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Collaborative Modeling and Social Learning in the Context of Joint Forest Management in East Sikkim, India

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In an effort to address challenges arising out of traditional forms of public participation, several alternative strategies for encouraging stakeholder engagement in conservation have been implemented. The role of social learning in addressing these ecological complexities has gained increasing attention in natural resource management over the last decade. Social learning forms the backbone of any collaborative conceptual modeling of complex human–environmental systems. Collaborative modeling, grounded in social learning theory, is the practice of building models *with* rather than *for* stakeholders. By enabling stakeholders to co-design and/or make joint decisions within the modeling process, collaboration manifests itself as cooperation and joint action through interactive, iterative, and reflective processes. Using a case study conducted in East Sikkim, India, we hypothesize that in situations where opportunities for formal environmental education are limited, and avenues for meaningful stakeholder engagement are few, collaborative modeling can help create a platform where stakeholders have meaningful opportunities to engage, learn, share, and (re)negotiate with a focus on joint problem solving. In particular, we engaged stakeholders in an iterative collaborative modeling process in an attempt to enable them to (1) openly interact with each other, (2) build trust, (3) unfold mutual interdependencies through social learning and thus see themselves as part of a complex human-dominated ecosystem, and (4) build and translate these shared visions toward collaborative forest management in the region. Using Senecah's *Trinity of Voice* as an analytical framework, we further examined how participation in the collaborative modeling process provided stakeholders with *access*, *standing*, and *influence*—the three critical dimensions of "voice." Our results demonstrate that the collaborative modeling process enabled key stakeholders to unfold mutual interdependencies, and opened spaces for critical thinking, knowledge (re)creation, sharing, and trust building. By moving beyond narrow technical strategies

for conservation, the collaborative modeling process helped create a platform that provided stakeholders with voice—a chance to share their environmental knowledge, experiences, and joint visions toward addressing and managing the growing uncertainties of complex human-dominated systems.

Keywords: collaborative modeling, social learning, systems-based thinking, stakeholder engagement, trinity of voice, natural resource management, Sikkim, India

INTRODUCTION

In a growing effort to address challenges arising out of traditional forms of public participation, several alternative and adaptive strategies for encouraging stakeholder engagement in conservation have been implemented (Bousset et al., 2005; Peterson and Feldpausch-Parker, 2013; Basco-Carrera et al., 2017). Building on this broader adaptive management and governance approaches, Wyborn et al. (2016) call for a "future oriented" conservation that moves beyond technical approaches to conservation by acknowledging the inherent sociocultural and political underpinnings of complex ecological change and adaptations. The role of social learning in addressing these ecological complexities has gained much popularity in natural resource management over the last decade (Yuen et al., 2013; Ensor and Harvey, 2015; Eriksen et al., 2015). According to Daniels and Walker (2001), social learning adds a new dimension to public participation, wherein, disagreement does not necessarily preclude cooperation or the adoption of collaborative strategies in natural resource management conflict situations. Social learning, according to Wyborn et al. (2016), is integral in facilitating ongoing "locally mediated dialogue" that seeks to "engage with change" rather than seeking narrow technical strategies for conservation (p. 1404). For Buck et al. (2001), social learning facilitates an ongoing process of understanding the knowledge, needs, goals, and interests of diverse stakeholders. This dynamic exchange of knowledge, vision, and values enable diverse stakeholder groups to recognize and understand the importance of mutual interdependency to work jointly toward common goals and ends. An increased awareness of interdependence, according to Gray (1989), may establish a willingness among stakeholders to look for trade-offs or alternatives that could potentially lead to mutually agreed upon solutions and joint actions. Social learning, according to Voinov and Bousquet (2010), forms the backbone of any collaborative conceptual modeling of complex environmental systems.

Grounded in social learning theory, collaborative modeling is the practice of building models *with* rather than *for* stakeholders (van den Belt, 2004; Langsdale et al., 2013; van den Belt et al., 2013). According to Basco-Carrera et al. (2017), collaborative modeling enables stakeholders to co-design and/or make joint decisions within the modeling process, wherein stakeholder collaboration manifests itself as cooperation and joint action. Emphasizing the need to engage stakeholders in critical learning and thinking in increasingly complex human-dominated systems, Sweeny and Meadows (2010) opine that social learning through systems-based thinking exercises can help create a non-threatening learning environment in which participants can engage in a wide range of learning styles that promote a greater awareness of different ways of seeing, understanding, and interpreting the complexity inherent in natural resource management. This approach encourages stakeholders to adopt a more holistic perspective that enables them to better understand complex human-dominated systems (Checkland, 2001; Purnomo et al., 2004). For Mobus (2018), the ability to perceive the wholeness of a thing and the interconnections among things helps a person "use knowledge of systems to reason about the future states of the world based on system behaviors" (p. 14). From this perspective, conceptual models that incorporate participants' perceptions, beliefs, and views while defining problems is crucial in helping them understand and share critical knowledge about environmental complexities.

Trust, as a key component influencing human attitudes toward knowledge sharing (Goh and Sandhu, 2013), plays a critical role in collaborative modeling process through sharing of information and communication among diverse stakeholders (Martin, 2007; Fast and Nourallah, 2018). By adopting a joint problem solving approach that establishes trust through social learning and information sharing, stakeholders can arrive at workable solutions for their concerns (Daniels and Walker, 2001). The need for trust building and effective stakeholder engagement is further emphasized by Peterson (2003), who argues that without broad social acceptability, agreements often fail to achieve legitimacy, and are difficult to implement. Through knowledge building, information sharing, and active engagement, trust helps strengthen relationships within and across communities (Stöhr et al., 2014; Clarke et al., 2015; Clarke, 2017).

Senecah (2004) maintains that trust forms the core of any effective participation process, and the integrity of community capacity is dependent on building, preserving, and enhancing trust and voice through ensuring that all stakeholders have the possibility of access, standing, and influence, or what she called the *Trinity of Voice* (TOV). Within this framework, *access* refers to appropriate opportunities for participants to express choices and opinions in an active capacity, while *standing* refers to opportunities for deliberation and dialogue among participants or civic legitimacy. *Influence*, as a direct outgrowth of access and standing, refers to the ability of participants to participate meaningfully in collaborative processes where their voices and ideas matter. Together, the TOV provides a rubric for creating a shared decision space where social learning, participatory

inclusiveness and power sharing create potential for engaged public participation (Walker et al., 2006).

We began this study with an informal hypothesis that in an environment where there is a general lack of trust among stakeholders, and opportunities for meaningful participation are limited, collaborative modeling grounded in social learning can help build trust and open spaces for communication among key stakeholders. Through active participant engagement, an adaptive, reflexive, and iterative collaborative modeling may help provide a platform where stakeholders have meaningful opportunities to co-create knowledge, share, and (re)negotiate with a focus on mutual understanding and convergence of environmental goals. However, keeping in mind Sprain's (2017) claim that such participatory spaces should not be taken as intrinsically positive, leading to sustainable outcomes or improved ecological standards (Sprain et al., 2011; Fritsch and Newig, 2012), this paper focuses on social learning that emerged through the collaborative modeling *process* rather than on products such as sustainable outcomes and better standards.

In this paper, we *first* describe engagement with key stakeholders in an iterative collaborative modeling process in an attempt to enable them to—(1) openly interact with each other, (2) build trust, (3) unfold mutual interdependencies through social learning, and (4) build and translate these shared visions toward collaborative forest management in the region. *Second*, we explain how participation in the collaborative modeling process provided stakeholders with a sense of voice using the TOV framework proposed by Senecah (2004). *Finally*, we discuss implications of our research findings for collaborative natural resource management both locally and across multiple spatial and temporal scales.

METHODS

Study Area and Context

We chose Sikkim, the small, mountainous, and landlocked northeastern state of India for our case study (**Figure 1**). Located in the foothills of the Eastern Himalayas bordering Nepal to the west, Tibet Autonomous region of China to the north and northeast, and Bhutan to the southeast, Sikkim is one of India's richest states in forest resources, and part of the Indo-Burma global biodiversity hotspot (Arrawatia and Tambe, 2011). Although it is the second smallest Indian state, covering only 0.2% (7,096 km^2) of the total geographical area of India, Sikkim includes one of the largest forested areas of the country with 47.1% (3,344 km^2) of its total geographical area under forest cover (ENVIS, 2011). Sikkim is the least populated state in India, with only 0.1% of the nation's population estimated at 610,577 in 2011. The state's population is 74.9% rural, with heavy dependency on forest resources for livelihoods and income generation (Directorate of Census Operations, 2011; Government of Sikkim, 2014).

The call for people's participation in forest management in Sikkim was operationalized through the adoption of Joint Forest Management (JFM) program in 1998. Through decentralization of financial and administrative powers, the JFM program seeks to provide rural communities meaningful opportunities to "enhance their livelihoods through forestry, ecotourism, and other income generation activities" (FEWMD, 2015, p. 23). As a nodal agency for programs related to forests, land use, and environment, Joint Forest Management Committees (JFMCs) consist of a General Body comprising a member from each household in the village ward and an elected Executive Committee. JFMC activities include forest protection and regeneration, entry point activities to create community assets, awareness programmes, soil conservation, wildlife fencing, and monitoring and evaluation of JFM. Funds are provided to JFMCs by the Ministry of Environment, Forest and Climate Change, Government of India, through the appointed Forest Development Agency (FDA) in the state (Banerjee, 2016).

In the years since its adoption, various governmental reports proclaim that JFM in Sikkim has been widely successful at integrating the livelihood needs of its forest-dependent communities along with the forest management goals of the state (FEWMD, 2008, 2009, 2015). As of 2009, there were 158 JFMCs established in Sikkim, with provisions for including additional ones in 90 newly created intervention villages by 2015 (FEWMD, 2015). Despite these claims of success, Banerjee (2016) calls for a closer scrutiny of JFM in Sikkim as it relates to active and meaningful community participation, issues of trust, devolution of power, and overall forest management goals of the state.

We conducted the study in the East District of Sikkim. Occupying the southeast corner of the state, East Sikkim is bounded by China and Bhutan in the east, the state of West Bengal, India, in the south, and the North and South Districts of Sikkim in the north and west, respectively (**Figure 1**). As of 2011, the East District had an estimated human population of 283,583, with a decennial population growth of 15.7% (Census Organization of India, 2015). For administrative purposes, the East District of Sikkim is divided into three subdivisions: Gangtok (the state capital), Pakyong, and Rongli subdivisions, which are further divided into *gram panchayat units* (GPUs) or village administrative units comprising of *gram panchayat wards* (GPWs). As of 2015, the East District comprised 52 GPUs and 290 GPWs (Government of Sikkim, 2016). Of the district's geographical area of 954 km^2, forest cover was 73.3% (699 km^2) in 2013 (Forest Survey of India, 2015). The East District is also home to three wildlife sanctuaries: (1) Fambong Lho Wildlife Sanctuary, (2) Kyongnosla Alpine Sanctuary, and (3) Pangolakha Wildlife Sanctuary—a trans-boundary protected area bordering Bhutan, China, and the Neora Valley National Park in West Bengal, India (ENVIS, 2019).

Study Sites

We selected 13 JFMCs within Rongli and Phadamchen Territorial Forest Ranges for analysis (**Figure 1**; **Table 1**). We selected the GPWs within each JFMC based on their dependency on forest resources. Approximately 81% of the population in the selected GPWs were dependent on forests for their daily livelihoods and income generation (Sub-Divisional Magistrate's Office Rongli, 2014). As of 2005, the estimated human population of the selected GPWs was 21,494, comprising 4,436 households (DESME, 2005). The annual per capita income of 89% of selected households in

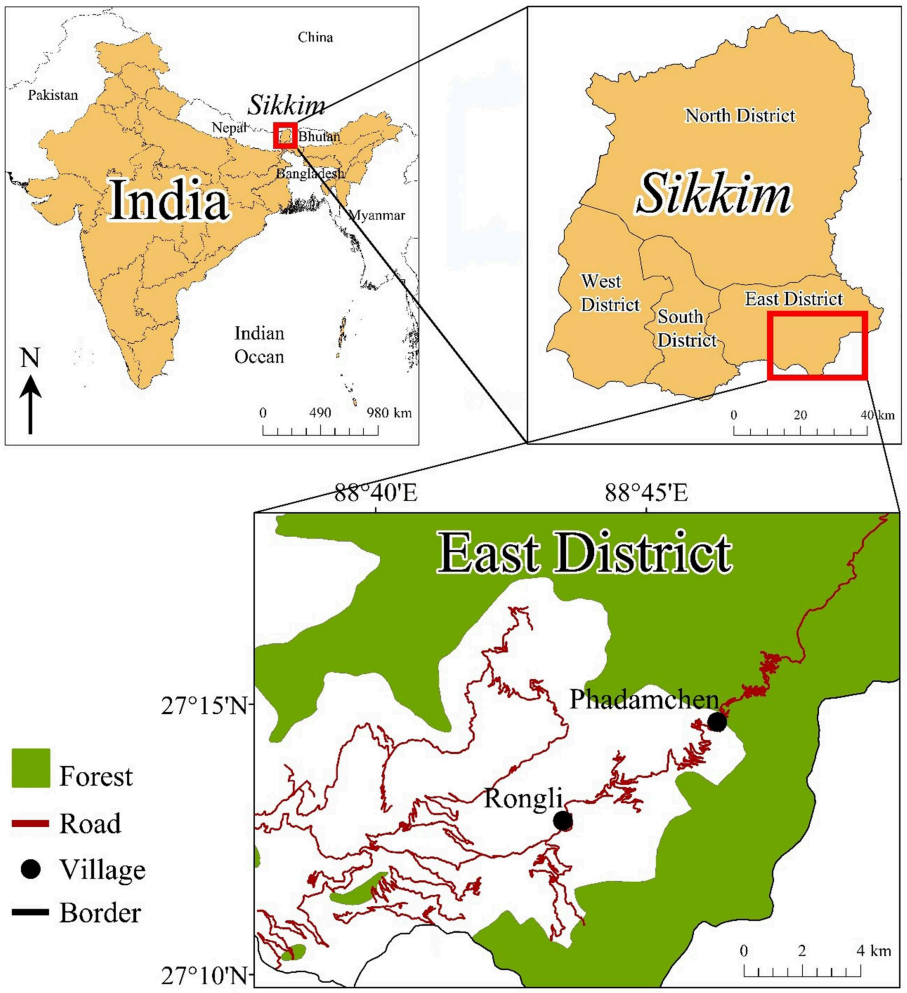

FIGURE 1 | Location of study area at Phadamchen and Rongli Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (2014–2016).

the GPWs was <INR 60,000 (US$884), 32% lower than the state average (DESME, 2005; Government of Sikkim, 2014).

Collaborative Modeling Process

Collaborative modeling provided the framework for social learning through information gathering and sharing, reflective discussions, and systems-based thinking exercises related to JFM in the Rongli and Phadamchen Territorial Forest Ranges, East Sikkim, India (**Figure 2**). Using a grounded-theory approach, we (co)designed the collaborative modeling process with active inputs from study participants. The workshops proceeded iteratively through three phases.

First Phase: Identification of Key Forest Management Components and Stakeholder Groups

The primary objectives of the first phase of collaborative modeling process were to identify—(1) key issues and components of forest management in the region and (2) key stakeholder groups in the JFM process (**Figure 2**). We recruited interested villagers and forest management professionals from nine JFMCs under Rongli and four JFMCs under Phadamchen Territorial Forest Ranges to participate in in-person interviews (**Table 1**). We recruited by word of mouth at the village level, and contacted forest management professionals through emails, phone calls, and face-to-face interactions. We purposively selected informants based on their role(s), power, and position(s) within the JFM process in the region. We interviewed 200 residents (one resident per household) of the selected JFMC intervention villages between May 2014 and February 2015.

We trained two interviewers (one local resident and Banerjee) with a strict interview protocol to ensure data comparability and consistency. We conducted interviews in Nepali, Hindi, Bengali, or English depending on each informant's choice. Interviews lasted 20–30 minutes, and were audio recorded with consent of informants. An initial comparison of results reflected no substantive differences in response content between interviewers, and both interviewers achieved 100% survey response and completion rates. We transcribed all interviews verbatim, and

TABLE 1 | Joint Forest Management Committees (JFMCs) under Rongli and Phadamchen Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (Banerjee, 2016).

JFMCs–Rongli Range	JFMCs–Phadamchen Range
Aritar	Gnathang
Chujachen	Lingtam
Dalepchand	Phadamchen
Kopchey	Subaneydara
Lamaten	
North Regu	
South Regu	
Rolep	
Rongli	

then translated them into English where the source language was different. Subsequently, we undertook back translations of all interviews both by the interviewers and independently through commercial translation services to ensure accuracy. As a member check, we sent a set of transcribed interviews to study participants for additional clarifications, feedback, and validation (Thomas, 2017). In this paper, we identify quotations from interview transcripts by respondent's unique identifying number. For example, a quotation identified (R001) indicates the quotation came from respondent number 1.

Interactions with informants during personal interviews helped us identify eight key components and nine actions related to JFM in the region (**Table 2**, pre-workshop components and actions). Additionally, we identified eight key stakeholder groups in the JFM process in the region. We define stakeholders broadly as people who have an interest or concern in an issue or place and its future. While each respondent associated themselves with at least a primary and secondary stakeholder group, for the purpose of this paper, we categorized individuals based on their primary stakeholder classification only. Subsequently, we sent workshop invitations to all 200 residents of the selected JFMC intervention villages interviewed during the first phase of the study representing each of the eight stakeholder groups. Groups representing state agencies included—(1) Forests, Environment & Wildlife Management Department (FEWMD), (2) *Panchayat* Committees (PCs), (3) JFMCs/Eco-Development Committees (EDCs), (4) Rural Management and Development Department (RMDD), (5) Roads and Bridges Department (RBD), and (6) Sikkim Tourism Development Corporation (STDC). The two non-state stakeholder groups included local villagers and non-governmental organizations (NGOs)/self-help groups (SHGs) from the region.

Second Phase: Collaborative Modeling Workshops

In March 2015, we coordinated two workshops in the Rongli and Phadamchen Territorial Forest Ranges of East Sikkim, India (**Figure 2**). We conducted a workshop in each of the two forest ranges to ensure greater local participation. We held the workshops on two consecutive Sundays (local market day ensures greater foot traffic) between 10:30 am (commenced with opening remarks and icebreaker games) and 3:30 pm (concluded with lunch) to obtain higher participation rates. We selected centrally located village community halls as workshop venues to ensure greater accessibility. Attendance was optional, and participants were free to leave the workshop as per convenience. We did not compensate the attendees either monetarily or otherwise for their participation. While most participants volunteered to attend the workshops, others attended on behalf of their institutional affiliation.

For each of the two workshops, we outlined four specific objectives enabling stakeholders to (1) freely interact with each other, (2) build trust, (3) through social learning, unfold mutual interdependencies and see oneself as part of a complex human-dominated ecosystem, and (4) build and translate shared visions toward collaborative forest management in the region (**Figure 2**). To achieve these objectives, we (co)designed three systems-based thinking exercises that would incite critical social learning skills. Activities included (1) mapping the forest history of the region, (2) qualitative resource mapping, and (3) storytelling as modeling using key components and actions of the forest management system. A brief discussion followed each activity, whereby we encouraged participants to address what they observed and learned from each system-based thinking exercise. This was followed by oral presentations wherein workshop participants talked about their roles, responsibilities, and interests in the JFM process. We also encouraged all participants to discuss their expectations from the various groups of stakeholders involved in JFM. We wrapped up the workshops with discussion sessions where all participants were encouraged to interact freely and share their experiences, insights, preferences, and knowledge regarding management of forests with each other.

Third Phase: Evaluation of Collaborative Modeling Workshops

We carried out the final phase of the collaborative modeling process between March and June 2016, a year after the conclusion of the second phase of the modeling process (**Figure 2**). The rationale for waiting a year was to allow participants enough time to assimilate and reflect upon what they had learned and experienced at the workshops (Thompson et al., 2010). The time-gap, we anticipated, would also allow stakeholders to apply any new knowledge and experience gained toward JFM in the region. The main objectives of this phase were to identify (1) participant's motivations to attend the workshops, (2) the effectiveness of the collaborative modeling process in terms of new knowledge gained, and (3) to understand how opportunities to interact and share stakeholder knowledge could translate toward joint problem solving within the context of forest management in the region.

To achieve these objectives, we conducted follow-up interviews with workshop attendees. As part of the interview, we requested each participant to draw a cognitive map of the forest ecosystem. We then compared these cognitive maps with qualitative resource maps drawn by participants during the workshops to understand changes (if any) in participants'

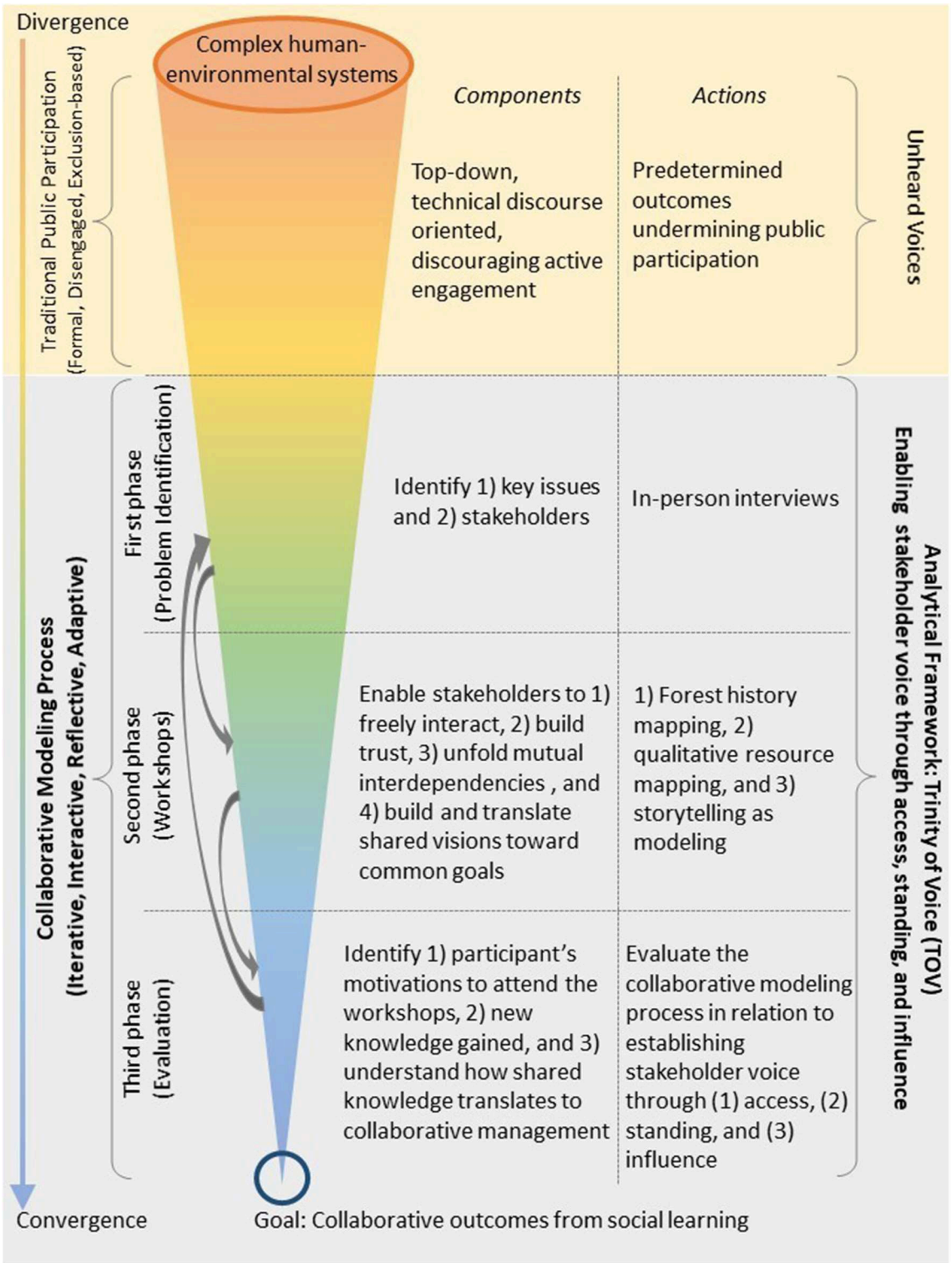

FIGURE 2 | Collaborative modeling framework for social learning through information gathering and sharing, reflective discussions, and systems-based thinking exercises related to Joint Forest Management in Rongli and Phadamchen Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (2014–2016). Divergence and convergence reflects directional relationships between traditional public participation and collaborative modeling. Collaboration contributes to temporary focus while recognizing that continued complexity of human-environmental systems exceeds current focus. The arrows in the collaborative modeling process indicate an iterative, interactive, reflective, and adaptive process.

TABLE 2 | Key forest management system components and actions identified by participants during pre-workshop and post-workshop evaluation phases at Rongli and Phadamchen Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (2014–2016).

Pre-workshop		Post-workshop additions	
Components	**Actions**	**Components**	**Actions**
Animals and birds	Birth and death	Air	Climate change
Fruits and vegetables	Fencing	Earth/Nature	Community development
Grass	Grazing	FEWMD officials	Conflicts
Lakes	Growing	Firewood	Crop damage
Rocks	Landslides	Fodder	Crop management/terracing
Soils	Logging	Insects and micro-organisms	Disease control
Streams	Planting	JFMC/EDC members	Drought management
Trees	Plants absorbing water	Local villagers	Economic development
	Water flowing	NGOs/SHGs	Eco-tourism development
		Other governmental departments	Forest ecosystem conservation and management
		Panchayat/Zilla members	Forest degradation and deforestation
		Roads & Bridges Department	Growing native plant species
		Rural management & development	Healthy environment
		Sunlight	Illegal hunting/entry in forests
		Traditional medicinal plants	Local employment
		Water cycle	Local participation
			Loss of animal habitats
			Management of water sources
			Pollution (air and water)
			Setting up local plant nurseries
			Social fencing
			Social forestry
			Soil management/ enrichment

representation and interpretation of the complex dynamic interconnections in the forest ecosystem.

For an in-depth evaluation of the collaborative modeling process in relation to establishing stakeholder voice in the collaborative management of forests in the region, we turned to the three dimensions of Senecah's (2004) TOV: (1) access, (2) standing, and (3) influence. First, we used our study findings regarding participants' motivations for attending the workshops to examine stakeholder *access.* Second, we focused on the effectiveness of the modeling process in terms of new knowledge gained to evaluate stakeholder *standing*, and third, we assessed stakeholder *influence* by examining how opportunities to communicate stakeholder knowledge could lead to mutually agreeable forest management outcomes in the region. By using TOV as a framework to establish a more nuanced understanding and consideration of stakeholder voice in collaborative modeling, we follow Wedemeyer-Strombel et al. (2019) in moving beyond the traditional applications of TOV within the domain of public hearings. Although, for the purpose of analysis, we have separated the three dimensions of TOV to demonstrate participants' access, influence, and standing throughout the collaborative modeling process, we understand that the heuristic power of Senecah's Trinity requires a holistic interpretation, and none of the three dimensions can be fully understood outside of that frame.

RESULTS

Workshop Attendance

Of the 200 interview respondents invited to participate in the workshops, 33 attended the first workshop held in Rongli on March 15, 2015, while 49 participants attended the second workshop held in Phadamchen on March 22, 2015. Of the 33 attendees of the first workshop, 10 (30%) were female and 23 (70%) male, with representatives from six of the eight key stakeholder groups identified by participants in the first phase of the study. Thirteen (39%) attendees represented local JFMCs/EDCs, eight (24%) were local villagers, four (12%) representatives from FEWMD, four (12%) from local PCs, while two (6%) attendees each represented local NGOs/SHGs and RMDD. Participants' age ranged between 18 and 64, with a mean of 46.3.

Of the 49 participants who attended the second workshop, 13 (27%) were females and 36 (73%) males, with representatives from six of the eight key stakeholder groups. Thirty-three (67%) attendees were local villagers, six (12%) represented local JFMCs/EDCs, four (8%) were members of local PCs, three (6%) represented FEWMD, two (4%) from RMDD, and one attendee represented a local NGO/SHG. Participants' age ranged between 18 and 82, with a mean of 48.1. Of the 49 participants, nine attended the first workshop as well. Repeat attendees included

two representatives of the local PC; three were local villagers, one representative from RMDD, and three members of JFMC/EDCs. Six repeat attendees cited work-related reasons for attending both the workshops, while three cited personal interest in the research topic. No representatives from RBD or STDC attended either of the two workshops.

Workshop Activities: Social Learning Using Systems-Based Thinking Exercises

Forest History Mapping

The first system-based thinking activity at the workshop employed forest history timeline mapping. Before the workshop began, we posted blank sheets of paper on the community hall wall. We requested that participants write important events and moments in Sikkim's forest history, from when Sikkim was a monarchy under the erstwhile Chogyals (pre-1975), to the current year (2015). Overall, 60.6% ($n = 20$ of 33) of attendees at the first workshop and 61.2% ($n = 30$ of 49) at second workshop participated in the forest history mapping activity.

During the two workshops, 68 contributions were made to the history wall. Participants' contributions to the forest history wall varied from historical details of forestry in Sikkim (5.9%, $n = 4$), such as the "Tibetan-war in 1971–72 and its impacts on the forests," and "Sikkim became a part of India in 1975," so Indian Forest Act now applied to Sikkim, to changing conservation ideals in the state (35.3%, $n = 24$). These changing ideals included, during "1960s, there were no restrictions on entering the forests … we were allowed to cut trees," "forests were for all," "around 1975, forests in Lingtam were degraded," and during "1998–2000, JFMCs were established in Sikkim... the forests have started improving." Similarly, participants noted, "In "2000, after declaration of Pangolakha Wildlife Sanctuary, all the people in our village stopped grazing cattle in the forests," and during "2002–2015, no one is allowed to enter the forests to cut trees, graze cattle free, or hunt …government has done little to compensate for that."

The years 2010–2015 show a marked shift in people's perception of forest management with a greater focus on community capacity building, social forestry, establishment of NGOs/SHGs, eco-tourism development, and the role of locals as protectors of forests (58.8%, $n = 40$ of 68). For example, contributions noted the "need to impart more awareness to people in order to protect and save forests," we need to "improve the nature and quality of our activities as protectors of forests," and "information on forest surveys, demarcation, land surveys, social forestry, land acreage need to be sent to panchayat" so locals have access to these data.

After participants wrote their observations on the history wall, we asked them to walk around the community hall to see what others had written and take mental notes of these contributions. Subsequently, we encouraged the participants to reflect upon their observations and share their perspectives. While the majority deemed differences in stakeholder perspectives as positive (e.g., "it was an eye opener, even as a forest officer I did not know all the history of the area"), some participants perceived the activity as futile as their observations did not match those of others (e.g., "ban on logging maybe good for his agency, but not for me"). This activity successfully assessed stakeholders' knowledge of Sikkim's forest history, and helped identify key forest management issues that were locally relevant and interconnected with broader developmental issues in the region.

Qualitative Resource Mapping

We provided participants with blank maps of their respective wards/villages, and requested they use two different colored markers to (1) identify existing natural resources and/or points of significance on the map and (2) mark resources and activities they would like to see more of in the village (**Figure 3A**, qualitative resource map). We also encouraged participants to indicate the key forest management components and actions on their resource maps. As a guide, we provided a list of key forest components and actions that participants had identified during interviews conducted in the first phase of the collaborative modeling process (**Table 2**, pre-workshop components and actions).

Overall, 42.4% ($n = 14$ of 33) attendees from the first workshop and 67.3% ($n = 33$ of 49) from the second participated in this activity. Of these 47 participants, location of forest boundaries were identified by 55.3% ($n = 26$), followed by the *panchayat* member's house (53.2%, $n = 25$), the participant's home (48.9%, $n = 23$), deforested and degraded lands (34.0%, $n = 16$), the participant's farming/agricultural land (31.9%, $n = 15$), and forest plantation areas (29.8%, $n = 14$,). Only 25.5% ($n = 12$) of participants were able to locate the house of their elected JFMC members. As one local villager stated, "I don't know who the JFM members are in my ward, or what they do. If I knew, I'd be able to mark it on the map" (R0141).

Regarding resources participants wanted to see more of, establishment of native plant nurseries ranked highest by the participants, with 42.6% ($n = 20$) in its favor. Participants also identified plantation activities (38.3%, $n = 18$), construction of footpaths and roads (34.0%, $n = 16$), fencing (29.8%, $n = 14$), common land for collection of fodder/firewood/grazing (25.5%, $n = 12$), water source development and maintenance in forests (21.3%, $n = 10$), and better monitoring and patrolling of forests (10.6%, $n = 5$) as resources and activities of interest. Protection of wildlife, development of eco-tourism, and better sanitation facilities each were identified by 6.0% ($n = 3$) of participants. Participants also showed a greater willingness to (re)evaluate their own demands and (re)consider the needs of others. For example, as one participant explained, "from what it seems, I can do without fencing in my property now … it would be better if the forest department helped finish the CC footpath construction before monsoons … more people will benefit from it" (R054). The qualitative resource mapping exercise helped participants identify key resources in the region, assess their accessibility to natural resources, and identify mutual dependency, interrelationships, interconnectedness, and causal feedback among natural resources.

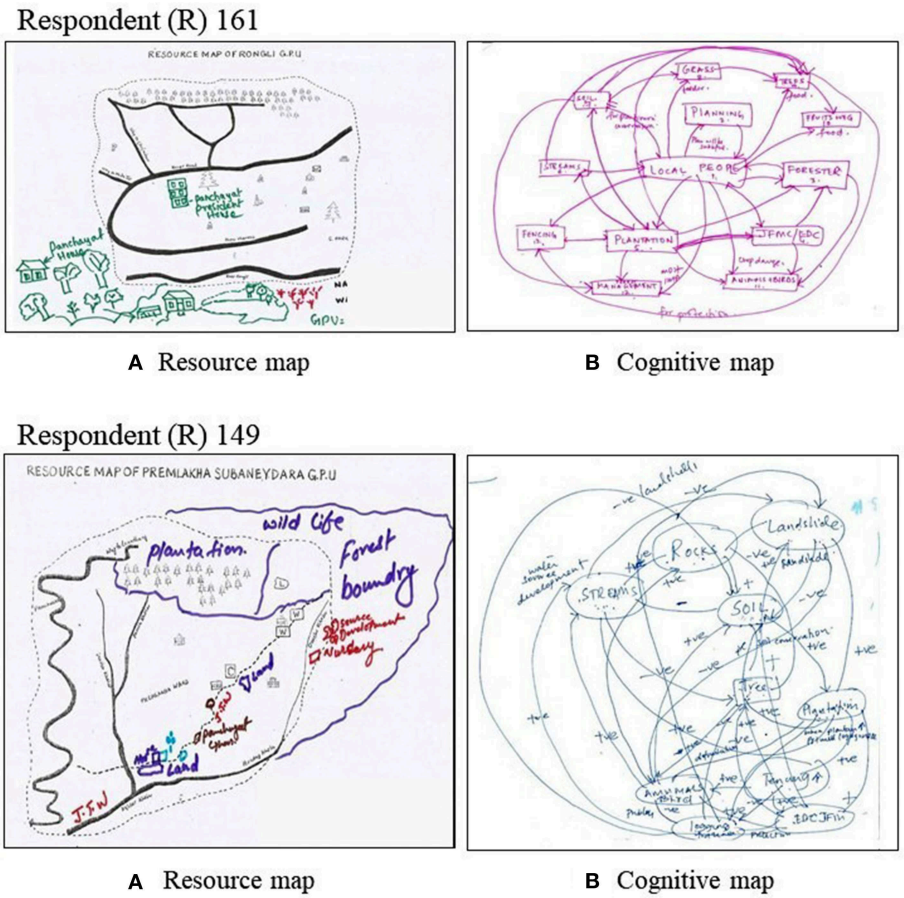

FIGURE 3 | (A) Respondent's qualitative resource map drawn during collaborative modeling workshop, Rongli and Phadamchen Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (2015). **(B)** Respondent's cognitive map drawn during post-workshop evaluation, Rongli and Phadamchen Territorial Forest Ranges, Rongli sub-division, East District, Sikkim, India (2016).

Storytelling as Modeling

For this activity, we encouraged participants to think about all the activities and discussions they participated in during the workshop, and from a list provided, select key forest management components and actions (**Table 2**, pre-workshop components and actions). We then requested the participants to add settings (e.g., day/night; indoor/outdoor; winter/summer/monsoons) and characters (e.g., humans/animals/plants) to the selected components, and tell a real-life story about their interactions with the forests using those components and related actions. Given the limited time frame for each workshop activity, nine attendees volunteered to share their stories over the course of two workshops. Volunteers included three representatives from JFMC/EDC, two representatives each from FEWMD, local PCs, and local villagers. All nine participants associated forests with positive memories from childhood, demonstrating a strong connectedness with the forests in their everyday lives. For example, one participant stated, "as a child, I would accompany my father to the [wildlife] sanctuary frequently.... I learned about medicinal plants, wild animals, [and] their habitats through these experiences" (R058). Six participants linked forests with deforestation and degradation, while four associated forests with sources of clean drinking water. Only two participants reported wildlife protection and forest management problems. Following this activity, we encouraged all workshop attendees to reflect upon what they had learned from the storytelling exercise, and to share their observations and perspectives with each other. One attendee stated that the knowledge gained through this exercise would help him make better choices regarding planting fruit trees in his agricultural field. According to the attendee, "I now have a better idea for tackling the *dumsi* (*Hystrix indica*; i.e., Indian crested porcupine) problem in my land. I will now start growing fruit bearing trees along the forest edge so that the *dumsi* has enough to eat and will leave my crops alone" (R067).

The story telling exercise helped us understand how participants linked individual components of the forest management system to a larger connected whole through information (re)collection, assimilation, and sharing. This activity also helped us understand the ways in which attendees were willing to incorporate the new knowledge gained into their everyday lives and their willingness to share their knowledge with others.

Evaluation of Collaborative Modeling Workshops

Of the 82 workshop attendees, 42 (51.2%) took part in the follow-up study. Among the 40 non-participants, 14 (35%) attendees declined to take part in the follow-up study citing personal reasons, while we were unable to initiate contact with 26 (65%) workshop attendees. In the following sub sections, we combine the findings from both the workshops to describe the social learning outcomes of the collaborative modeling process. We also describe how learning outcomes relate to the three dimensions of Senecah's TOV (i.e., access, standing, and influence).

Workshop Logistics

All 42 participants of the follow-up study either strongly agreed (9.5%, $n = 4$) or agreed (90.5%, $n = 38$) they were given adequate prior notice about workshops. Similarly, all participants strongly agreed (16.7%, $n = 7$) or agreed (83.3%, $n = 35$) that the venues chosen for the workshops were accessible. Most participants strongly agreed (21.4%, $n = 9$) or agreed (59.5%, $n = 25$) that conducting the workshops on weekends enabled them to attend without missing work, whereas 19.0% ($n = 8$) of participants indicated a neutral response to the statement. Of these eight respondents, three were representatives of PCs, three were FEWMD employees, and two were local villagers. In explaining her rationale for choosing a neutral response, a PC member stated, "As a zilla panchayat member, I do not have weekends off, so it did not matter that the workshop was on a Sunday" (R189). All participants either strongly agreed (38.1%, $n = 16$) or agreed (61.9%, $n = 26$) that the seating arrangements at the workshops made them feel comfortable. Similarly, all participants strongly agreed (33.3%, $n = 14$) or agreed (66.7%, $n = 28$) that the overall informality of the workshop was appealing. Further, 47.6 and 52.4 % ($n = 20$ and 22) of participants strongly agreed or agreed, respectively, that participating in the workshops denoted an overall positive experience. Finally, 38.1 and 61.9% ($n = 16$ and 26) of participants strongly agreed or agreed, respectively, to participate in future workshops on forest management in the area. Overall, these results indicate that stakeholder *access* was established through prior and timely notice about the workshops, accessible venues, convenient scheduling, informal and open seating arrangements that facilitated active participation and created opportunities for opinions to be heard and considered.

New Knowledge Gained Through Workshop and Post-workshop Activities

All but one of 42 participants completing the evaluation study either strongly agreed or agreed with the four statements designed to identify whether participants gained new knowledge during the collaborative modeling process. Of these 41 participants, 34% ($n = 14$) strongly agreed that the workshops helped them better understand time-related issues in the forests/JFM process, whereas 66% ($n = 27$) agreed with the statement. Only one participant indicated a neutral viewpoint, stating, "I am a little confused; with time, maybe I will understand [time related issues] better" (R199, JFMC/EDC member). Regarding whether participating in the workshops helped them understand the interconnections and interrelationships among forest components, 47.6 and 52.4% ($n = 20$ and 22) of participants strongly agreed and agreed with the statement, respectively. While 40.5% ($n = 17$) of participants strongly agreed that they had a greater understanding of the complex nature of feedback loops in the forests/JFM process, a greater proportion (59.6%; $n = 25$) agreed with the statement. Finally, 52.4 and 47.6% ($n = 22$ and 20) of participants strongly agreed or agreed, respectively, that participating in the modeling process helped them understand the complexity of forest management system.

To supplement and broaden our understanding of how participants gained a more nuanced knowledge of interconnections and feedback loops associated with forest management, we encouraged each participant of the follow-up study to draw a cognitive map of the forest ecosystem, identifying the interrelationships and interconnectedness among its various components (**Figure 3B**, cognitive map). We provided each of the participants with the qualitative resource maps they had drawn during the workshop phase of the project for reference (**Figure 3A**, qualitative resource map). A comparison of the qualitative resource maps alongside the cognitive maps drawn in the evaluation phase indicated a greater understanding of the components of the forest management system among participants (**Figure 3**). For example, participants identified an additional 16 components and 23 related actions integral to the forest management system in addition to the eight components and nine actions previously identified during the first phase of the modeling process (**Table 2**, post-workshop additions).

Further, participants displayed a greater understanding of the interconnectedness of the forest management system through the identification and mapping of negative and positive feedback loops among its various components (**Table 2**; **Figure 3B**). Acknowledging the importance of systems-based knowledge for the management of natural resources, a JFMC member stated, "Yes, I am now better [aware] of the complex nature of forest ecosystems. The interconnections among the various elements, how the forest ecosystem affects the aquatic ecosystem and vice versa.... This knowledge is very important for forest management or any other natural resource management for that matter" (R049). Overall, participant's positive evaluation of new knowledge gained about the nature of forest management in the region through workshops and post-workshop activities indicate that stakeholder *standing* was established during the study.

Opportunities to Communicate New Knowledge Gained

All 42 participants either strongly agreed (19.0%, $n = 8$) or agreed (81.0%, $n = 34$) that participation in the workshop provided them with opportunities to gain new knowledge about forest management in the area. Similarly, 11.9 and 88.1% ($n = 5$ and 37) of participants strongly agreed and agreed, respectively, with the statement that they could use the newly gained knowledge to inform others about forest management in the area. This trend of agreement continued with 16.7 and 83.3% ($n = 7$ and 35) of participants strongly agreeing and agreeing, respectively, that the workshops provided them with opportunities to communicate

ideas about forest management with others. We found that 28.6% ($n = 12$) of participants strongly agreed that participating in the workshops provided them with opportunities to interact with other parties involved in forest management, while 69.0% ($n = 29$) agreed with the statement. One participant indicated a neutral response. Finally, 9.5 and 76.2% ($n = 4$ and 32) of the respondents strongly agreed or agreed, respectively, that they felt more confident in approaching forest officials with their concerns after participating in the workshops. Six (14.3%) participants expressed a neutral response to the statement. Explaining his rationale for a neutral viewpoint, one respondent stated, "I am somewhat confident to approach the forest officials with my own problems, but with my limited knowledge of the area [forest], I will not be able to talk about other bigger problems with them" (R178, RMDD representative). By enabling participants to gain new knowledge about forest management in the region, opportunities to interact with diverse stakeholder groups, and avenues for communicating stakeholder knowledge with others including resource management professionals, the collaborative modeling process was successful in establishing stakeholder *influence*.

DISCUSSION

The collaborative modeling workshops were the first of their kind in East Sikkim, and provided a diverse group of stakeholders a platform for informal and open dialogue about their knowledge, experiences, preferences, and perceptions of JFM in the region (**Figure 2**). Opportunities for active participation enabled workshop participants to engage in social learning, build rapport and trust, unfold mutual interdependencies, and demonstrate critical systems-based thinking. By moving away from traditional public engagement that often demand consensus, the collaborative modeling process affirmatively sought to create an environment conducive to effective engagement through social learning and trust building, wherein apparent differences among participant's expectations and experience were minimized, giving way to more adaptive and inclusive collaborative problem solving strategies.

Activities employed during the collaborative modeling process such as forest history mapping, qualitative resource mapping, storytelling, stakeholder presentations, and cognitive mapping, along with feedback and evaluations of the modeling process reflected stakeholders' voice through access, standing, and influence (Senecah, 2004) (**Table 2**). Below, we illustrate examples of participant's comments during the collaborative modeling process that correspond to these three pillars of TOV. To highlight the transition of stakeholders' learning process over the course of the study, we compare these comments with thoughts expressed by the same participant during the pre-workshop phase of the study.

Access

Respondents during the pre-workshop phase of the study often expressed the lack of meaningful opportunities for local communities to participate in JFM in the region. According to a respondent, lack of prior notice, and inadequate publicity about upcoming meetings often prevented her from actively participating in the JFM activities: As she explained:

> We never know when or where the meetings are held. If I know in advance, I will definitely attend the meetings. I am interested in knowing what is going on in the village, about the funds that have been allocated for plantations, and the projects a nd schemes sanctioned by the government.... I hear about the meetings after they have taken place. What is the use of holding such meetings then? (R098; pre-workshop phase) (Banerjee, 2016).

Further, this lack of relevant information and non-participation resulted in greater mistrust between forest resource professionals and local community members. As the respondent continued to explain:

> I think the [JFM] committee does this on purpose. If no one is present, they can do whatever they want. No one will ever come to know where the funds have gone (R098; pre-workshop phase) (Banerjee, 2016).

Another respondent echoed similar sentiments reflecting limited access and potential lack of influence in resource management outcomes:

> What is the use of attending these meetings if what we say never matters? The officials note down our concerns in a copy, and then forget about it altogether. They say they will take necessary actions but they never do. Perhaps, if I were someone influential and important, my problems would be solved by now (R87, pre-workshop phase) (Banerjee, 2016).

Interestingly, evaluation of respondents' comments during the post-workshop evaluation phase unfolded a changing attitude toward participation in collaborative processes in the region. In particular, the respondents reflected a growing trust for forest resource professionals in the region, and felt confident in approaching the forest officials with their concerns after participating in the collaborative modeling process. As pointed out by a respondent:

> I was given prior notice about the workshops, its goals, and objectives. Because I knew forest officials would be there too, I was curious. The meeting was on a Sunday in the *panchayat* hall, so I went with my son. I participated in the mapping activity with a JFM member, and listened carefully to his presentation. He was nice, we drew the maps together, and I learned from him a lot. He asked me about good plantation areas in my ward.... I feel confident to approach this member with my forest related issues in the future. I will attend future workshops on forest management in the area (R098; post-workshop evaluation).

Similarly, evaluations of comments by forest resource professionals reflected a common thread. For example, a forest official actively involved in forest management decisions in the region stated:

> Yes, [the workshop] was very helpful because we were given time to talk with the people and all. Normally we do not get to interact

> at all with EDCs and all. Therefore, I think it was helpful, because I could tell them our viewpoint, like what we are planning to do, and what the status is right now. Therefore, they [the locals] are also quite aware of what the department is doing now. I think if we had we had a common platform like *your workshop* [emphasis added], we could interact with all the JFMCs and EDCs together (R162; post workshop evaluation).

Standing

While JFM in Sikkim calls for the incorporation of location-specific ecological knowledge of the rural community members in the forest conservation and management process, the failure of the JFM to seek community input in local forestry activities has often resulted in less than positive forest management outcomes. For example, studies show that plantation schemes in JFM intervention villages have mostly been unsuccessful regarding regeneration of primary oak forests due to a thick undergrowth of quickly growing exotic species (JICA, 2009). Additionally, these secondary forests often fail to maintain species biodiversity and other crucial ecosystem functions (Murali et al., 2002; Rao et al., 2002; Banerjee, 2016). For example, despite his repeated requests to the local forest department officials to undertake planation of native species, a respondent stated that his requests yielded no immediate results. As he explained:

> Forests are not what they used to be 20–30 years ago. The species are not native to our area. The forest department brings saplings from just about anywhere. The survival rates of saplings are very low. Most saplings die within weeks of planting, and those that survive will be of no value to us in the future (R104; pre-workshop phase) (Banerjee, 2016).

Reflecting on the importance local knowledge experience and the immediate need of engaging villagers in the JFM processes, a JFMC member commented:

> It is necessary to engage the locals in all our activities. All decisions concerning our forests should be made jointly with the people. I cannot decide on my own what needs to be done in order to protect our forests. The villagers have a lot of experience and local knowledge too (R91; pre-workshop phase) (Banerjee, 2016).

Analysis of respondents' comments during the collaborative modeling evaluation phase, not only revealed a more nuanced understanding of the mutual interdependencies between forest professionals and local villagers in the JFM process, but also demonstrated the value of accumulated knowledge and intergenerational communication in natural resource management (Gadgil et al., 1993; Vaughan et al., 2003; Thornton and Scheer, 2012) (**Figure 3B**, cognitive map). For example, a respondent agreed that social learning through systems-based thinking exercises helped him gain a better understanding of the interconnectedness in the forest ecosystem, and because of his experience and accumulated knowledge about forests in the region, he was willing to interact with other parties involved in JFM in the village. As he explained:

> We have to work jointly to make this [JFM] work. We are all connected with each other. All departments and personnel should work jointly.... Yes, I strongly agree to attend future meetings so that I can share my ideas with the officers. I am 78 years old; I have a lot to teach these young people. They respect me a lot here (R104; post-workshop evaluation).

Similarly, an evaluation of the JFMC member's post-workshop comments revealed a greater emphasis on the mutual interdependencies among different stakeholder groups, and the need to incorporate diverse stakeholder knowledge in JFM in the region (**Figure 3**, cognitive map). As the member pointed out:

> JFM involves so many components. Not just trees, animals, or forest personnel. Look at the connections. It is very complicated as you can see. Community and local panchayats are all so important. All JFM meetings should involve these people more (R130; post-workshop evaluation).

While creation of opportunities for meaningful and active stakeholder participation in the collaborative modeling process demonstrated access, social learning through systems-based thinking exercises indicated standing by enabling participants to think about forest management as part of a larger complex human-dominated ecosystem (**Figure 3**). Together, access and standing created opportunities for diverse stakeholder groups to translate and integrate these shared knowledge and visions into tangible and meaningful forest management outcomes in the region, demonstrating influence.

Influence

The collaborative modeling process established the importance of integrating local stakeholder knowledge with the technical expertise of natural resource professionals. As preliminary first-steps, we shared the results from the collaborative modeling process with local forest professionals. Diverse stakeholder knowledge of the forest ecosystem reflected in forest history mapping, qualitative resource mapping, and cognitive maps laid the groundwork for forest professionals to incorporate local community knowledge in forest management micro-plans in the region. Pointing out the importance of community knowledge and active engagement in forest management, a forest resource professional stated:

> The villagers too will have knowledge about the forests, how to conserve the forests. That is why we have to work jointly with them; undertake plantations with their local knowledge too. Moreover, if they attend workshops like these then the villagers can go and inform others who did not participate. They can give others information and the word will spread in that manner.... It is better to combine all our knowledge and work together (R179, post-workshop evaluation).

In addition to the integration of diverse stakeholder knowledge in the JFM process, results from the collaborative modeling process further implies the urgent need to integrate *panchayati raj institutions* (PRIs) or local self-government institutions with

JFMCs in the region. While both PRIs and JFM represented critical steps toward devolution of power and control over resources in India (Bose, 2019), differences in institutional structures and purposes often created a barrier to successful linkages between the two. Constituted in 1992, the PRIs were mandated by the Constitution of India, while JFMCs created under the National Forest Policy in 1988 were registered under the state forest departments with no legal identity. While the JFM Guidelines published in 2000 and 2002 emphasized on building strong relationships with the PRIs in the conservation and management of forests, critics argue that PRIs as political entities often reflected the vested interests of the dominant class (Kumar, 2002). Proponents for the establishment of stronger linkages between PRIs and JFMCs, on the other hand, point out that JFMCs failed to emerge as autonomous institutions, with decision-making authority primarily remaining in the hands of the state forest departments (Ravindranath et al., 2000). PRIs as democratically elected institutions, however, would reflect local conservation priorities and interests. Further, Bose (2019) notes that greater involvement of the PRIs could provide JFMCs with developmental assistance necessary for its establishment and functioning as a sustainable broad rural development effort by creating linkages between the JFMCs and the three tiers of PRIs at the village, block, and district levels.

The importance of PRIs in the economic, political, and social-cultural milieu of rural-East Sikkim is reflected in the evaluations of the collaborative modeling process. As grassroots institutions that sustain community interests and needs, PRIs form the backbone of rural self-governance and community-based democratic participatory process in the region. Evaluations of workshop activities indicated an overarching importance of PRIs in rural East Sikkim. For example, while 57% ($n = 27$ of 47) of workshop attendees who participated in the qualitative resource mapping exercise successfully identified the location of a PRI member's house (**Figure 3A**, qualitative resource map), only 25.5% ($n = 12$ of 47) were able to locate the house of their elected JFMC members on the qualitative resource maps. Similarly, of the 82 workshop attendees, 58.5% ($n = 48$) indicated that they would first approach PRI members for forest related problems, while only 41.5% ($n = 34$) attendees opted for forest resource professionals. In explaining her rationale for choosing a PRI member over a forest resource professional for forest related problems, a local villager stated:

> I know all the PRI members in the village, their house, and *panchayat bhavan* [local PRI office]. I do not know who the JFMC members are in my ward, so I would not be able to go there for my forest related issues.... I will definitely go to my panchayat and ask for help (R200; workshop phase).

Similarly, during the collaborative modeling evaluation phase, 54.8% ($n = 23$) of 42 participants favored PRI members over forest resource professionals regarding management of forest-related problems. Only 40.5% ($n = 17$) chose forest resource professionals as their first choice for any forest-related problems. While explaining his rationale for preferring a forest officer to a PRI member, a respondent stated:

> If it is forest related issue, then of course I will go to a forest officer. They will have the technical knowledge to resolve the problem. For example, if I need a permit for cutting a tree on my land, I have to go to RO [local forest range office] for permission. No one else can help (R181; post-workshop evaluation).

Lack of transparency among JFMC officials also influenced participant's decisions regarding approaching forest resource professionals with their forest-related concerns. As one villager disappointedly explained:

> I have heard from a reliable source that this year the JFMC has received funds to undertake plantations in our village. The year is almost coming to an end now, but where are the plantations? I ask where did all the money go.... Who needs a salary from the government when you can make more money this way? I do not trust the committee (R41; workshop phase) (Banerjee, 2016).

Overall, familiarity with PRI members, accessibility to panchayat offices, and trustworthiness were cited as the primary reasons for selecting PRI members over forest resource professionals. Greater technical knowledge and experience were cited as the main reasons for selecting forest resource professionals for solving forest-related issues in the region.

Interestingly, a comparison of the post-workshop cognitive maps with the qualitative resource maps drawn by participants during the workshops indicated an opposite trend. Of the 26 participants who drew a cognitive map in the post-workshop evaluation study, 65.4% ($n = 17$) identified forest resource professionals as a key component of forest management system, with strong positive interconnectedness and mutual interdependencies among other components (**Figure 3**). Only three participants perceived PRI members as key components of the forest management system. Four participants placed local villagers at the center of forest management, while forests/trees and rocks/soil/ were chosen as key components by one participant each. In explaining his rationale for placing local villagers above any other forest resource component, one respondent stated:

> Local villagers form the core of the forest management system. If villagers are not involved in the protection of forests, forest department or panchayat cannot do anything. Everything starts here, with us.... Community involvement is very important (R201; post workshop evaluation).

Précis

The collaborative modeling process provided diverse stakeholder groups with meaningful opportunities to engage in JFM in the region (**Figure 2**). Through social learning, stakeholders unfolded their mutual interdependencies and made important interconnections amongst the various components of the forest ecosystem. Further, the collaborative modeling process opened spaces for knowledge (re)creation and sharing, power sharing, and trust building, and helped (re)create a decision space where interactive and innovative participation provided stakeholders with access, standing, and influence—the tools to provide

voice and share their joint visions toward collaborative forest management in the region.

While this paper demonstrates how the collaborative modeling process helped open spaces previously limited to natural resource professionals, and reintegrated local communities with natural resource management decisions in this rural forest-dependent community, its applicability to populations in other sociocultural, political, and economic contexts requires further validation. While previous studies have evaluated the plausibility and effectiveness of complex systems modeling through collaborative modeling processes (van den Belt, 2004), there is a dearth of studies that focus primarily on participant's preferences, knowledge, and understanding in the modeling process (Thompson et al., 2010). This gap in research is widely evident in the global south.

Our findings indicate important first steps toward understanding people's preferences regarding conservation efforts in East Sikkim, India, and (re)integrating this knowledge with meaningful opportunities for people to share their values and viewpoints through a dynamic collaborative modeling process. Although it was beyond the scope of this paper to quantitatively analyze how the collaborative modeling process lead to better forest management in the region, stakeholders' evaluation of the modeling process suggest that future collaborative efforts in the region are more likely to be successful at garnering greater community interests. Engaged and meaningful community participation through social learning, we posit, can help diverse stakeholders arrive at mutually agreed upon recommendations or workable solutions for their concerns, leading to more socially acceptable and procedurally legitimate natural resource management.

CONCLUSION

In communities where opportunities for formal environmental education are limited, collaborative modeling using social learning activities can create and open spaces for engaged and meaningful stakeholder engagement in natural resource management. In our case study conducted in East Sikkim, India, the collaborative modeling process provided key stakeholders a platform to learn, share, and (re)evaluate the complexities of forest management (**Figure 2**). With a focus on social learning and joint problem solving, the iterative collaborative modeling process enabled stakeholders to unfold mutual interdependencies that encouraged (re)integrating participant's knowledge, visions, and values into collaborative forest management in the region. The paper demonstrates a novel application of Senecah's *Trinity of Voice*—access, standing, and influence—as a frame for analyzing how social learning and collaborative modeling encourage participants to celebrate the reciprocal rights and responsibilities of natural resource management. Learning how to build and translate shared visions of mutually agreeable conservation plans that address the growing uncertainties of managing complex human-dominated ecosystems is crucial to rural East Sikkim, India, as well as across multiple spatiotemporal scales.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available because the raw data sets generated from the interviews in this project are protected by The Human Subjects Protection Office at the University of Texas at El Paso (UTEP), El Paso, TX, USA (IRBNet ID# 841069-2), and the Institutional Review Board at Texas A&M University (TAMU), College Station, TX, USA (IRBNet ID# 2012-0327). Only those authorized under these IRB protocols are able to access the raw data for this study.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Human Subjects Protection Office at the University of Texas at El Paso (UTEP), El Paso, TX, USA, IRBNet ID# 841069-2 and Institutional Review Board at Texas A&M University (TAMU) College Station, TX, USA, IRBNet ID# 2012-0327. The ethics committee waived the requirement of written informed consent for participation.

AUTHOR CONTRIBUTIONS

PB and TP designed the study. PB, TP, and MP collected the data and conducted preliminary analysis. PB and WG identified core systems thinking concepts and exercises. PB and H-HW developed the conceptual diagram. PB led writing of the manuscript with critical feedback from all co-authors. All authors assisted with data interpretation.

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