P2) highlighted a scenario when the clients are introduced to the library they can listen and engage with the lived experiences of their community members, something they would never have access to till now. Such engagement will encourage the clients to share their own lived experiences through contributing to the library, (S3G2P2) "I can share with the clients the videos we create and encourage them to share their knowledge in the same way. When I share with them the information we know, they will share with me what they know. This can motivate the client to try out CHL and also suggest this to whom they know." Furthermore, one HN (S3G1P2) wondered if she could choose and pick different audio fragments from across three or more audios and weave them together to make new audio/video content. Other HNs built on this idea to explore how they could create and add narratives and voiceovers and create relatable content off the library to share with their clients. Later, we termed this idea Pickle, a tool that helps to search CHL, and synthesize narratives from two or more audio/video materials from the library.

Another HN (S3G1P2) highlighted that when they visit a client and they sometimes do not have the knowledge about certain health

issues, then they can quickly refer to the health library and suggest to the client the required information, "Sometimes we might not know what can be done about certain health issues. In such cases, we can access the health library quickly anytime to suggest to a client about what others in the town or surrounding areas have done to address this issue."

The HNs' visions for building the CHL network grounded in the healthcare realities of their clients and their community members' requirements. The visions for building the resilient network are mostly derived from their clients situations and needs they have encountered in their past and present field visits. An HN (S3G2P3) imagined how with the well-curated recordings of Covid experiences and recovered cases of people in the community, they can leverage the network infrastructure to reach out to more community members and share this information with the clients to reduce the fear in the community and successfully help them to navigate the challenges during pandemic like situations, "We can show people examples, details of previous cases, and stories of people who got and recovered from COVID. What actions did they take and how do they handle it? We can show these as videos to people. This can help reduce fear and make them more self-confident and braver in navigating through their own experience with COVID. We can give them information on what to do during this, either by visiting them or via phone only."

Another HN (S3G3P3) highlighted that the CHL holds information about people's experiences, challenges, and resolutions from the previous Covid-19 induced lockdown. If there is a lockdown again then the HNs can guide their community members towards the resources in the health library. She also mentioned that the HNs can teach their clients to search for information that they want and use the network infrastructure to send them videos and instructions: "Then we can send them videos that are present in the health library. Or we can teach them how to use the health library to search for what they want. And many people ask us that since they are at home ever since the lockdown happened, they don't know how to do certain things or what they should do. Then we can guide them towards resources in the health library and show them YouTube videos. Or if they have WhatsApp, we can tell them that we will send them videos and instructions that they can look at."

The HNs see the development of CN and its infrastructure as a collection of tools and services that can foster and nurture their primary healthcare work. We understood that their visions for a resilient network mostly highlight strategies to anticipate and tackle challenges and struggles they have been encountering or might face in their daily practices of providing healthcare services. For example, while speculating what different types of health knowledge can be helpful to build the network infrastructure, S2G2P2 mentioned how more information about different diseases and health issues in the CHL collection can be useful: "I want to get more information about conditions that affect my community members. This information can be fed to the Health Library." Similarly, the other HN, S3G3P4 mentioned that she is interested in archiving the local homemade medicines and using the infrastructure to share them with the other clients. She said: "While on field visits, we may meet people who know about local homemade medicines. I am interested in getting to know such things and sharing with other clients."

The other use of the CHL, as highlighted by S3G1P3 is to increase abilities in the community members to take responsibility for one's health. She also expressed that the CHL network can be used to share the lived experiences of the people within the same locality with the community members to avoid unnecessary health issues in the community and move towards preventive healthcare, "*With CHL, people can be aware of their health. This information can avoid unnecessary health issues. I can use the library to share about how people have been cured of their diseases.*"

5.2.2 Building Infrastructures to Negotiate Local Relationships. The HNs have built trust over the years of working with community members and local public health institutions. The infrastructure that fosters this trust and builds local relationships in the community by creating spaces for negotiation reflects HNs' visions of a resilient network.

The third premise was set in a world where the ASHA workers¹⁴ do not approve of some of the local/ground-up knowledge the Health Library contains. While speculating on this premise, few HNs described their relationship with ASHA workers in their respective areas and emphasized the trust they have built with their clients over the years of groundwork. An HN (S3G3P4) mentioned that the ASHA worker in her area usually asks for the data collected by the HN to reduce their workload, along with help to carry out other tasks while visiting the households. She also expressed that she prefers sharing the data with the ASHA workers and helping them with their work because if the HNs don't do that the ASHA workers will also not help them in their difficult times. She likes to maintain a healthy relationship with the public health officials in her respective area: "*The Asha workers usually ask us our collected data to reduce their work. I sometimes prefer giving them the data because if I do not help them, they might not help me when I need it.*" Such 'give and take' approach highlights the importance of building collaboration and maintaining relationships with the local health-care institutions and community members as a key part of HNs practice to further the building of resilient network infrastructure.

One of the threats to the collection of lived experiences and household remedies is from public health institutions, which may consider these as misinformation. While speculating in the situated alternative world where the public health officials questioned and/or disapproved of the CHL experiences, the HNs latched on to the fact that this knowledge collected are lived experiences of people living in the same community as ASHA workers. An HN (S3G3P4) mentioned: "*We are not recording or showing our clients any random content but experiences of themselves and people around the locality. That's why they [ASHA workers] cannot say the videos are wrong. These are the videos about what happened in our village.*" Another HN, S3G3P2 also reiterated that the recordings are of local peoples' lived experiences, living in the same community that focuses on the conditions they face, experiences of getting a diagnosis and treatment, and if and how it helped them, "*We are simply recording people's experiences in the Health Library. Furthermore, we are just*

gathering information from local people about what treatment they did, its usage, and how the treatment helped. Hence, I think they will not have a right to question anything about the Health Library." The responses to the premise brought forward the importance of the infrastructure to enable the HNs and the ASHA workers to constantly negotiate with each other's agendas and matters of concerns while keeping the health of their communities at the center of such negotiation.

5.2.3 Co-Curation of Local Content Services and the Network Infrastructure. For the HNs building the network infrastructure meant building the digital Channapatna Health Library and related content services. In particular, the HNs strategies for creative content creation of the CHL to enhance engagement with their community members, and activate them towards their health, drove the visions of sustaining the network.

In S3, the HNs mentioned how once they have a well-curated and collected repository of local health experiences in the form of CHL then they will collaboratively start co-designing and developing their own content over the archived material using creative mediums and tools. One of the HNs (S3G3P3) mentioned, "*If they are bored with watching the same types of videos, we can create short web-episodes, performances, or dramas to educate them about health care. Awareness about the causes and effects of certain diseases can be presented. This might be an interesting way for them to learn and pay attention.*" Similarly, during the discussion, S3G3P1 said, "*If people are bored with audio and video content in the library, we can also create books.*"

Furthermore, the HNs have visions of building and expanding the network nodes in their own house and public health institutions around the locality. During S4, while mapping the wireless network infrastructure to speculate the challenges to building and deploying the network, HNs expressed that with nodes deployed in their houses or locality, they can invite people to their houses for engagement and education. S3G3P1 said, "*the clients can visit our house for their periodic check-ups and we can also show them the CHL collection and do the check-ups.*" Similarly, Muni Ramakka suggested that they can also deploy nodes with a monitor in PHCs (Primary Health Centers) for the people visiting to listen to the health recordings in the waiting room. The HNs also brought forward anticipated challenges of possible theft of network equipment, maintenance of the equipment at home, and importantly data sharing and pricing challenges with respect to usage for health education versus general entertainment.

6 DISCUSSION.

In this section we reflect on our process to share our methodological learnings, and point to specific future pathways for collective infrastructuring, not only for the two CNs but also for other such CNs across the world.

6.1 Facilitating Collective Infrastructural Speculations: Learnings & Reflections.

Our approach of designing, facilitating, and synthesizing the collective speculative design workshops was informed by the notion of infrastructural speculations [84, 96] to elicit community-based visions for the future, while enmeshed with the realities of the

¹⁴ASHA workers are social volunteers who have been trained to provide information and help individuals in obtaining benefits from the government's different healthcare programs. They provide a link between marginalized populations and public health resources across the three-tiered health systems [79]. The National Rural Health Mission (NRHM) created the function of these community-based health volunteers in 2005.

community members' struggles and challenges from the past and present. In designing the workshops, we were also informed by the researchers' collective experiences of conducting similar sessions and other co-design engagements with the respective CNs over time, as well as our local collaborating researchers' experiences with their community members' everyday lives. Hence, we designed each of the workshop activities to specifically align with and draw upon past and ongoing practices and experiences of imagining, deploying, and maintaining the respective CNs, and shaped the activities to invite participation in the articulation of past and present challenges and solutions as well as future aspirations and anticipating anxieties. Through situating our PSD activities in the community's practices, we could collectively imagine futures that are not in isolation and that replace old ones, but the ones that coexist with them in complex interrelations and interactions within the socio-material and cultural dynamics of CN's operations [40, 95, 96].

Our being closely linked to the communities' everyday lives helped us to tailor the prompts for speculating alternative worlds to be very specific, relevant, and meaningful for the participants. For example, while the prompts hold some common ground across the two sites, they focused on unique aspects centering the respective concerns: affordance, vandalism, and economic sustainability for OV; and community health work for the CHL. Furthermore, our being-in-context helped us modify our facilitation across the two sites. The researchers in India have been engaging with the HNs since 2016 and were familiar with their everyday primary healthcare practices, where the HNs have had experiences of drawing and writing day-in-a-life but have not continued it beyond those project duration¹⁵. When we introduced the activity of day-in-a-life, the HNs immediately pushed back stating that they would prefer not to sketch or write but rather sit and converse about their day, and asked the researchers to sketch along. The activity turned into an act of graphic recording. In the case of SA, the participants were never a part of any participatory activity before, so here when they were asked to sketch and presented with the colourful chart papers and markers during the activity there was excitement in the room. They enthusiastically sketched and wrote during the activity and shared it with the group. In this sense, our approach is aligned with emerging PSD work [22, 35, 55, 89, 96], that calls for an embedding of participatory speculative design approaches in the socio-cultural, economic, and political settings of the communities.

Furthermore, the design fictions were not our projection of a desirable future (utopia) or something to be avoided (dystopia), but an attempt to capture the nuanced intermingling of pasts, presents, and futures of resilient CNs as expressed collectively by the participants. The speculative design workshops offered spaces for the participants to pause briefly their ongoing work of building, using, and maintaining the components of the respective CN, and to collectively reflect on the specific challenges as well as solutions and everyday workarounds during their daily practices. Such situated workshops helped the participants to be rooted in the enmeshed realities of the past and present while speculating not only the immediate actions [69] but also moving towards resilient futures

embedded with deep local understanding [21]. They envisioned a resilient community by moving towards a community-owned and managed network—an infrastructure for the community and by the community. Enabling this vision means not only enabling the community members to become skilled technicians but also enhancing the local economy of the community and fostering to sustain the infrastructure ground up while navigating the inconsistencies of external grants and funding.

In this way, we could manage to artfully integrate [14, 50] the workshops as a part of the ongoing work of infrastructuring, giving impetus to envisioning futures, while engaged with the ongoing work of use and maintenance.

6.2 Future Paths for Collective Actions of Infrastructuring.

The design fictions become a form of research synthesis that can be open for the community members to interpret and own in ongoing, emerging, and future pathways of infrastructure building [19]. The co-imagined resilient plural futures presented in the form of design fictions entail local awareness and everyday details embedded in socio-technical infrastructures and situated socio-material relationships [70] built on the past and present realities of the community networks in the respective sites. These bring forward a more-than-human aspect of CN infrastructure.

Jungnickel [47] reflects on how community members encounter an array of interruptions in the form of trees, birds, bugs, thieves, weather, and technical complications and further shows how they build these interruptions into their network. Facilitating situated infrastructural speculations allowed us to be amenable towards the more-than-human aspects of community members' lives by highlighting the interruptions caused by human-non-human aspects. The participants in SA living in and around *flats* in the township highlighted interruptions in the WiFi signal because of vandalism and theft in the OV township due to the gang culture in the community. While participants living near the football field expressed interruption due to windy weather conditions and regular power cuts/load shedding. Bidwell [18] emphasized how the fabric of CNs is embedded in the ongoing trajectories of inhabitants' lives and everyday nuances and situated dynamics of local practices of communities—trust, reciprocating, and cooperating [18]. In India, the interruptions encountered were not technical or environmental, but socially linked to building trust with the clients, community members, and public healthcare institutions to sustain the engagement with the CHL. It is reminiscent of the social structures that shape imagination and usage of internet connectivity in remote rural communities [32]. The design fictions bring such interruptions into consideration while designing and deploying the network in the futures, moving away from the technological emphases of CNs that restrict the word 'infrastructure' to technical networks compromising software, hardware, and interfaces [53]. The design fictions nuance our understanding of the lived experiences of resilience and sustainability that are shaped by the assemblages of human and non-human elements including the situated politics, values, practices, and relationships that are often hidden in the socio-technical arrangements that make the CNs [15, 18]. Although

¹⁵For more details of this engagement, refer to <https://infrastructuringforcommunitycare.wordpress.com/2016/05/11/enhancing-the-quality-of-meeting-between-clients-health-navigator/>

recent initiatives have highlighted the use of more-than-human design approaches [99, 100], our study highlights the need to further understand the community's lived experiences with CNs and the socio-technical complexities of CNs in context from a more-than-human perspective.

Moreover, the design fictions also entail strategies and opportunities for the collectives working with the communities on the ground to sustain their long-term engagement through infrastructuring the above visions; they act as design things; drawing together collective aspirations and frictions [33]. The speculative design workshops fostered ongoing work of imagining, designing and development of digital tools across both sites such as Pickle and data usage tracking and network management tools. Pickle holds the potential for a tool that enables the HNs and community members to move from passive to active content creators by easy-to-use creation and sharing of audio-image-text content from the annotated digital repository. In SA the requirement for data tracking and management tools hosted on the local server as a free service for community members to track their data usage was iterated throughout the sessions. This vision reflects the nuanced understanding of affordable networks through building and hosting local platforms on the server for community members specific to the OV township embedded in their individual and collective practices [57].

Additionally, the SA design fiction (DF 1) emphasizes the need for continuous support along social and technical capacity building in the community through, for example, collaborative workshops and short-term courses with tools and instructions (physical/digital), as well as fostering group of network maintainers/co-ordinators requires infrastructures with distributed network connectivity that can enable community participation and learning. While realising the vision of local network maintainers the fictions point to possibilities for supporting and fostering volunteering and mutual accountability. Prior work [79] has highlighted how frontline workers work as maintainers of community infrastructure, particularly in the context of community health & wellbeing, and has called for a 'Maintenance centered design'. The fictions align with such a call.

Prior work [16] highlights women's access to the CN services are limited by interactions between the sites for access and social and cultural constraints that hinder women's mobility and access to particular places. An ethnographic study [64] of WiFi hotspots focusing on rural communities in India also shows the easy exclusion of women from access and use of public WiFi due to inhabited social norms owing to gender politics of space and mobility that limit and surveil their movements. DF 2 holds the HNs' imagination of setting up nodes at their houses and in the nearby PHC, which further highlights the rootedness of HNs' vision in the communal spaces, and the local spatial politics [16]. The HNs seeing their home as spaces for engagement with the community members through network nodes reveals the connections and trust they have built throughout the years with their clients and the local public health institutions. More importantly, the active role the HNs see in the design, deployment, usage, and maintenance of the CHL network infrastructure addresses the issue of gender gap in the imagination & deployment of CN and WiFi hotspots [64]. The co-imagined fictions therefore allowed us for social dreaming together towards resilient futures while acknowledging the situated social, cultural, spatial, and economic realities.

CONCLUSION.

In this paper, we reported on four speculative design workshops set in the ongoing collective work of designing, deploying, and maintaining community networks at two specific sites: the Ocean View community, South Africa, and the Channapatna Health Library, India. We conducted two workshops enabling collective speculations at each of these sites, informed by works of participatory speculative design [22, 35, 65, 96]. We synthesised our insights into three design fictions and presented them as infrastructural speculations [84] that highlight nuanced visions of alternative futures, as well as hold the past and ongoing matters of concerns of the respective CNs.

The strength of our work is its rootedness in the specific settings of the two CNs. We understand that this may also be a limitation, particularly from the perspective of the generalisability of our findings. However, we hope that our reporting offers transferable methodological insights for participatory design researchers, particularly working with communities in sites across the Global South. We also understand that our reliance on our local collaborating researchers and participants who already have a stake in the CNs would have resulted in excluding potential participants who are currently not users or maintainers of the CN; who do not yet have a stake in the CN. In our ongoing and future work, we are continuously working to expand the members of the communities we engage with in the respective sites, through our local collaborating researchers and their teams. In particular, we are inspired by the visions brought forward by the design fictions, as well as the paths they point for us to realise these visions through collective, situated actions of infrastructuring.

ACKNOWLEDGMENTS

This work is funded by the International Telecommunications Union (ITU) under the Connect2Recover initiative. We thank our collaborators Janastu, MAYA, Design Beku, Focus, Black Equations for their active participation and support. We are grateful to all our participants for actively shaping this research.

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