Innovative Applications of O.R.

Understanding housing preferences of slum dwellers in India: A community-based operations research approach

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ABSTRACT

A significant number of India's urban population living in slums face large-scale challenges to access adequate housing and essential services. However, the solutions implemented by government agencies have been inadequate as they fail to understand the diversity of challenges and preferences of slum residents. While the traditional prescriptive approaches to study slum communities do not capture the uncertainties that riddle slums, we explore this domain of inquiry alternatively through theories of Community Operational Research (COR) and Community Based Operations Research (CBOR) that develop an understanding of housing problems from slum resident perspectives. In this paper, we study slum communities' housing priorities by learning how they structure their concerns and identify specific solutions that could enable access to improved housing facilities. This is one of the first studies to apply Strategic Options Development & Analysis (SODA) and Value Focused Thinking (VFT) to engage with slum residents and generate in-depth insights into the lives of slum communities. Our findings from a slum in the Indian state of Odisha highlight the diverse challenges and needs of the community with regard to housing and basic infrastructure facilities from the slum-dwellers' perspective, a voice often missing in slum policy-making. We believe that our findings could inform policymakers about most valued preferences of slum residents among many possible slum upgrading interventions. The study contributes to the extension of Operations Research tools and methodologies for meaningful engagement of vulnerable communities to develop interventions for improving social welfare.

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1. Introduction

About 880 million people live in slums, mostly in the cities of the global South. Of these, approximately 154 million live in slums of cities in India, representing a third of all urban residents. Slums in India are characterized by temporary structures, with limited access to basic infrastructure such as water supply and sanitation, inadequate living space, high densities, and limited property rights (UN-Habitat, 2004). Slums are the manifestation of extreme inequalities reflected not only in the immediate living conditions of slum dwellers, but also through many aspects such as access to healthcare and education that affects their lives. Despite decades of governmental interventions at the city, state, and national levels to address this challenge, slums persist in India. One of the main reasons for the policy failure is the top-down nature of design and implementation of interventions that follows a one-size-fits-all approach (Tiwari & Rao, 2016). These policies have traditionally

sought solutions from the technocrats and bureaucrats but rarely relied on people themselves to find alternatives. Policies have also failed to recognize the variation in the multi-dimensional nature of housing challenges commonly found in slums (Patel, Koizumi & Crooks, 2014, 2020).

Slums pose a challenge that could be considered a 'wicked' problem. Rittel and Webber (1973) originally classified policy problems as tough to describe, have numerous causes, involve multiple stakeholders, and do not have a right answer. These problems have also been referred to as 'messy' (Vennix, 1999), 'swamp conditions' (Rosenhead, 1992), or ill-structured (Jackson, 2004). We posit that the challenges that slum dwellers face have all of these characteristics. First, conceptualizing slums has its own difficulties. For example, there is an inconclusive debate about conceptualizing a slum as a place vs. a household's living condition (Mahabir, Crooks, Croitoru & Agouris, 2016). Second, there is no single explanation for slum formation and growth. There are multiple causes cited in literature that includes extreme income inequality (Cavalcanti, Da Mata & Santos, 2019), rapid urbanization rates (Ooi & Phua, 2007), lagging infrastructure provision (Galiani et al., 2017), and lack of affordable housing supply (Gandhi, 2012) to name a few. And third, multiple stakeholders are directly or

indirectly related to this policy challenge, including local, state, and national level governments, non-government and community-based organizations, slum dwellers, and non-slum residents in the neighborhoods.

Slums have been studied using multiple disciplinary approaches and varied perspectives. Common approaches include ethnographic studies that focus on a particular intervention or community (Doshi, 2013; Walker, 2016); estimations using demographic surveys and censuses (Dupont, 2008; Patel et al., 2014); delineating slum boundaries and housing structures using satellite images (Gruebner et al., 2014; Kohli, Sliuzas, Kerle & Stein, 2012); and using simulations to test scenarios (Debnath, Bardhan & Jain, 2019; Patel, 2012). However, none of these approaches consider slum dwellers' perspectives as central to their inquiry and treats them as context experts. Moreover, these approaches primarily rely on aggregation of socioeconomic data, which fail to capture the complexity in the lives of slum dwellers, and their multi-tiered and interrelated connections within society and environment (Mahabir et al., 2016).

In contrast to these approaches, decision sciences offer an added potential benefit. They place a greater emphasis on the assessment of problems and have an orientation to action-able recommendations for actual policy practice (Johnson, Drew, Keisler & Turcotte, 2012). In particular, the analytical approach of community-based operations research (CBOR) is well-equipped to identify the concerns of vulnerable communities and solve problems within the public sector that are often localized in nature (Johnson, 2012). In this paper, we demonstrate the usefulness of CBOR methods in advancing our understanding of the challenges that the slum communities face by inviting them to structure their problems from their own perspective. We believe that by incorporating slum residents' voices into the policymaking processes, it may be possible to generate efficient, effective, and equitable slum policies.

The primary objectives of the paper are twofold. Firstly, the paper aims to generate a better understanding of the slum challenges. The key idea is to learn how slum dwellers structure their problems to assess the slum dwellers' preferences and needs based on their own perspectives and values. Secondly, we aim to co-create solutions for these challenges in collaboration with the community to generate alternative courses of action that are weighted by their priorities. To this end, we use CBOR as an overarching framework to develop a bottom-up understanding of challenges in slums and generate alternative solutions to address them using the case study of a slum named Raghupatinagar in the state of Odisha, India. In particular, we employ two analytic methods, namely, Strategic Options Development and Analysis (SODA) and Value Focused Thinking (VFT) in a sequential design within CBOR that contribute in complementary ways to learning about the problem context, understanding stakeholder perspectives, and setting agendas for interventions. As such, they can be classified as Problem Structuring Methods (Keisler, 2012). We demonstrate our approach with a case study of a slum named Raghupatinagar in the state of Odisha in India.

The paper contributes to the field of operations research as well as slum literature in multiple ways. This research aims to advance the use of decision sciences towards problems of social importance with a focus on individual and community decision modeling. The study is the first known attempt to employ the CBOR framework along with OR methods such as SODA and VFT in the developing world context. The study is also one of the first to engage slum communities as the primary stakeholders for using problem structuring methods. Finally, the research makes an innovation to the existing slum literature by studying the problems of slums from a decision sciences perspective.

The rest of the paper is structured as follows. Section 2 provides a brief overview of CBOR, highlighting the limitations of traditional OR approaches for understanding vulnerable community needs and the scope of alternate OR strategies that use multiple methods to engage with communities. The section further elaborates on the use of problem structuring methods in our study context. Section 3 briefly reviews the literature on CBOR and PSMs in general and SODA and VFT in particular, to highlight the gaps in extant literature. Section 4 describes the research methodology by first providing details on the case study of Raghupatinagar slum, and then elaborating on the data collection approaches and analytical strategies using CBOR. Section 5 summarizes the findings from the study using SODA and VFT in the framework of CBOR. Finally, Section 6 provides a discussion describing the significance along with the policy implications of this study.

2. CBOR approach to engage vulnerable communities: a brief overview

This section provides a brief overview of OR methodologies that engages members of marginalized communities, which are not often the focus of traditional decision science methods. In particular, we look at the role of Community Operational Research (COR) and CBOR that treat vulnerable communities, such as slum dwellers in our case, with the respect usually accorded to more educated and high-status informants. Our study builds on Ackoff's (1970) argument of using OR to deal with critical social problems and study vulnerable populations. COR and CBOR are sub-fields of public-sector OR (Pollock & Maltz, 1994) that generally refers to the use of methods and application of OR in domains where the general public bears the effects of decision-making, and the analyses or methods used to inform decisions are subject to public scrutiny (Midgley & Ochoa-Arias, 2004).

It has been observed that mathematical modeling has been the dominant approach to solving public-sector OR problems (Sinuany-Stern & Sherman, 2014). This mathematical orientation and emphasis on quantitative methods such as modeling, simulation, and data mining have value in solving well-defined problems, but fail to build a comprehensive understanding of complex social problems that the marginalized populations face (Midgley & Ochoa-Arias, 2004). COR and CBOR are the primary responses within the public-sector OR field to address this challenge as they are capable of integrating quantitative and qualitative approaches, both from the hard and soft OR, in a single framework. Specifically, both the methodologies use appropriate tools to engage vulnerable communities to structure, formulate, and capture the complexities of ill-structured problems (Sommer & Mabin, 2016).

Our study philosophically belongs to the subfield of COR, originally developed as a problem-solving framework for community development in the United Kingdom during the 1980s. COR places critical importance on direct engagement with stakeholders to better understand the problem situation (Midgley, Johnson & Chichirau, 2018). While COR primarily focused on problem identification and formulation, CBOR broadens its methodology and applications to identify and implement solutions for vulnerable communities. The commitment to using multi-methods and the desire to yield specific and implementable recommendations to empower local communities are the defining characteristics of CBOR that broadens the scope of traditional COR. The two approaches can be bundled together under the rubric 'Community-Engaged OR.'

CBOR is defined as 'the collection of analytical techniques applied to problem domains in which interests of underrepresented, underserved, or vulnerable populations in localized jurisdictions, formal or informal, receive special emphasis, and for which solutions to problems of core concern for daily living must be iden-

tified and implemented to jointly optimize economic efficiency, social equity, and administrative burdens' (Johnson & Smilowitz, 2007, p. 102). CBOR has a philosophical orientation towards Pareto-optimal solutions and accepts problem-solving principles tradition-ally rooted in the OR literature. CBOR is a 'bottom-up' approach (Smit & Wandel, 2006) that involves communities in decision mak-ing and, in the process, improves their adaptive and coping ca-pacities (Goulding, Kelemen & Kiyomiya, 2018). It is well known that such involvement brings a meaningful input into what is be-ing decided, as not only do communities have relevant knowledge of the problems they are facing, but also empowers and combats the alienation of vulnerable groups (Ulrich, 1983). CBOR's empha-sis on engagement with communities makes it an essential part of 'enhanced OR' frameworks (Jackson, 1988; 2004) as it has been explicit about its social role, has been systematic in its orientation, and embraces a wide range of quantitative and qualitative methods to alleviate social problems. .

Johnson, Midgley and Chichirau (2018) and Midgley et al. (2018) consider COR/CBOR as a methodological framework or as a worldview that provides multiple ways of understanding a sys-tem, using multiple analytical methods. CBOR embraces the con-cept of multi-methodology (Jackson, 1997; Mingers & Brocklesby, 1997) in its framework to include principal methods such PSMs, decision analytics methods, and math programming that are used to engage communities for problem identification, formulation, so-lution, and implementation. Adopting multiple methods in a single framework allows us to deal with the richness of the real world (Mingers & Brocklesby, 1997), and helps in the logical develop-ment in answering a complex a multidimensional problem situa-tion (Mingers, 1997). In the context of our study, we rely on using PSMs to highlight the different aspects of the problem situation of housing challenges for slum communities. We elaborate on PSMs in the next section.

2.1. Problem structuring methods

PSMs are a class of qualitative modeling approaches that were first developed 40 years ago, particularly to study ill-structured problems. Mingers and Rosenhead (2004) defined PSMs as a group of methods that enables participants to clarify their predicaments, converge on potentially actionable problems, and agree on com-mitments that will at least partially resolve them. Various def-initions of PSMs have been proposed since then, some focusing on the nature of problems that PSMs typically address, while others on the ways these problems are resolved (see Smith & Shaw, 2019 for discussion and review of various definitions). Com-monly used PSMs include Soft Systems Methodology (SSM), SODA, Robustness Analysis (RA), Strategic Choice Approach (SCA), and Value-Focused Thinking (VFT). PSMs have been one of the growth points for operations research, extending its fundamentally ana-lytic approach into problem domains with which traditional OR had previously failed to engage (Rosenhead, 2006). A compre-hensive review of PSMs can be found in Mingers and Rosenhead (2004) and Smith and Shaw (2019).

Among different PSMs, the methods of SODA and VFT are par-ticularly well suited to our domain of inquiry to stimulate a dialog within the community (Mingers & White, 2010). Both SODA and VFT have minimal barriers to participation, a central consideration in engaging vulnerable communities such as slum dwellers. SODA's focus in identifying the diverse viewpoints of the stakeholders and VFT's in eliciting the values of the stakeholder make it relevant to use both the methods in the context of our study. A recent review of PSM applications found that a combination of methods pro-duced a richer view of the decision situation and could handle dif-ferent decision-making phases such as problem identification and generating alternatives more efficiently (Marttunen, Lienert & Bel-

ton, 2017). Many advocates of PSM consider mixing methods as a way to enhance flexibility and responsiveness of the otherwise rigid OR practices and consequently promote methodological plu-ralism in the field of OR (Boyd et al., 2007; Foote et al., 2007). Our study combines SODA and VFT to identify problems and to gener-ate solutions, respectively. We discuss each of them in the follow-ing sub-sections.

2.2. Strategic options development analysis (SODA)

The fundamental theories that inform SODA derive from cog-nitive psychology and social negotiation, where the model acts as a continuously changing representation of a problematic situation (Eden & Ackermann, 2006). The use of SODA helps participants to explore problem situations in detail before thinking about a solu-tion or making a decision (Ackermann & Eden, 2010). SODA is con-sidered as one of the core groups of PSMs (Mingers & Rosenhead, 2004) that uses cognitive maps as formal models designed to elicit and record diverse individual views of a problem situation (Eden & Ackermann, 2001). The methodology involves a framework that blends the individual perspectives of decision-makers whose ex-periences, personal goals, and subjectivism are captured for struc-turing the problem (Guarnieri, e Silva & Levino, 2016). SODA en-ables a group or individuals to construct a graphical representation of the problematic situation, and thus explore options and their ramifications concerning a complex system of goals or objectives (Ackermann & Eden, 2010). The approach allows a problem-solving team to work together efficiently and effectively in reaching fea-sible agreements, and appropriately analyze the interconnected problems that members of the group wish to address (Eden & Ack-ermann, 2001). Our primary rationale to use SODA over other PSMs was its advantage in highlighting the diverse subjective views of the problem situation, as identified by different participants. We think SODA is better suited for such a purpose, especially because we were able to build a cognitive map that provided a joint under-standing of the problem. Thus, the preparation of cognitive maps presents an interconnected content of issues, problems, strategies, and options – all of which provide inputs for understanding the decision-making choices using the second PSM of VFT.

2.3. Value-focused thinking (VFT)

Keeney (1996) originally developed VFT as an analytical method to identify the preferences of multiple stakeholders in a complex decision making context facing a high degree of uncertainty. While it is traditionally associated as a quantitative modeling approach, the advocates of using it as a part of PSM methodology suggest that it is capable of incorporating various concerns of stakeholders to structure them into a smaller, tractable, and measurable set of variables using both qualitative and quantitative analysis (Keisler, 2012).

The VFT approach is about deciding what is essential to the decision-makers and identifying ways to achieve it (Keeney, 1996). Keeney defines values as 'principles used for the evaluation of the actual or potential consequences of action and inaction, of proposed alternatives, and decisions' (p.6,7). While primarily built on the concepts of decision analysis, VFT reflects insights from cognitive psychology, policy analysis, and behavioral economics (Gregory, McDaniels & Fields, 2001). In its conception and appli-cation, VFT is also consistent with the motivation and practice of Soft OR, which places emphasis on value judgments and consti-tutes engagement between various stakeholders (Eden & Acker-mann, 2004).

VFT is relevant for this study as it advocates the inclusion of stakeholder values in setting objectives as a way of defining and

formulating the problem; and in generating alternatives and solutions that reflect those values (Keeney, 1996; Mwiti & Goulding, 2018). VFT helps uncover hidden objectives and leads to a collection of productive information, made explicit by identifying objectives in the form of a hierarchical network. Combining VFT within an overall decision framework allows people to be better able to: 1) identify, clarify, and organize their values and objectives; and 2) evaluate and select among alternatives (Arvai, Gregory & Mc-Daniels, 2001).

3. Literature review

This section briefly reviews the literature that applies CBOR and PSMs in general and SODA and VFT in particular, in a variety of contexts to highlight the gaps in extant literature. CBOR has been extensively used to study vulnerable communities across multiple domains including in urban planning and community development (Johnson et al., 2015; Keisler, Turcotte, Drew & Johnson, 2014); disaster relief (Goulding et al., 2018); indigenous peoples' issues (Brocklesby & Beall, 2018); and community-based non-profit organizations (Privett, 2012), with most of them applied in developed countries. A review of CBOR applications can be found in Johnson (2012) and Midgley et al. (2018). To the best of our knowledge, only three studies have used CBOR to understand the challenges of marginalized communities in developing countries, all of which appeared in a special issue of EJOR on community operations in 2018. These studies include participatory research on marginalized populations in Bangladesh, Myanmar, India, and Nepal (Burns, 2018); peri–urban water management issues in Bangladesh (Gomes, Hermans & Thissen, 2018); and gender and poverty issues for women living and working in slums of Nairobi (Mwiti & Goulding, 2018). Our paper contributes to this growing body of literature that applies CBOR to study vulnerable communities in developing countries.

Few studies have used PSMs in the urban planning context to understand the housing needs of residents and determinants of sustainable development in urban areas (Ball & Srinivasan, 1994; Bender, Din, Hoesli & Brocher, 2000; Fernandes, Ferreira, Bento, Jalali & António, 2018; Mulliner, Smallbone & Maliene, 2013; Suresh, 2019). All of these studies primarily interact with housing and planning experts (e.g., Mulliner et al., 2013); architects, engineers, and founders of non-profit organizations (e.g., Fernandes et al., 2018); but none of them interact with the residents themselves. One notable exception is Bender et al. (2000) that surveyed homeowners in Europe to understand their environmental preferences. Our paper is the first PSM study that uses direct interactions with slum communities to understand their housing preferences. Our paper also adds to the growing body of research of using PSM to study developmental issues in the Indian context (Bunch, 2003; Ghosh, Roy & Sanyal, 2016).

Many scholars have relied on using multiple PSMs in a single study to provide a richer view of the decision situation and handle different decision-making processes (e.g. Franco & Lord, 2011; Kotiadis & Mingers, 2006; Marttunen et al., 2017; Small & Wainwright, 2018). Few studies such as Brocklesby and Beall (2018); Henao and Franco (2016) have used multiple PSMs using the framework of COR. Of particular interest are the studies by Abuabara, Paucar-Caceres and Burrowes-Cromwell (2019), Castellini and Paucar-Caceres (2019), Françozo, Paucar-Caceres and Belderrain (2021)); and Paucar-Caceres, Ribeiro dos Santos, Wright and Belderrain (2020)) that have applied multiple PSMs in Brazil and Argentina to address ill-structured issues that are commonly found in developing countries . To the best of our knowledge, this is the first study that uses multiple PSMs in the Indian context to study slum communities and adds to this growing body of literature.

Within PSM, SODA and cognitive mapping have been extensively used in multiple fields, including the public sector (Bryson & Anderson, 2000; Eden & Ackermann, 2004; Simpson & Beeby, 1993), management (Guarnieri et al., 2016; Manso, Suterio & Belderrain, 2015) and planning (Hjortsø, 2004). Abuabara and Paucar-Caceres (2020) provide a systematic review of application of SODA in variety of contexts including those in developing countries. While multiple studies (Fernandes et al., 2018; Ferreira, 2016; Pires, Ferreira, Jalali & Chang, 2018; among others) have used SODA to explore housing challenges and satisfaction, our paper is the first to apply it to understand the challenges of slum dwellers. Similarly, VFT has been applied to understand decision making in large organizations (Keeney & Mc-Daniels, 1992; Merrick & Grabowski, 2014), environmental policymaking (Badami, 2004; Bernardo, Gaspar & Henggeler Antunes, 2018; Merrick & Garcia, 2004), security (Boylan, Tollefson, Jr, L. & Guckert, 2006; G. L. Keeney & Von Winterfeldt, 2010; Pruitt, 2003), tourism management (Kajanus, Kangas & Kurttila, 2004; McDaniels & Trousdale, 1999), and community-based organizations (Keisler et al., 2014). Almeida, Morais and Almeida (2014), Françozo et al.,(2021) and Abuabara, Paucar-Caceres, Neyra Belderrain and Burrowes-Cromwell (2018) have combined SODA and VFT in the contexts of pharmaceutical, education and aviation sectors in Brazil. Our study builds on and complements this growing body of literature by applying SODA and VFT in a novel context of slums in India.

While studies such as Keisler et al. (2014) and Alencar, Priori Jr, and Alencar (2017) use VFT to identify solutions for housing improvements, we extend the application of VFT to understand the housing preferences of slum communities. With the exception of Mwiti and Goulding (2018), this paper is the only application that uses VFT to study slum communities. Our study builds on Nair, Vergragt, Van Breugel, Fraaij and Enserink (1997)) suggestion to use VFT as an analytical method in structuring objectives and criteria concerning the multi-dimensional nature of housing issues. Our study builds on Gregory, Halteman, Kaechele, Kotaska and Satterfield (2020)) use of VFT in understanding the needs of marginalized communities, that includes indigenous tribal communities and slum dwellers. Use of CBOR/COR and PSMs towards this goal provides an alternative approach and contributes to the other established analytical approaches to study vulnerable communities in developing countries that include participatory action research (Nix et al., 2019), participatory appraisals (Annett, Rifkin & Organization, 1995), and companion modeling (Gurung, Bousquet & Trébuil, 2006) to name a few.

Our paper aims to contribute to nascent but growing body of literature that uses CBOR and PSM in developing countries context, where unique challenges such as slums await solutions. Our study makes a unique contribution by interacting with slum dwellers in a developing country context to understand their housing preferences using two different PSMs in a single case study. In the process, we also advance the field of urban studies by applying a CBOR lens to study the challenges of slums.

4. Research design and analytical strategy

This section provides the case study context, followed by a detailed description of our data collection strategies. Next, we discuss the four-step analytical strategy of CBOR. The research design was reviewed by the University of Massachusetts Boston's Institutional Review Board.

4.1. Case study context: Raghupatinagar

Raghupatinagar is a slum located in the outskirts of Brahmapur city in the state of Odisha, India (Fig. 1). Odisha has one of
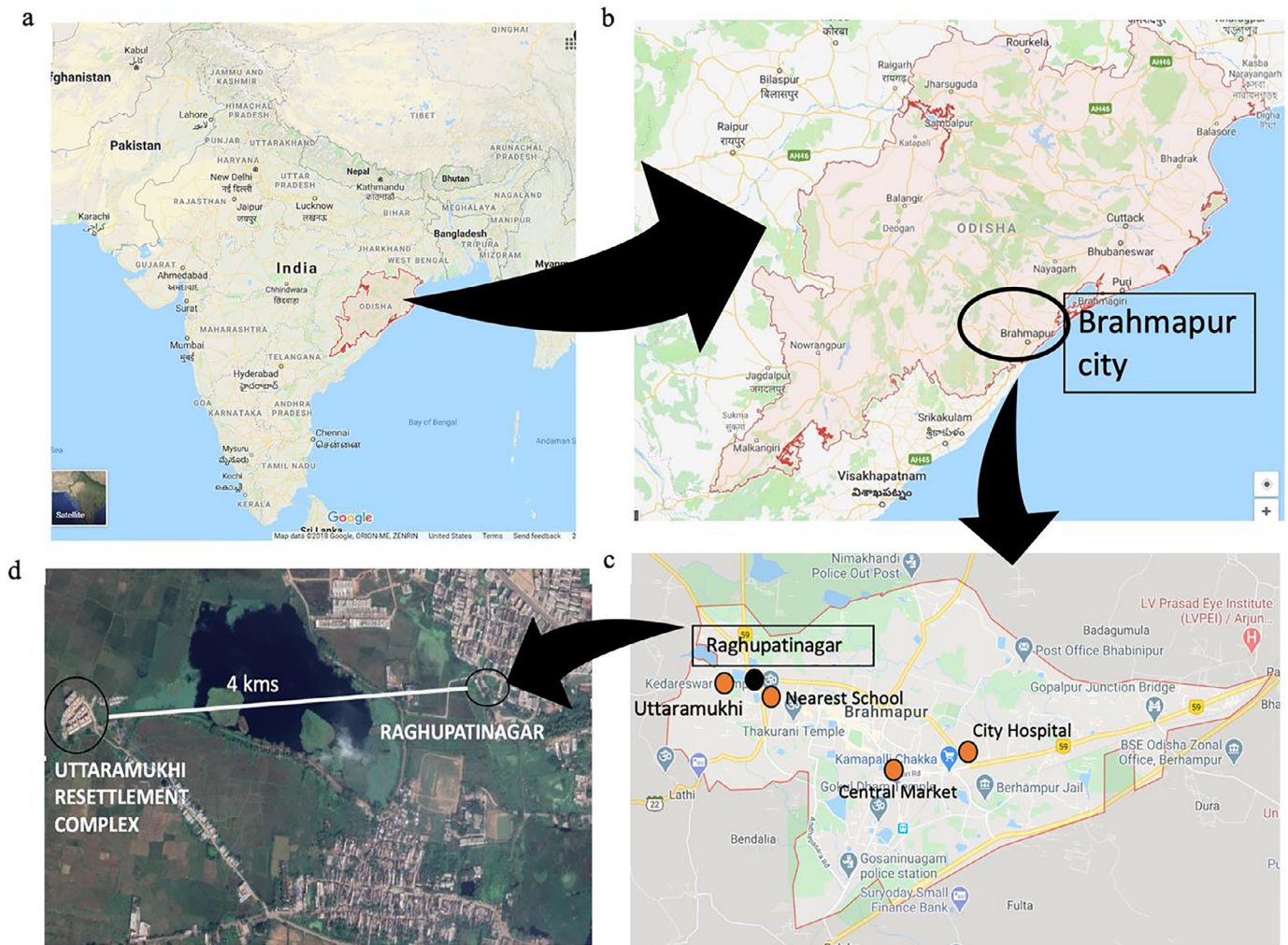
Fig. 1. Location of Raghupatinagar Slum in Brahmapur city, Odisha (India). Map d shows the distance between the slum and the resettlement complex. (Source: Adapted from Google Maps)

India's highest poverty rates (Planning commission of India, 2013), with 23% of the state's urban population living in slums (Census of India, 2011). The coastal city of Brahmapur is the 4th largest city in Odisha, with 34% of its population living in 137 slum communities. Raghupatinagar was built in the 1990s when migrants from nearby rural areas first moved to Brahmapur in search of livelihood options. The community is built around an open sewage drain and is occupied by seventy-two households that suffers from a lack of access to basic infrastructure facilities. The settlement is on government land, and the residents do not have any formal ownership documents.

The structures built by the residents are of temporary nature and have faced two major cyclones, in 1999 and 2013, causing severe damage to their property and lives. Rajiv Awas Yojana (RAY), a central government housing program, subsequently identified Raghupatinagar residents as beneficiaries for resettlement into a public housing project called Uttaramukhi, located two miles (four kilometers) from Raghupatinagar, further away in the city's periphery (Fig. 1d). This was a critical issue as Raghupatinagar was already located at the outskirts of the city where it had minimal access to infrastructure services and social facilities such as adequate healthcare and education facilities. Relocating the community to Uttaramukhi would push them further away from the city center, thereby increasing the severity of challenges for the residents.

Six years after the introduction of this project, households have primarily chosen to remain in Raghupatinagar; the completed public housing project remains mostly vacant. Forty-two families in Raghupatinagar have received beneficiary identification cards by RAY and have been served with eviction notices indicating that they should move to Uttaramukhi. However, the beneficiaries are not assigned to specific units and the timing of the proposed move remains unclear. The remaining 30 families have not been included in the beneficiary list and hence live under constant fear of eviction with no place to move to. The community has been eagerly waiting for the implementation of the recently enacted Odisha Land Rights to Slum Dwellers (OLRSD) Act, 2017 in Raghupatinagar, which provides de jure tenure rights to all landless slum dwellers living in urban areas of Odisha state. The Act subsequently allows the beneficiary families to access the Government of India's flagship housing scheme PMAY - Pradhan Mantri Awas Yojana (translated to Prime Minister's Housing Program), which gives grants up to INR 200,000 ($2725) to build a permanent house, which is approximately only half of the total costs for constructing a typical 200 sq. ft home in the region. However, the guidelines of the Act mention that tenure rights would only be provided to slum dwellers living in medium and small-sized towns. Slum-dwellers living in large cities such as Brahmapur would instead be offered alternate housing at affordable housing complexes (Odisha Gazette, 2017).

Fig. 2. Focus Group discussion with residents of Raghupatinagar.

4.2. Data collection strategies

We conducted fieldwork for 45 days in July and August of 2019. The lead author made daily visits to the slum to conduct interviews and focus group discussions (FGD). The author used the first week to make direct observations of the living conditions and develop a rapport with the residents. A local NGO, called Youth for Social Development (YSD) that works with this community, facilitated the author's visits and fieldwork. The interviews and FGDs were conducted in Odia, the primary language in the region, which were audio-recorded and translated to English for further analyses.

VFT is traditionally conducted in 1 to 2 FGDs with professionals, usually with experts from different domains discussing a problem statement. However, in the context of slums, there are no such distinctions in terms of residents' expertise. Consequently, in our pilot FGDs with slum residents, it was observed that once the first participant discusses a specific issue, the subsequent comments by other residents anchored around the same issue. At the same time, some residents were not comfortable sharing their views in public. To avoid such issues, we used individual semi-structured interviews to collect diverse viewpoints (Keeney, 2012) in the first phase of our data collection.

We interviewed 18 participants; the first two participants were identified with the assistance of YSD, and the subsequent 16 participants were recruited with snowball sampling. The recruitment of participants was stopped once we reached a saturation in responses. We made a conscious effort to diversify our sampled respondents across gender, age groups, and occupational backgrounds to achieve external validity. The interviews were conducted at residents' homes and typically lasted between 30 min to 2 h. The interview protocol was divided into two parts, primarily using open-ended questions. The first part was designed to identify the housing challenges and problems of the residents to construct the cognitive maps. The second part focused on understanding their housing-related values and preferences and identifying potential objectives that highlighted their housing and basic services' needs, and identify possible decision action solutions to achieve those objectives. Multiple prompts, transitions, and talking points guided the open-ended discussions.

The second phase of data collection included an FGD with a smaller group of eight original interview participants. The focus of the discussion centered around the validation of the initial VFT networks created from the interviews. In addition, the FGD was also used to create a shared understanding of the collective priorities of the residents by ranking the objectives identified in the VFT networks through deliberations and consensus-building. The FGD lasted for approximately two and a half hours. The volunteer from YSD facilitated the FGD, and the lead author took notes in the field (Fig. 2).

4.3. Analytical strategies

The community-based operations research process consists of four logical steps (Fig. 4) based on conventional decision modeling – problem identification, problem formulation, problem solution, and implementation (Johnson, 2012). This framework embodies the complexity of decision modeling in localized and ambiguous contexts. The study uses two problem structuring methods to implement each step of CBOR to identify the problems of localized nature concerning the slum communities, structure their multiple objectives for a stable housing situation, and have a deep understanding of their values and motivations from the data collected from interviews and the FGD. We describe each step in detail in subsequent sub-sections.

4.3.1. Problem identification

The first step, problem identification, 'addresses the critical role of place and neighborhood, personal and social values, impact of social inequities, and the nature of institutions and organizations in determining the spatial extent of a problem to be solved' (Johnson, 2012, p. 11). We used SODA to observe how slum communities perceive and express their problems. Data from the first part of the semi-structured interviews with individual participants formed the basis of this analytical step to create an aggregate cognitive map that identified the challenges faced by the slum community. SODA is useful in organizing challenges in a structured way based on their thematic similarities even if they were identified and experienced by different individuals in related but distinct forms. The issues are structured and connected with each other as causal pathways (Ackermann & Eden, 2010). For example, a home that is prone to disasters leads to leaking roofs during monsoons, which in turn leads to financial implications for the household due to repairs involved. Once the participants have provided their inputs in the interviews, we identified action-oriented phrases that highlight a particular issue (e.g., slum built around an open-drain).

Phase 1
Informal Discussions with slum communities for rapport building and developing contextual knowledge of the case study

Phase 2
Semi-structured interviews with 15 slum residents for understanding of community challenges and their values

Phase 3
FGD with 8 residents for validation of VFT networks and ranking of objectives.

Phase 4
Creation of draft VFT network based on authors understanding

Phase 5
Calculation of weights based on identified ranks

Fig. 3. Summary of various phases of the research.

The phrases were then aggregated to build a causal hierarchy network that connects the issues to its consequences in the form of a cognitive map that represented a comprehensive understanding of the community's challenges as a whole. The process of building the cognitive map and the map in itself reflected the concept of a plural subject, as highlighted by Fregonese, Lami and Todella (2020), where our maps were based on individual knowledge of the participants on the problem situation.

4.3.2. Problem formulation

The process of problem formulation in CBOR is associated with 'deepening the understanding of problem context and developing parameters and indicators that link actions with outcomes'(Johnson, 2012, p. 12). We use VFT in the problem formulation stage that allows the slum dwellers to identify values that could alleviate their problems at hand. For example, maximizing ownership (one of the values in VFT) in slums could alleviate potential forced evictions (one of the challenges perceived in SODA). Such a problem formulation allows the community to determine the relevant solutions for such problems.

The researchers aggregated the responses from the interviews through thematic analysis and pattern matching to highlight the challenges of the communities in the cognitive maps and elicit the values of the residents in the VFT networks. The individual responses from interviews were first analyzed to identify objectives for each respondent. The researchers then aggregated the list and sorted them into unique objectives using pattern matching technique. Pattern matching is commonly used to analyze qualitative data such as those from the multiple interviews to identify main themes and collapse similar responses into fewer categories (Hyde, 2000). Next, we sorted these fewer objectives from multiple responses into fundamental objectives and means-ends objectives. In VFT, the objectives that are essential to solving a specific challenge are considered fundamental objectives, while the objectives that are means (e.g., securing tenure) to achieve a fundamental objective (e.g., maximizing ownership) are classified as means-ends objectives. The means-ends objectives, in turn, are used to identify a list of alternatives that are considered decision actions (e.g., requesting title deeds from the government) discussed in section 4.3.3.

4.3.3. Problem solutions

Solving a CBOR problem refers to 'identifying and evaluating the impact of different system configurations, or establishing consensus on changes to be made to a process, or common goals to be achieved'(Johnson, 2012, p. 13). While individual slum community members identified numerous decision actions in the problem formulation stage, their relative importance to the community as a whole was not immediately apparent. Traditionally, VFT networks use weights to assign relative importance to the decision actions, using mathematical modeling methods such as swing weights (von Winterfeldt & Edwards, 1986) or the analytical hierarchy process (Saaty, 1994). However, it was observed that many community members did not have adequate numeric literacy required to assign exact weights using these methods. Therefore, we used a rank-sum method (Barron & Barrett, 1996) because it only asks participants to rank the listed objectives in their desired order. We subsequently calculated the weights based on those ranks, thus making the exercise accessible for the community.

To establish a consensus over the preference of identified solutions, we conducted an FGD with community members to rank fundamental objectives in the order of importance in their view. For example, residents ranked the quality of built environment as the most preferred objective over the other two objectives, namely, human services and social environment. We use the rank-sum method to allocate weights from the strategic fundamental objectives (the fundamental objective at the highest level) to fundamental objectives, then to the means-ends objectives, and finally to specific decision alternatives. We convert ranks provided by community residents into corresponding weights by normalizing them

Fig. 4. Methodological Framework of CBOR with Problem Structuring Methods (adapted from Johnson, 2012).

(EQ (1)). The most important attribute has the highest weight, and the least important attribute has the lowest weight. Appendix 1 provides a glimpse of the calculations of the weights using the rank-sum method.
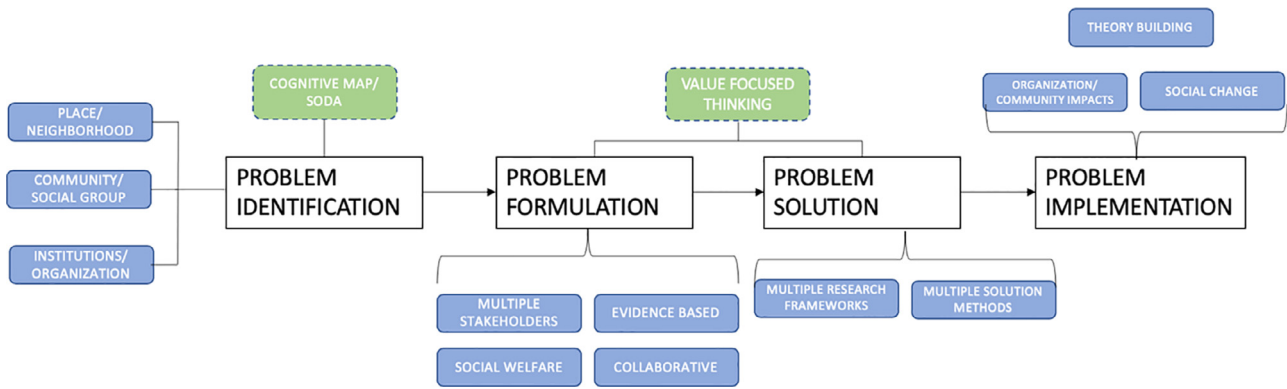
$$w_i = \frac{2(n+1-i)}{n(n+1)}, \ i = 1, \ldots \ldots, \ n \qquad (1)$$

Where, w_i is the weight of rank i; n is the total number of objectives;

The final score for each decision action allowed us to understand its relative importance to the community. Next, we grouped decision actions within fewer policy-relevant themes since many of the decision actions identified by different individuals were related to each other. For example, decision actions related to water supply and sanitation were grouped as part of basic infrastructure provision.

4.3.4. Problem implementation

The last step of CBOR is the implementation of the identified and preferred solutions from the previous step. Johnson (2012, p. 14,15) argues that solutions to problems in CBOR range from 'an increased understanding of the problem under consideration; to agreement of objectives, goals, and metrics associated with solving a problem; to revised rules-of-thumb and procedures; and to design problem-specific policies derived from analytic solutions to multi-period problems.' It is not within the scope of this study to implement the identified solutions, primarily because many of the decision actions require authority such as those of the governments to implement them. However, the value structures and weighted hierarchies resulting from this exercise have the potential to become the basis for better policy design of affordable housing programs by providing a deeper understanding of the problems faced by the communities.

5. Findings

In this section, we elaborate on the findings from our research in Raghupatinagar using SODA and PSM in the framework of the four steps of CBOR, as discussed in the previous section.

5.1. Problem identification

The cognitive map (Fig. 5) shows that two distinct themes emerged from the primary challenges that the community has identified: i) the challenges anticipated at Uttaramukhi, the proposed resettlement housing complex, and ii) the challenges at Raghupatinagar, their current location. While the anticipated challenges at Uttaramukhi were based on their fear of forced eviction from Raghupatinagar and resettlement to the public housing complex, the challenges in their current residential location mostly focused on the poor infrastructure services in the slum and the associated struggles of living in semi-permanent structures.

5.1.1. Anticipated challenges at uttaramukhi

The residents were primarily concerned about forced eviction from Raghupatinagar and subsequent resettlement at Uttaramukhi. In addition to the emotional trauma of getting uprooted from the original residence, residents had four main concerns about the relocation: quality of housing units, undesirable location, reduced safety, and adverse impacts on their financial conditions.

Housing quality: Residents were not happy with various aspects of the housing units that they were allotted at the new location. All selected beneficiaries, regardless of their family size, were allotted the same-sized one-bedroom apartments with less than 150 square feet of area, which was not an adequate living space for larger families. The apartments had poor ventilation in the kitchen and common spaces and no outdoor or semi-covered spaces such as a balcony attached to the individual unit. . The prospect of living in a multi-storeyed building with no elevators raised many other concerns as well, as the old and people with disabilities were anxious about climbing 3 to 4 floors on a daily basis at the new location. Meanwhile, some could not trust the quality of construction given the long history of corruption in public sector contracts. They anticipated that the buildings would collapse anytime within the next couple of years, putting their lives at risk.

Location: The community was concerned about the location of Uttaramukhi on several dimensions. First, the primary road leading to the housing complex from Raghupatinagar was through an unpaved street with no streetlights. Second, families worried about commuting to their current jobs at extended distances with minimal travel options from the remotely located housing complex. In addition, there were no health facilities nearby, making it difficult to avail timely help in case of medical emergencies and for routine healthcare. There were no educational facilities nearby either. Hence, children would be required to cover long distances to access their current schools near Raghupatinagar on a daily basis, or dropping out of schools altogether.

Safety: The community was also concerned about the safety of women and children who would have to walk such long distances in the absence of streetlights. The apartments did not have any designated spaces to park handcarts or cycles, increasing the risk of theft and property loss. Finally, the complex was built right next to a cremation ground that generated fear among many households due to their traditional belief in spirits and the afterlife.

Financial Implications: The local government has mandated that households pay a registration fee of INR 40,000 ($530) before they
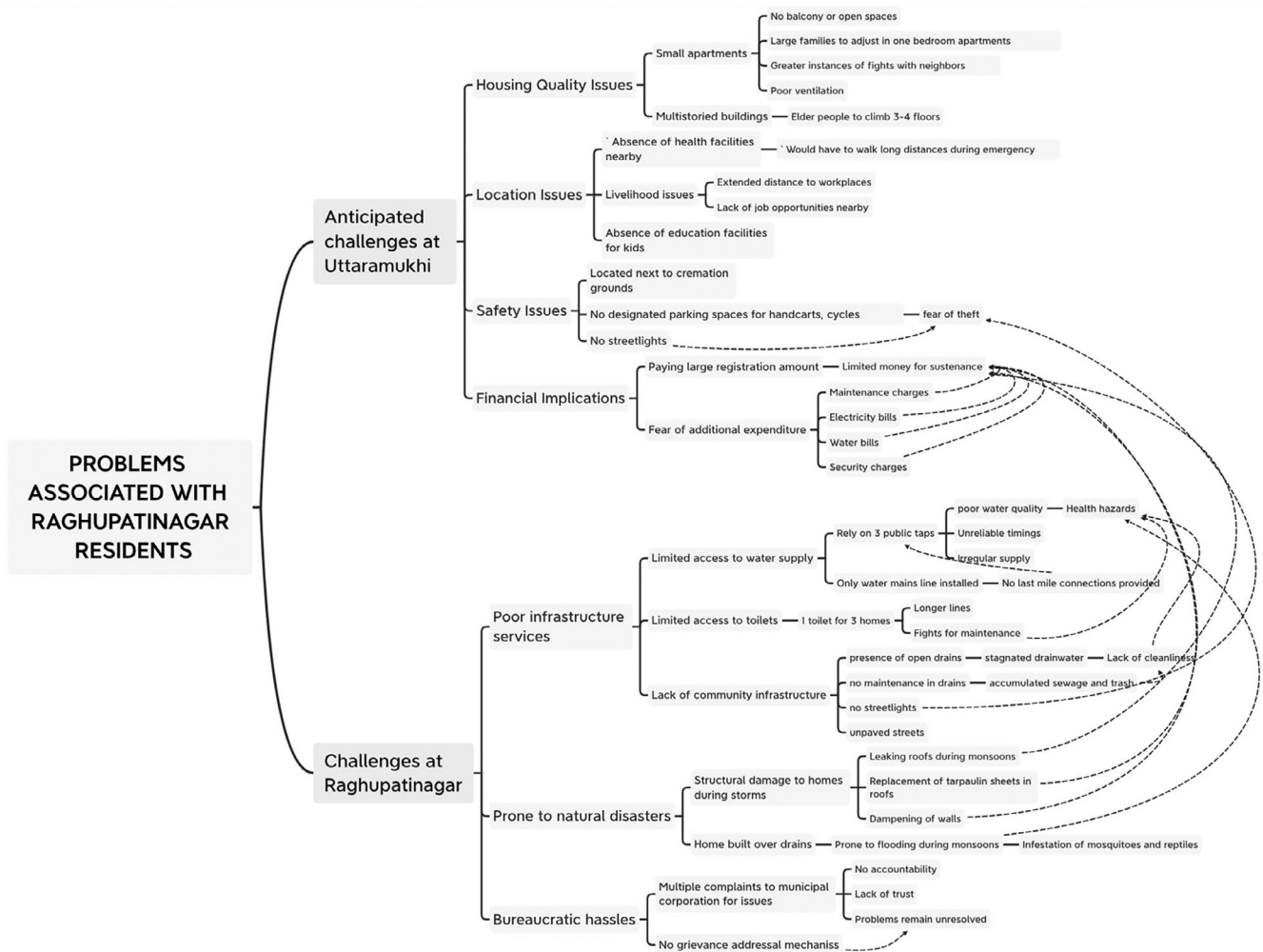
Fig. 5. Cognitive map of housing challenges identified by residents for Raghupatinagar.

may move to their new apartments. This is a substantial amount for most families whose daily income is around INR 200 ($3) and have little or no savings. The local government also declined the request to pay the registration fees in smaller installments, a preference expressed by many families. The fear of eviction forced some families to pay the registration fees by taking loans at a very high-interest rate, often amounting to INR 20,000 ($250) in interest, further jeopardizing their already difficult financial conditions. The families were also worried that they would have to incur additional expenses for maintenance, security, water, and electricity in the resettlement building, putting an extra financial burden on them.

A combination of these factors ensured that residents wished to continue residing in their original location, which was not without its own set of challenges either, that we discuss in the next subsection.

5.1.2. Challenges at Raghupatinagar

The challenges in their original location centered around three primary issues – poor infrastructure services, vulnerability to natural disasters, and bureaucratic inconveniences.

Infrastructure Services: The slum had poor access to infrastructure services such as water, sanitation, and solid waste management. Families had limited access to water supply, with only three public water taps and a hand pump shared by over a hundred fam-

ilies. The unreliable timings and the irregular supply also meant that one family member had to stay at home all day just to be available to collect water. The slum had 20 toilets constructed in 2018, with three families sharing one toilet. While some shared toilets were in good condition, there were few where the maintenance was inadequate. Approximately 40 families who were not allotted a toilet had no option but to defecate in the open. Most of the houses in the slum were constructed around an open sewage drain that had not been cleaned for years. Limited physical access to drains restricted the entry of excavators for cleaning the drain. Furthermore, in the absence of a regular solid waste collection system, the open drain has become the dumping site for trash, leading to a high prevalence of waterborne diseases such as malaria, dysentery, and dengue because of the unhygienic conditions. The adverse health effects also lead to increased financial stress on households due to additional healthcare expenditure. Finally, the absence of paved streets and streetlights was a concern for many residents due to the rising incidents of thefts and violent attacks on residents in the dark hours.

Natural Disasters: Raghupatinagar is particularly vulnerable to cyclones and floods because of their hazardous location near the open drain and semi-permanent housing structures. Houses are typically constructed with brick walls and aluminum or tarpaulin sheets as roofing materials, which face extensive structural damages in the monsoon season every year. Many families regularly
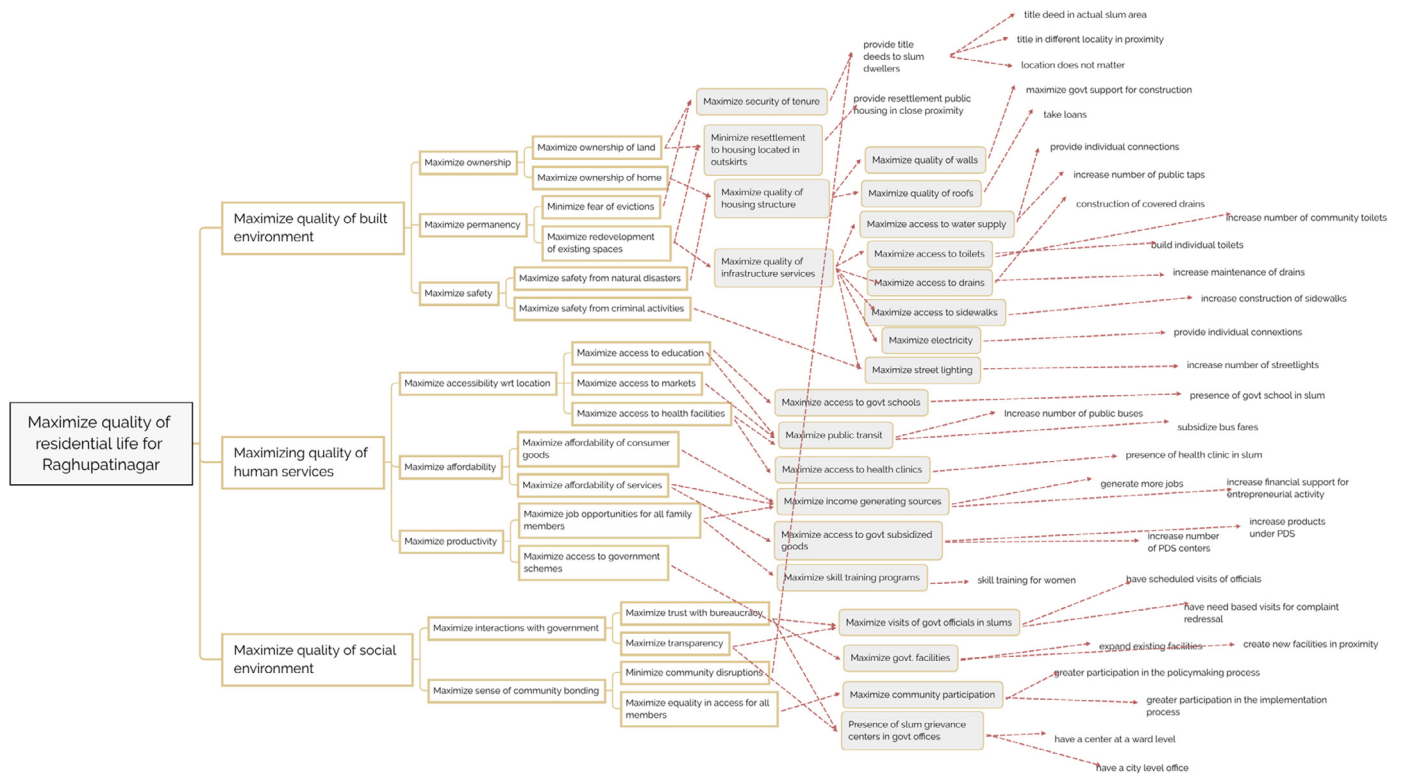
Fig. 6. Value Focused Thinking network on housing preferences of residents in Raghupatinagar.

face substantial expenses in repairs after every monsoon that puts an additional financial burden on them.

Bureaucracy: A critical challenge raised by most participants was the endless inconvenience in dealing with bureaucracy. The community was disappointed with the lack of response by the local government to the registered complaints, and a complete absence of a grievance addressal mechanism that could hold the government accountable and help the community to solve their problems related to infrastructure services and access to government programs.

The cognitive map captures all the challenges that residents of Raghupatinagar experienced in their access to housing and basic infrastructure services. As observed in Fig. 5, many challenges faced by the residents often led to common issues such as additional financial worries or health concerns. These challenges form the basis for identifying the choices and priorities of slum communities, elaborated in problem formulation, the next step of CBOR. We discuss them in detail in the next section.

5.2. Problem formulation

Fig. 6 depicts the VFT network created for Raghupatinagar. The residents' primary fundamental objective, also referred to as the strategic objective, was to maximize the quality of residential life in the slum. Maximizing residential quality primarily focused on improving their quality of living in the slum, and minimizing the challenges they face every day. When asked to elaborate on the ways to maximize the quality of residential life, their responses revolved around three distinct themes – i) maximizing quality of the built environment; ii) maximizing quality of human services; and iii) maximizing quality of the social environment. Questions were asked to the participants to elaborate on what is essential for each objective and to provide specific details to the greatest possible extent. Next, we identify specific fundamental objectives that stem

from the three general fundamental objectives listed above. The specific fundamental objectives subsequently lead to the listing of means-ends objectives in the network, which in turn identify the list of decision actions or solutions that may lead to achieving the fundamental objective. The following paragraphs elaborate on the objectives and the decision actions for the three primary fundamental objectives.

5.2.1. Maximizing quality of built environment

Objectives on maximizing quality of built environment focused on the slum's physical spaces. The community identified three main fundamental objectives that could improve the quality of the built environment in Raghupatinagar: i) sense of ownership, ii) permanency, and iii) safety. Participants believed that secure tenure would provide them with a sense of ownership and considered it the most critical aspect among all three objectives. The community felt that receiving de jure rights to the land under OLRSD Act 2017 would allow them to invest in the physical structure of their existing houses without fear of eviction and property loss. They also felt that secured tenure would provide them an entitlement to receive individual access to basic infrastructure services such as water and sanitation from the local government. However, building permanent structures is both financially risky and impossible for many families without de jure rights and subsidies from government programs such as PMAY. Permanent structures will help the community in being safe from destruction caused by the frequently occurring cyclones and thus minimize their financial losses.

In addition to the location, tenure security, and permanent structures, the community also considered an improvement in basic infrastructure services as one of the fundamental objectives. In particular, they expected the local government to invest in providing individual and piped water supply, access to individual toilets,

legal electricity connections, and infrastructure at the community level such as paved streets and streetlights installed.

Finally, the community expressed a strong desire to remain in the vicinity of the current location if resettlement is inevitable. Their first preference was to receive a land title in neighboring areas of their current location to build their own home, followed by allocation in a public housing complex that is not too far from their current location or is near the city center. They strongly opposed the idea of resettling at Uttaramukhi primarily due to the locational disadvantages, as discussed earlier.

5.2.2. Maximizing quality of human services

Objectives focused on maximizing the quality of human services emphasized values essential to improve the residents' socioeconomic conditions. The three main fundamental objectives that could improve the quality of human services were: i) accessibility, ii) affordability, and iii) productivity. Residents wished to improve the accessibility to healthcare, education, and markets from their current location in Raghupatinagar. Many felt that accessibility to all social infrastructure services would become even more challenging once they get resettled to Uttaramukhi. The community wished for the government to either create new primary schools, health clinics, and a market area near the neighborhood, or expand the existing facilities. The alternative suggested was to improve the city's public transportation system to provide better connectivity to existing human services. With the slum's location in the outskirts of the city where livelihood generating sources were minimal, residents found it crucial that the government create more jobs in the area or by providing financial support to individuals to pursue entrepreneurial activities. The residents also believed that greater implementation of skills-based training programs would improve their productivity. They also believed that special programs for women to pursue home-based enterprises would enhance the household's financial condition. In addition, the community found it essential that new fair price shops and public distribution system (PDS) shops could be opened closer to the community.

5.2.3. Maximizing quality of social environment

The third theme of maximizing quality of social environment referred to those objectives that aimed to improve the trust and transparency of residents in the local government and improve the community's social cohesion. The residents suggested that the government officials should regularly make pre-scheduled visits to the slum so that residents do not have to make special visits to government offices that often presented financial hardships to residents, especially due to loss of daily wages. The community also suggested that the government offices at the city and the ward level have specific grievance centers for addressing slum-dwellers' concerns.

The community felt a greater need to maintain existing social cohesion in the face of natural and manmade calamities such as forced eviction and relocation, which had potentially devastating effects on the community's social fabric. The residents considered tenure security at the current location as the critical pathway to maintain existing social ties that could be disrupted if many families relocate to Uttaramukhi. The possible solutions listed in the form of decision actions are analyzed to identify the most preferred set of solutions in the next section.

5.3. Problem solution

The decision actions were grouped into three policy-relevant themes that reflected various components of improvements in the built environment, socioeconomic conditions, and interactions with government bodies, as highlighted in the VFT network (Fig 6). Table 1 provides a detailed list of the 32 decision actions organized

by these themes to achieve these fundamental objectives. We applied the Rank-Sum method (Eq. (1)) to generate the weights and are converted into percentage shares (col. 3). Appendix 1 provides details on the calculations of the decision action weights from the VFT network.

It is evident that the primary focus of Raghupatinagar residents was on the provision of housing and basic infrastructure services in the slum. Decision actions related to housing services accounted for 52% of the total share of the weights. Considering that majority of slum dwellers were due to get evicted and were not satisfied with the prospect of relocating at Uttaramukhi, the highest share of weights were towards receiving government support for the construction of a permanent structure at their original location (14%), as well as for receiving title security for the land they currently occupied (9%). Many residents believed that having a permanent structure would solve many of their existing housing problems and ensure a safe future for their children. Moreover, residents believed that title security would not only remove fears of evictions and enable access to basic services, but also ensure that all the households could continue living together. Recognizing the fact that the likelihood of relocation is high since the government has already taken the path of relocation and provision of public housing and that it remains a powerful actor, slum residents also conceived ideas that could enhance that solution and meet their needs better. For example, a small fraction of residents expressed that they public housing will be desirable if they were built in proximity to their existing slum location. A few residents were willing to support the government's decision of resettlement at a distant site if it was augmented by increased access to social amenities such as health clinics, schools, and public transportation facilities at the relocation site. These proposed alternatives expands the solution space that is both likely acceptable to slum residents and desirable by the government actors. It is interesting to note that actions focusing on providing basic infrastructure services had a low share of weights. These values suggest that slum dwellers have the highest priority on the provision of housing first, and they do not prioritize basic services over tenure security.

Decision actions focusing on the provision of socioeconomic facilities had the next highest share after housing provision, accounting for 33% of the total weights. This emphasis on social services is not surprising given the remote location of the slum in the outskirts of the city, and their possible subsequent relocation to Uttaramukhi where such facilitates are minimal or completely absent. While residents preferred the provision of healthcare, education, and livelihood generating sources next to their residences, they were apprehensive that any of those facilities would be provided in the near future. However, they felt that provision of local public transportation is more likely, and hence assigned higher ranks to improvement in frequency of buses (6%) and subsidized bus fares (3%).

Finally, decision actions pertaining to awareness within the slum community and interactions with government officials were considered the least important among the three themes, accounting for only 14% of the total share of weights. The low share could be a reflection of their limited expectations from the government to include them in the policymaking and implementation process based on their prior experiences. The weights could provide the basis for designing specific prescriptions or policy recommendations that match the residents' priorities and needs.

5.4. Problem implementation – future implications

It is not within the scope of this study to implement the identified solutions, primarily because many of the decision actions require formal authority such as those of the governments to implement them. Our initial plan was to communicate the findings

Table 1
Rank-sum Weights for decision actions.

Policy Relevant Themes	Decision Actions	% Share of Weights (Wi X 100)	Aggregate% Share of Weights
Provision of Housing and Basic Infrastructure	Maximize government support for in-situ construction of home	14.19	52.45
	Providing security of title in actual slum area	8.64	
	Provide resettlement in public housing in proximity	7.41	
	Take loans for construction of home	7.10	
	Providing security of title in nearby localities	5.76	
	Increase number of streetlights	5.64	
	Providing security of title in any location	2.88	
	Provide individual water supply connections	0.18	
	Increase maintenance of drains	0.15	
	Provide individual electricity connections at home	0.13	
	Build individual toilets	0.12	
	Increase number of public taps	0.10	
	Construction of covered drain	0.07	
	Increase number of community toilets	0.06	
	Increase construction of sidewalks	0.04	
Provision of Socio-Economic Facilities	Increase number of public buses	6.17	33.35
	Presence of health clinic in slum	5.56	
	Government provides skill training to women	4.94	
	Create new government facilities in proximity	4.12	
	Subsidize bus fares	3.09	
	Maximize financial support to pursue entrepreneurship	2.47	
	Government generates more jobs	2.47	
	Expand existing government facilities	2.06	
	Presence of govt. school in the slum	1.85	
	Increase number of products under PDS	0.41	
	Increase number of public distribution system centers	0.21	
Ensuring grievance redressal and increasing awareness	Have scheduled visits of officials	4.94	14.20
	Have need-based visits for complaint redressal	2.47	
	Have a city level office at the municipal corporation	2.47	
	Have a grievance center at ward level	1.23	
	Greater participation in the policymaking process	2.06	
	Greater participation in the implementation process	1.03	

with all the stakeholders – slum residents, government officials, and civic society members that could inform and influence the future course of developmental efforts in these communities. A discussion of these solutions acceptable by all groups would have led to the creation of an informed policy design process that incorporates diverse stakeholder needs in the spirit of participatory planning. Unfortunately, the COVID-19 pandemic and the mandatory lockdowns implemented in India from March-July 2020 has prevented us from carryout this step in the field, primarily because of the health and safety risks to both our participants and researchers for over a year at the time of this writing.

While the implementation of the decision actions identified and prioritized by the community is not within the scope of our research, we have developed a novel framework with the potential for doing so. YSD, the organization that actively works with this community and has supported this research in the field, is interested in using this framework and extend it to other slum communities in their service area in a large part of Southern Odisha. However, the impact of the study is hard to measure as it relies on the implementation of new policies based on the community's inputs. Nonetheless, the community was grateful that they could express their choices and preferences even in this academic exercise, and hoped that the government and implementing agencies utilize this framework to document their needs and preferences as part of the policymaking process. We have shared our results with YSD to further communicate it to the community and to the government agency as they continue their community engagement and advocacy efforts. We hope that knowledge generated from the community with the use of the CBOR framework will be helpful both to the community leaders and YSD in their advocacy efforts. If scaled to all the slum communities in the state, our framework has the potential to leave a positive impact on over a million slum residents in Odisha.

6. Discussion

Our research contributes to both the methodological literature on PSM and COR/CBOR, and to the literature on community engagement in the policymaking process. Specifically, the study contributes to the literature on community-engaged OR, decision sciences, and urban studies. In this section, we discuss these contributions in detail.

First, our study represents a novel integration of elements of 'soft OR' (SODA, VFT), 'hard OR' (decision analysis), and policy analysis. This is also one of the first attempts to combine SODA and VFT in a single framework. The graphical representation of problems through SODA and a structured understanding of the values and preferences of participants through VFT provides an in-depth perspective of the problem situation and the needs of slum communities, which is difficult to achieve using a single method. The analysis resulting from multiple PSMs can capture the multi-dimensional nature of challenges, which in turn can be used to design interventions that are not possible with traditional approaches. Second, the project reflects the core principles of CBOR of meaningful engagement of individuals from vulnerable communities to develop interventions for improving social welfare. Such a community-based approach overcomes social and political challenges that individual households face in advocating for their needs. Aggregation of individual interviews to build composite structures at a slum level turns individuals' problems into a community's challenge that could lead to community-level organizing and mobilizing efforts. Third, the lived experiences of the slum community collected at the grass-root level provide rich details that are impossible to capture by interacting with professionals such as government officials and NGO staff alone, a traditional route that VFT studies usually take. We believe that the community's involvement increases residents' awareness about their

needs, and empowers them to have an informed discussion on probable solutions with government agencies and NGOs such as YSD.

Fourth, the aggregate weights assigned to various decision actions places the residents' values at the center of policy design and implementation. It is worth noting that communities' objectives were in line with what we know about successful slum policies from the literature. For example, communities expressing a desire for secure tenure followed by residents' investments in permanent housing and local government's investments in basic infrastructure services and neighborhood amenities in that sequence, is very close to a policy design commonly referred to as in situ slum upgrading strategy (Patel, 2013). Similarly, we have also learned from past policy experiences that slum resettlements are only effective if the relocation site is not far from the current slum location. The community has clearly expressed their locational preferences, as we have discussed earlier. It is important to note that our CBOR exercise that relies on slum residents as domain experts come to the same conclusion within a single exercise that has taken decades of policy experimenting and program evaluations by professional experts. For example, lessons from 'sites and services' on the importance of housing location were learned much too late in the policy life cycle to meaningfully inform the subsequent in-situ upgrading policies and were adopted over a decade later (Owens, Gulyani & Rizvi, 2018). We believe that CBOR has the potential to tap on the wisdom of the community to avoid costly and ineffective policy experiments to reach an effective solution.

Finally, while this study is just the first step, we hope that the study's findings inform government agencies and NGOs that work with slum communities in designing and implementing appropriate interventions. In this sense, the study devises a technical solution in the form of a bottom-up policy support tools and techniques that complements the current top-down practices of providing housing and infrastructure services. The framework treats slum dwellers as experts and provides opportunities to have their voices heard, supporting the need of participatory slum upgrading, as advocated by Mitlin (2015) and Imparato and Ruster (2003).The use of cognitive maps and VFT allows identification and a comprehensive understanding of the diverse housing needs ranging from provision of physical structure to social amenities and interconnections between them, that complements traditional studies on slums only focusing on a singular aspect of housing improvement such as relocation (Desai, 2012), upgrading (Boonyabancha, 2005),livelihood (Lloyd-Jones & Rakodi, 2014), and health (Corburn & Sverdlik, 2017), among others.

The framework could also provide the base for designing governmental welfare programs that reflects the needs of the slum community. Consequently, local governments can make informed decisions on the efficient allocation of existing resources. The framework developed in this paper has the potential to transform policymaking not only in this case study city but also in other cities in Odisha and India. We hope that the framework could be adapted in the future for applications in other critical policy areas such as healthcare and education that are in sore need for slum-dwellers in India.

Declarations of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ejor.2021.06.055.

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