Towards Advancing Theorization of Knowledge Exchange Processes: Unpacking Linkages and Sequences among Concepts via Tacit-Explicit Knowledge Conversion Notion

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Abstract

Knowledge Exchange (KE) bridges the gap between science and practice. Situated in the context of Knowledge Management for Development, this study proposes a theoretical advance in understanding KE processes by leveraging on the notion of tacit-explicit knowledge conversion, and the SECI model. Using a case concerning climate change adaptation planning in Botswana, it examines how KE processes combine and sequence to drive effective engagement in an empirical setting. Results reveal a partial SECI spiral of Externalization, Combination, and Internalization modes, with these modes offering insights for understanding and interrogating the combination and sequencing of the KE process concepts. We identified a horizontal (chronological) linkage including knowledge integration, and practice and learning, which provided insights into how the process-related concepts are sequenced. This was found to be built on what we termed a 'Knowledge Foundation' comprising linked concepts of trust, information usability, boundary objects, and research capacity (from knowledge broker to campaigner). Together, they comprise a proposed framework by which key KE process-related concepts can be organized,. demonstrating how the KE process-related concepts combine and sequence over time. These findings suggest that the perspective of knowledge as dynamic, coupled with the consideration of the notion of tacit-explicit knowledge conversion, is invaluable for understanding, and ultimately driving, effective knowledge exchange. The study thus advances KE theory, and calls for future exploratory works to consider other interfaces, levels of governance, and context-transcendence of the findings.

Keywords: science-practice interface; tacit-explicit knowledge conversion; knowledge exchange; shared values; SECI model; theory building

1. Introduction

Knowledge Exchange (KE) is increasingly recognized as a critical mechanism for bridging the gap between science and practice in sustainability science. Transdisciplinary collaborations—spanning policy making, research, and on-the-ground action—rely on KE to integrate diverse forms of knowledge to address multifaceted environmental and social challenges (Cvitanovic et al., 2016; McGill et al., 2023). Over decades of scientific inquiry and applied practice (Knapp et al., 2019), KE has been conceptualized as a comprehensive process that includes knowledge production, sharing, storage, mobilization, integration, and translation (Fazey et al., 2013). Yet, despite its central role, theoretical development in KE has lagged behind empirical advances, limiting the systemic

understanding of its dynamic, multifaceted, and complex nature (Fazey et al., 2014).

The evolution of KE research has been marked by a concerted effort to identify key concepts, referred as 'enablers'—such as trust, information usability, social learning, and boundary objects—as well as 'barriers' like the challenges in effectively translating scientific knowledge into practice (Fazey et al., 2013; Westwood et al., 2023; Karcher et al., 2024). These studies typically treat KE elements as isolated, static factors rather than as parts of a dynamic, interrelated process. However, reviews by Fazey et al. (2013, 2014) and Reed et al. (2014) have underscored the urgent need for theoretical elaboration that can move beyond a mere catalog of concepts. Regardless of theory type (e.g. descriptive, prescriptive, predictive, practice), components of a theory should include purpose and boundaries, concepts, relationships – and then go forward towards representations, predictive statements, prescriptive statements, philosophy and methodology, quality, related research (Svejvig, 2021). Such theoretical components have not yet been fully developed here.

Therefore, this oversight leaves a significant gap in our understanding: while knowing which concepts matter, we remain unclear about how these concepts combine and sequence over time to drive effective KE outcomes (Reed et al., 2014; Eisenhardt & Graebner, 2007). Besides, current process-driven frameworks are primarily practice-centered. While having provided guidance for implementation, they are lacking the concept-driven insights needed to delineate the relationships among key concepts (Cvitanovic et al., 2015a; Nguyen et al., 2017; Roux et al., 2019; Zhang et al., 2022). To fill this theoretical gap, we need an approach that not only identifies what matters in KE, but also rigorously delineates how these mattered concepts are interdependent and temporally structured.

Before a selection of approach to fill the recognized gap, recognizing the need for precision and transferability, we deliberately confine the scope of this study to the process dimension of KE. We exclusively analyze process-related concepts, excluding broader institutional concepts such as power dynamics and funding opportunities to capture the dynamic conversion of knowledge that is most clearly manifested within the KE process itself. This targeted scope not only simplifies the complexity inherent in KE but also aligns with the core tenet of dynamic knowledge, wherein iterative interactions among knowledge producers and users drive more salient and legitimate problem-driven outcomes (Evely et al., 2011; Phillipson et al., 2012; Reed et al., 2014).

Our selection of theoretical lens is guided by the overarching conceptual framework of Knowledge Management for Development (KM4D) and Knowledge Management for Sustainable Development (KM4SD) (Boyes et al., 2023). KM4D originated in the late 1990s when organizations such as World Bank began positioning knowledge as a central development asset, embedding knowledge-sharing and organizational learning into development practice (World Bank, 1998). It fundamentally diverges from traditional KM (e.g., focused on competitive advantage and corporate efficiency, Davenport and Prusak, 1998) by shifting its ultimate goal to social relevance and the achievement of Sustainable Development Goals (SDGs). It also explicitly recognizes and prioritizes the integration of multiple knowledge (encompassing local, tacit, experiential, community, and indigenous knowledge) viewing this knowledge as a vital, yet often marginalized, asset in development (Brown, 2010). KM4D rejects the notion that scientific knowledge alone is sufficient, advocating instead for the decolonization of knowledge by elevating local wisdom (Boyes et al., 2023). Crucially, for contexts across the Global South, KM4D provides the essential theoretical foundation for analyzing how local communities can harness their unique knowledge assets to drive resilience and adaptation and emphasizes that successful knowledge integration in development is achieved not through top-down mandates, but through the facilitation of dynamic community-level processes and integration of local knowledge into learning systems by which ownership and control (by knowledge holders) are ensured (Boyes et al., 2023, Cummings et al., 2025).

This pronounced focus on dynamic, decentralized knowledge conversion and the imperative to integrate local tacit knowledge precisely points us to a pathway to address the identified theoretical gap in KE: our study leverages the notion of tacit–explicit knowledge conversion as originally articulated in Polanyi's Personal Knowledge Theory (Polanyi, 1962) and later conceptualized in Nonaka's Knowledge Creation Theory (Nonaka, 1994; Nonaka & Takeuchi, 1995). Central to our approach is Nonaka's SECI model which builds on those, and which delineates the continuous transformation of tacit into explicit knowledge (and vice versa) via socialization, externalization, combination, and

internalization.

By situating the SECI model within the KM4D framework, we argue that the model is transformed from a corporate learning mechanism into the most suitable micro-process mechanism for analyzing the critical knowledge conversion tasks demanded by sustainability science. The KM4D mandate gives SECI new purpose: to rigorously delineate how local, often tacit, indigenous values knowledge (the core asset acknowledged by KM4D) is converted into actionable, shared explicit knowledge for community-level sustainability (in this study, climate adaptation planning). This dynamic model, rooted in organizational studies of knowledge management (Roux et al., 2006; Stern et al., 2020), offers a powerful lens to examine the interplay among KE process-related concepts. By applying this model, we aim to uncover the dynamic interplay among KE process-related concepts over time rather than merely listing them. In turn, we assess the usefulness of SECI model and the Knowledge Creation Theory to shed light on the question of "Which academic theories or models are useful for what kinds of practice of KE?" (Fazey et al., 2013, 2014; Reed et al., 2014).

While theoretical models provide conceptual clarity, the lack of pragmatic significance in direct theoretical mappings can limit their relevance for KE research. This is particularly crucial in KE, where real-world complexity, uncertainty, and context dependency make purely theoretical insights insufficient. To mitigate this gap, we employ an empirical case study as a proof-of-concept to illustrate the utility of applying the tacit–explicit knowledge conversion notion to map the KE process, serving as an intermediary between theoretical constructs and practical realities. By embedding theoretical concepts in an empirical KE process, we integrate both empirical insights and theoretical elaboration, reinforcing the applicability of the theory in real-world sustainability challenges. Our approach aligns with two 'ideal types' of theorizing in sustainability science (Schlüter et al., 2022): (1) theorizing in embedded research, where empirical data drives conceptual refinement, and (2) basic research-driven theorizing, where existing theory is used as a foundation to interpret empirical findings. By doing so, we enhance both theoretical depth and practical applicability, ensuring our insights are relevant beyond the specific case.

Specifically, we examine the KE process between a researcher and local Village Development Committee members in Botswana, Africa, within the context of climate change adaptation planning. Acknowledging KE process can be promoted and studied on multiple governance levels with multiple interfaces and types of knowledge involved (Karcher et al., 2024), we refine our research scope according to this empirical setting, where knowledge is understood as the interplay between perceived local knowledge and scientific knowledge aimed at producing more legitimate and actionable outputs (Raymond et al., 2010; Young, Corriveau, et al., 2016a). By restricting our focus to process-related concepts, we ensure a clear and precise investigation into the dynamics of knowledge conversion.

In sum, we aim to advance KE theory in this study through a qualitative exploration making use of empirical data. We identify a specific combination of KE process-related concepts and reveal a distinct sequence in which these combinations occur empirically. Together, these comprise a new 'framework' by which key KE process-related concepts can be organized. In addition, we demonstrate the utility of the tacit–explicit knowledge conversion perspective, operationalized through the SECI model, as a means to understand the dynamic interrelationships among concepts involved in KE process. In this way, we provide both substantive and methodological stepping stones for KE theory building.

Through these contributions, our study not only addresses a critical gap in the existing literature but also provides a pivotal stepping stone toward more integrated and actionable approaches for designing and optimizing KE processes in sustainability science. Although a single-case study does not allow broad generalization, it serves as an analytical generalization (Yin, 2018) by illustrating how theoretical relationships manifest in practice. We demonstrate the functional application of the SECI model in KE and validate its conceptual utility. Thus, while the empirical findings are limited to the specific setting, the theoretical contribution extends beyond the case, offering a foundation for future research aimed at generalizing these dynamics and refining KE theory to enhance the design and implementation of more effective KE interventions in sustainability science.

We organize the paper as follows. We first review and identify common KE process-related concepts and introduce the selected theory of KCT and its SECI model. We then provide the multi-case-study

background and the data collection and analysis methods; report our findings on linkages among the key KE process-related concepts; and discuss the usefulness of SECI model for KE theory building before concluding with future research suggestions.

2. Theoretical Foundation

2.1. The notion of tacit-explicit knowledge conversion and its adaptation in KE research

Knowledge Exchange (KE) is an inherently social process. It has feedback-learning loops and a non-linear process that goes beyond generating and communicating new knowledge and acting upon it; it extends to the provision of reliable and relevant knowledge to decision-makers and academics (Reed et al., 2014). KE is a two- or multi-directional interactive approach to engaging, producing, sharing, co-creating, co-managing, learning, and brokering knowledge in relevant contexts, for defined purposes and participants, through various methods (Nguyen et al., 2021; Cvitanovic et al., 2025; Fazey et al., 2013; Reed et al., 2014). It is multi-dimensional because it involves diverse participants such as the local communities, researchers, practitioners, policymakers and organizations (Mrazek and Haggerty 1994), multiple channels such as face-to-face communications, written documents, seminars, collaborative projects, online platform and workshops, knowledge heterogeneity (Raymond et al., 2010), context dependency, diverse exchange directions (Lepore et al., 2021), involving multiple stages such as knowledge generation, dissemination, reception, application and feedback, and diverse impacts.

KE is founded on the assumption that knowledge and knowledge exchange processes are dynamic (Fazey et al., 2013; Reed et al., 2014; Nguyen et al., 2021). Dynamics within/of the KE processes is characterized by varying interpretations and uncertainties regarding its effectiveness across different contexts (Fazey et al., 2013). The flexible nature of KE processes emphasizes the need for continued monitoring, reflection, and refinement (Reed et al., 2014), with adaptive mechanisms that synthesize an array of knowledge types from diverse sources (Ward et al., 2012). In a study on environmental governance within China's NEP, Kong et al. (2023) position KE as a vital and dynamic component that underscores its adaptability to shifting circumstances and the involvement of multiple stakeholders with varied backgrounds. In another study, Cvitanovic et al. (2021) stress that trust, a key element in KE, is inherently dynamic and fragile, necessitating persistent efforts to establish and sustain it, thereby reinforcing the ever-changing essence of KE processes.

The dynamic perspective of knowledge within KE is crucial because historically, knowledge was viewed as a static entity. However, knowledge is also perceived as a dynamic process linked to an individual's perceptions and worldview, is context-specific and evolving (Evely et al., 2011). More so, the dynamics of knowledge within KE is hinged on the fact that the knowledge shared is constantly updated and refined through interactions among different stakeholders in different contexts (Tschirhart et al., 2016).

Despite the emphasis on multi-directionality and inclusivity in KE, it is widely acknowledged that not all forms of knowledge are equally accessible or translatable. Dismore et al. (2024) observe that some forms of knowledge could be exchanged because they are codified-explicit knowledge-whereas others are contextual, personal, dependent, and are more challenging to exchange- tacit knowledge. In Knowledge Management literature, tacit knowledge is often linked to local knowledge which Li and Zhao (2023) refer to as localness. Tacit knowledge is viewed as such because it embodies the common practices and strategies of the local people in dealing with uncertainties (Rantanen and Kahila, 2009). Local knowledge, which we focus on in this study, could either be tacit or explicit (Raymond et al., 2010); if tacit, it is rooted in personal experience, context, and intuition (Polanyi 1962) and perceived as hard to communicate or share with others (Nonaka and Takeuchi, 1995). For tacit knowledge to be communicated, it must be converted into words, models, or numbers that can be commonly understood by others (Desouza, 2003). It can be learned and exchanged through participation and by 'doing' (Nonaka 1991; Holste and Fields 2010) and relies on local trust (Foos et al., 2006). Because of how hard it is to access, interpret and communicate the tacit local knowledge of the local people to the researchers, policy makers or a third party, knowledge brokers who have access to the tacit and explicit local knowledge usually summarize it into a medium that other actors can use (Reed et al., 2014).

KE facilitates the reciprocal exchange of knowledge between knowledge producers and users of all aspects and recognizes that each of the parties contributes important knowledge during the interaction (Bautista et al., 2017; Cvitanovic, et al., 2021). It enables the integration or synthesis of diverse forms of knowledge (Ward et al., 2012), recognizing the need to engage with a range of groups to decide and achieve desired outcomes (Cash et al., 2003; Aswani and Hamilton, 2004; Pretty, 2011). This knowledge includes experiential or local, scientific and hybrid (Raymond et al., 2010), practice, horizontal and vertical (Tschirhart et al., 2016), and producer and user knowledge (Bautista et al., 2017). Local knowledge in environmental management is further divided into 11 types: indigenous, traditional ecological, local ecological, personal, lay, situated, tacit, implicit, informal, non-expert/novice and expert (Raymond et al., 2010). These well-defined types of knowledge are to be exchanged among each other or with scientific knowledge. In this study, the nature of the local knowledge being considered is personal and tacit. A person or group holds this knowledge, derived from their experiences and tied to their worldview, values, and expertise (Raymond et al., 2010).

Similar findings have been reported from other fields. In public health communication and decision-making, Sanford et al. (2020) emphasize the importance of tacit knowledge in managing Emerging Public Health Incidents (EPHIs). They found that local knowledge and clinician feedback in Ontario have not been adequately engaged. Participants drew on their prior experiences and field observations to address EPHIs and established strong relationships that promoted tacit knowledge learning, trust, and credibility. Rist et al.'s (2016) study showed local residents' knowledge aided forest management and built mutual understanding. Bliss et al. (2019) found that tacit knowledge of farmers' practices is hard to formalize, but collaboration, like workshops, exchange visits that can facilitate the observation of contextual practice, and videos can bridge knowledge gaps among farmers, researchers and advisors. In Habiyaremye (2023), university-community engagement projects facilitated co-learning and knowledge co-creation between South African researchers from the University of Johannesburg and local Soweto communities. This led to the merging of local tacit knowledge with the researchers' scientific insights, co-producing knowledge to improve and sustain Soweto's local food systems. In conservation planning, local hunters, loggers, farmers, and researchers in eastern Canada's Chignecto Isthmus engaged in participatory mapping, interviews, and workshops. Locals offered valuable data on wildlife and habitat issues linked to human activities (Needham et al., 2020).

These studies reveal that local knowledge is tacit, contextual, and individual, often shared through social interactions and trust-building. These characteristics align with the dynamics of knowledge in KE. The tacit nature of local knowledge can enhance KE, bridge the gap between research and practice, promote the co-creation and integration of different knowledge, and strengthen the sustainability of KE. Thus, this study suggests incorporating tacit knowledge and the notion of tacit-explicit knowledge conversion into KE literature because of their potential and underrepresentation. Although, the increasing attention to participatory and co-productive processes, little research systematically incorporates T–E conversion into the KE literature, even though the literature extensively uses related terms such as sharing, transfer, brokerage, transformation, and translation (Fazey et al., 2013; Ward et al., 2009; Best & Holmes, 2010).

While KE approaches and frameworks have evolved—through boundary organizations, co-production, knowledge brokering, and trust-building (Bednarek et al., 2018; Fazey et al., 2014; Walsh et al., 2019; Karcher et al., 2024) - a critical conceptual and practical gap persists. Few KE frameworks explicitly incorporate mechanisms to address the dynamic conversion between tacit and explicit knowledge forms. Bogatinoska et al. (2024) and Stern et al. (2020) are among the few that reference the SECI model to enhance KE, especially in environmental contexts. These studies found that concepts such as lack of common language, professional background, and organizational cultures hinder effective KE, while social learning and trust are foundational to facilitating tacit-explicit conversion. Furthermore, Cvitanovic et al. (2018; 2021) identify seven categories of core capacities for KE, yet these capacities are rarely aligned with the nuanced conceptual mechanisms necessary for effective T-E conversion.

With these process concepts scattered in different KE works, KE remains under-theorized in the way its process concepts have not been organized into a useful dynamic process theory that applies to different KE contexts and in the way it has overlooked the intrinsic challenges of tacit knowledge and the notion tacit-explicit knowledge conversion for advancing KE effectiveness.

2.2. Key KE concepts associated with the process condition

A wide variety of KE concepts have been identified in current literature. Given the scope of this study which is the KE process between science and practice interfaces on the local level, we only consider process condition concepts. There is no systematic review matching our scope, but reviews of KE from wider scopes or different aspects can provide insights.

The first systematic review regarding KE on science-policy interface for forest science (Westwood et al., 2023) indicated common key enablers for KE were trust, funding, and established relationships; and major barriers were translation of science, and lack of time. Building on Cvitanovic et al. (2015a), the latest review on KE progress by Karcher et al. (2024) particularly emphasized "the need to better understand enabling factors to effective KE" in a comprehensive manner. They reported key concepts of KE from ten dimensions (process, interpersonal, individual, financial, group, resource & information, institutional, focus, timing and public pressure) and 28 concepts (referred as 'enablers' in the reference). Those within our research scope and context were: process, interpersonal, individual, resource & information, and we looked therein to locate concepts for our theory-building.

Drawing on previous reviews and related literature concerning **process-related concepts** (e.g. Cvitanovic et al., 2015b; Cvitanovic et al., 2016; Cvitanovic et al., 2021; Fazey et al., 2013; Nguyen et al., 2019; Walsh et al., 2019), we identified all relevant concepts, while remaining open to new concepts that may emerge during the analysis. Because of the declared exploratory nature of our study we did not require nor conduct a systematic literature review but built on our understanding and accumulation of previous literature. We acknowledge this limitation and advocate future systematic review work building on our exploratory findings. The key KE process-related concepts identified directly relevant to our research scope are:

Trust: long identified as a critical pre-condition for achieving evidence-informed policy (Cvitanovic et al., 2021). Building and maintaining trust can lead to impactful KE (Kapoor et al., 2023). With trust in place, open communication and collaboration can lead to development of boundary objects that are relevant and accessible to knowledge users (Kapoor et al., 2023).

Information usability: which concerns its credibility, salience, legitimacy (Dilling & Lemos, 2011) , often discussed alongside actionable knowledge (Stern, 2018), and associated with the commonly desired social outcomes of KE (e.g. networking, awareness, learning, trust-building) (Karcher et al., 2021).

Learning: (especially social learning) is implicit throughout KE process (Reed et al., 2010). Learning can support joint knowledge production for socially robust knowledge generation (Hegger et al., 2012; Nowotny et al., 2003). When learning space is cultivated between science and practice, knowledge can be transferred to be actionable faster (Stern et al., 2020).

Boundary object: Increasing attention has been paid to roles of knowledge broker, boundary organizations, and boundary object in producing useful information and facilitating mutual learning among research, policy and practice (Bednarek et al., 2016; Bednarek et al., 2018; Cash et al., 2003; Cvitanovic et al., 2017; Maag et al., 2018; Reinecke, 2015), When culturally sensitive, boundary work is more likely to gain acceptance among practitioners (Dannevig et al., 2020).

Knowledge integration: Highly discussed sub-process of KE given its precondition for effective collaboration and meaningful outcomes (Stepanova et al., 2020), but remains challenging. Knowledge integration aims for development of action-oriented solutions (Hoffmann et al., 2017).

Practice 'beyond': New projects, initiatives, funding and other uptake of outputs are desired beyond original project contexts, through co-production (Karcher et al., 2024).

Researcher capacity: Engagement and participatory research is needed for co-production in KE process, consequently, the researcher's capacity as a facilitator is required: they should align their communication with the need of users in the behavioral and intellectual sense, e.g. using narratives and story-telling (Young, Nguyen, et al., 2016b). The role of knowledge brokerage in facilitating mutual learning is increasingly recognized (Cvitanovic et al., 2015a; Maag et al., 2018): brokers hold unique positions to build and maintain relationship with knowledge users (Kapoor et al., 2023). Researchers need to be clear about their role and purpose to conduct stakeholder interaction (Knaggård et al., 2019).

Upon reviewing and selecting the above KE process-related concepts to be included in this study, we noted that they are currently discussed in a disconnected and isolated manner, reinforcing our view of this hindrance to theoretical development and the need to systematically synthesize them for development of the KE field.

2.3. The SECI model from the Knowledge Creation Theory (KCT)

To address these challenges, our study leverages the SECI model's capacity to integrate tacit–explicit knowledge conversion within a KE process. The SECI model is from the Knowledge Creation Theory. The notion that knowledge is categorized into two different types, i.e. tacit and explicit (Polanyi, 1968), and that the conversion between them through sharing, translation, integration and embedding, laid the foundation of Nonaka's Knowledge Creation Theory (Nonaka, 1994). Tacit knowledge usually refers to knowledge that is embedded in experience and difficult to communicate and transfer because it is hard to be codified. Explicit knowledge refers to knowledge that is codified and documented with words or symbols thus can be easily shared and transferred. The identification of the importance of the tacit dimension of knowledge, and the adaptation of Nonaka's SECI model to elaborate understanding on the value of tacit knowledge and knowledge conversion in environmental management (Roux et al., 2006; Stern et al., 2020) support this theoretical selection for this study

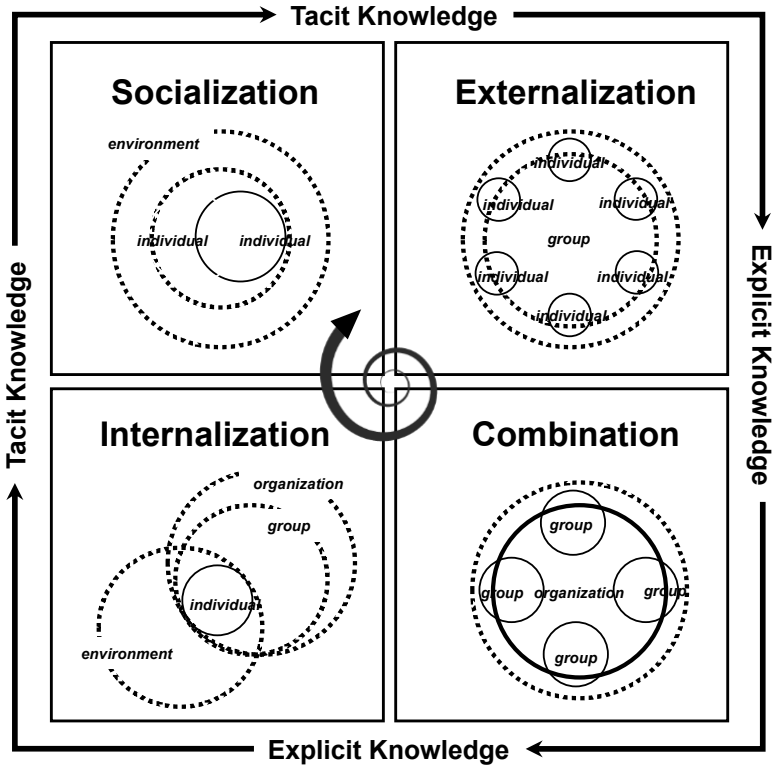

Figure 1. SECI model as the spiral evolution of Knowledge Conversion Process. A schematic illustration based on Nonaka and Takeuchi (2021).

At the center of KCT, SECI model consists of four modes, namely Socialization, Externalization, Combination, Internalization, representing different conversions between tacit and explicit knowledge (Figure 1). Detailed definition of each mode is presented later alongside the findings.

By foregrounding the tacit knowledge dimension—especially as it relates to local knowledge—we enhance the explanatory power of KE theory and clarify the conceptual linkages that underpin it. This allows us not only to refine existing KE frameworks but also to propose a more robust and dynamic theoretical model that better accounts for the nature of knowledge itself in its most elusive forms.

Our approach contributes to theory-building in KE by offering a rigorous conceptual integration of knowledge dynamics grounded in well-established organizational learning theory. This enriches the KE discourse and provides practical pathways to improve the exchange, co-creation, and application of knowledge in sustainability and environmental governance.

3. Method

This exploratory study adopts a retrospective interpretive qualitative approach, supported by empirical data collected through pertinent qualitative methods. The research aimed to uncover linkages among knowledge exchange (KE) process-related concepts by employing the SECI model, which incorporates the critical notion of tacit-explicit knowledge conversion. The empirical data came out of a study which utilized a methodology which centers on such tacit-explicit conversion. By analyzing an empirical KE process—first with respect to pre-identified KE process-related concepts and then through the SECI model—the study aligned these concepts with the distinct modes of the SECI model, thereby identifying linkages between conceptual dynamics and knowledge conversion stages.

3.1. Case description

The empirical data used in this study is originally from a project exploring whether decisions of local climate change adaption which are strongly influenced by values (Adger & Barnett, 2009; O'Brien & Wolf, 2010) can be improved by a values-crystallization process, named *WeValue InSitu*, in which participants are facilitated to articulate not only themselves, but also the shared values-in-action of their group. It includes a meaning-making and meaning-checking process in which participants are facilitated to iteratively share, examine, challenge, and make conversions between their tacit and explicit knowledge (Odii et al., 2021). This values-based process was used as a pre-process to standard participatory Vulnerability Risk Assessments (VRA) in a multiple-case study carried out in four villages in the North-East District of Botswana - one of the most climate-vulnerable countries worldwide. In each of these four villages, the researcher with a local background carried out the above-mentioned combined processes with local practitioners from the Village Development Committee (VDC), the official local representation of the village, to develop their local adaption plan. The *WeValue InSitu* process was demonstrated (Sethamo et al., 2019) and suggested to have positive effect on local adaptation plan (Locatelli et al., 2022).

Upon retrospective interrogation of the data we noticed the data was promising for generating process-related learning for KE because it satisfied three out of four aspects by which KE is usually evaluated: process, understanding, practice/policy and impact (Fazey et al., 2014). This project had a comprehensive implementation of a design which provides rich process-related data which is very useful for exploration; it was demonstrated to facilitate local stakeholders' attitude and intention of local adaptation which counts as a meaningful KE outcome; it involved production of local level climate change adaptation plans which counts as meaningful KE outcome (see Sethamo et al. (2022)). Although documentation of the impact dimension was absent from the design, the results are still rich enough to provide insights for future studies. Therefore, we decided to conduct a retrospective analysis with a focus on the process of this project, with the research objectives to identify linkages among the process-related concepts and to generate insights. We provide schematically illustrate the case design and implementation in Figure 2 and would anticipate that if the results are promising then future study can be designed to provide further proofs.

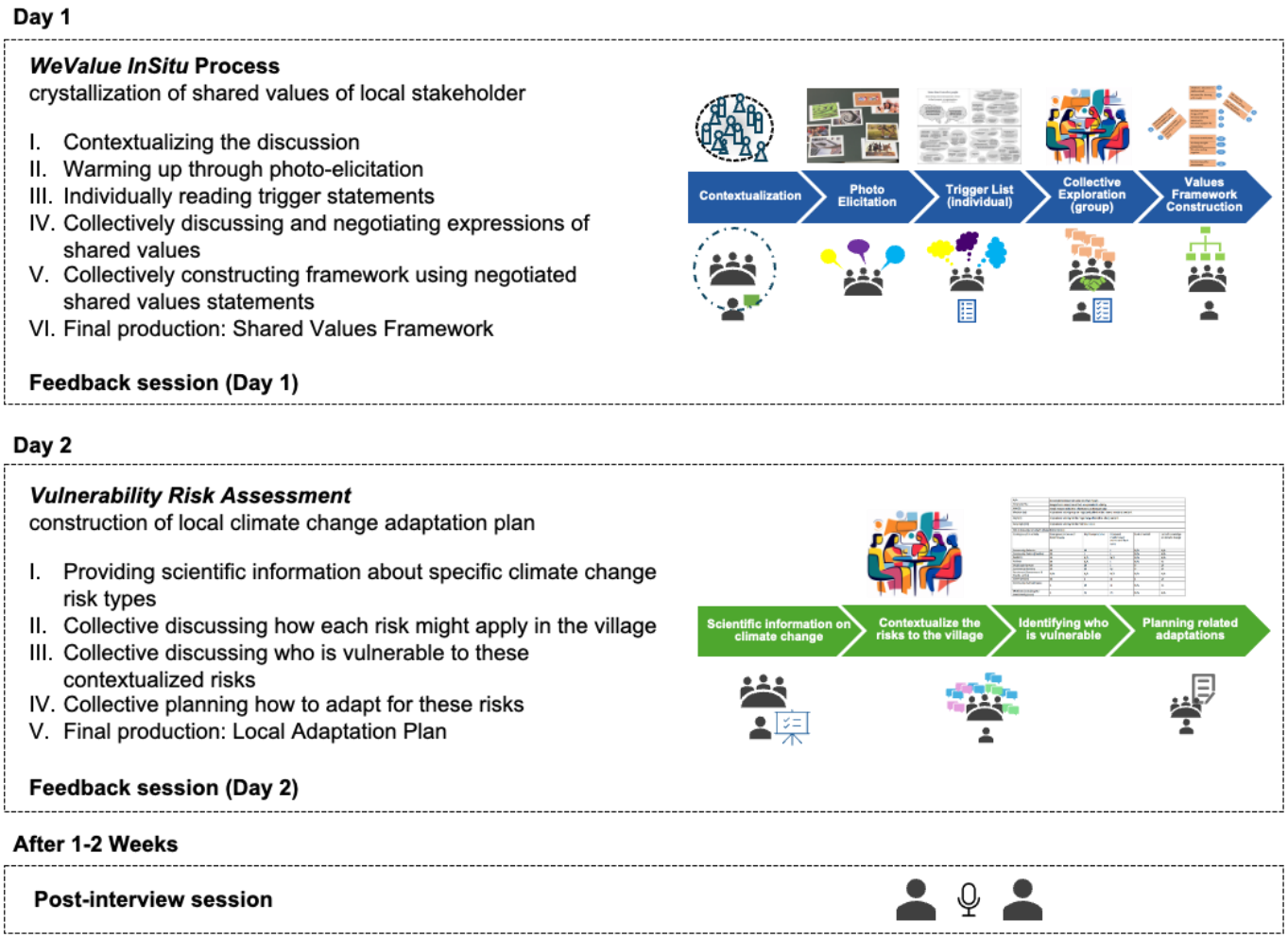

Figure 2. A schematic illustration of the case design and implementation applied in four villages in the North-East District of Botswana for local climate change adaptation planning.

3.2. Data collection and analysis methods

All sessions, including *WeValue InSitu* process, VRA process, and interviews were audio recorded in the field, with informed consent from participants. Later, verbatim transcriptions of the recordings in local language were conducted by a local native speaker, who then worked with the practice-based field researcher to jointly translate the transcriptions into English to minimize any loss of meaning of the qualitative data.

Regarding the retrospective analysis, we took a directed content analysis approach (Hsieh & Shannon, 2005) to identify the appearances of each SECI mode and process-related concepts in our initial coding list derived separately from existing literatures. During the analysis, we immersed ourselves in the data and allowed new themes to emerge to construct the final coding list (Miles & Huberman, 1994). We expected new influencing KE process-related concepts to emerge since no such systemic literature review has yet been carried out that we could rely upon, as mentioned above. To ensure analysis validity, three researchers who did not deeply interact with this research but who practiced in the field were commissioned to carry out the analysis independently first, and then compare their results followed by a session of debate and critical reflection to finalize the results, all as suggested by Lincoln and Guba (1985).

4. Results

By interrogating the KE process data with respect to the key KE process-related concepts and the SECI model, we identified one horizontal and one vertical linkage, hence, we present this as a 'framework' in Figure 3 by which key KE process-related concepts can be organized. We illustrate the inputs and outputs of knowledge of each SECI mode in terms of their nature of knowledge (i.e. being tacit or explicit) in a chorological order, in which different activities were carried out. Our data indicates that the KE process in this study is a partial SECI spiral process, suggesting that facilitating such a SECI spiral could lead to desired KE process, aligning with Stern et al. (2020).

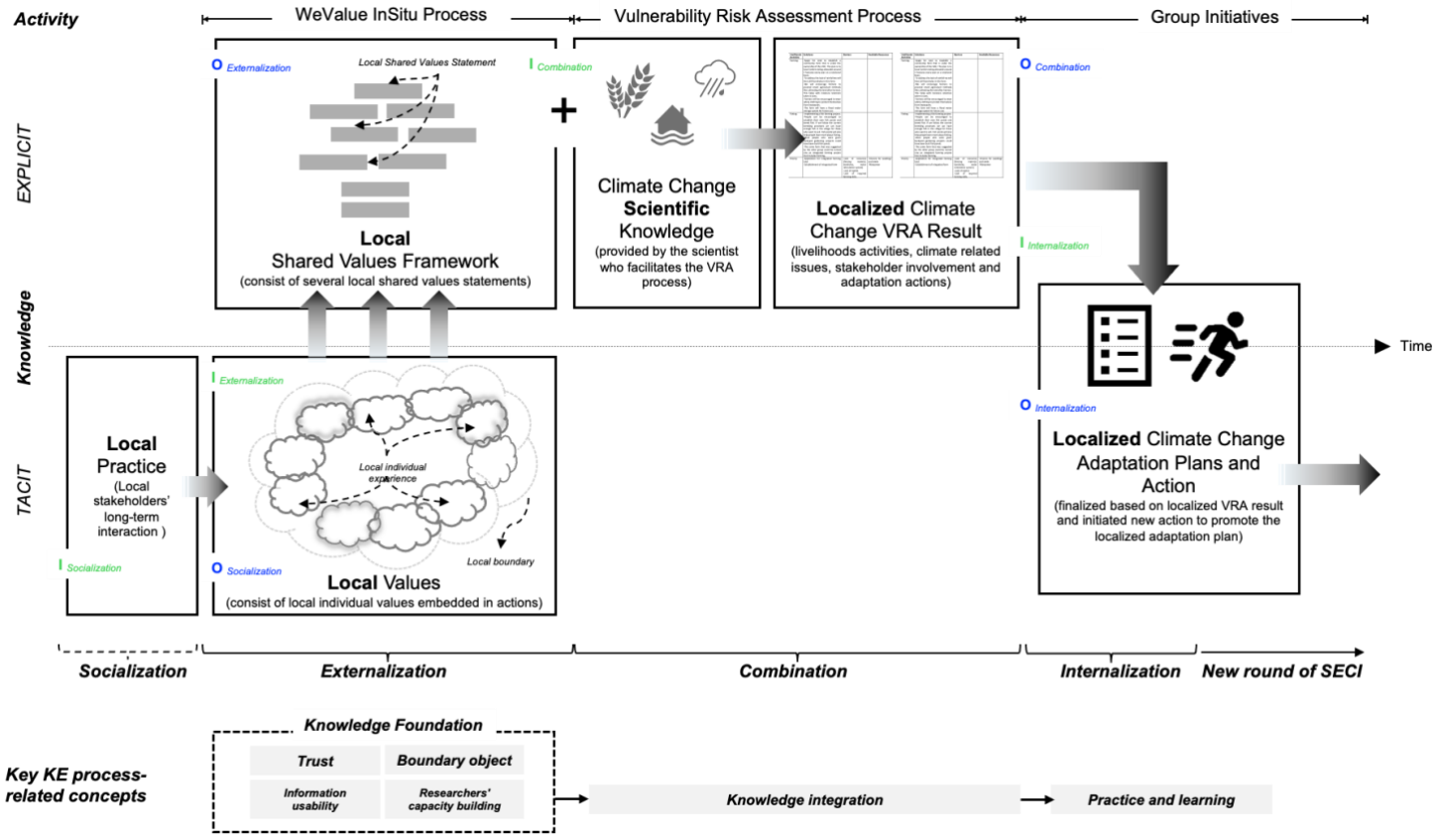

Figure 3. A schematic illustration of how the case activities, key KE process-related concepts, SECI model sequences, are connected in the KE process between the researcher and the local village development committee members in this study. Input (I) and Output (O) of each mode are indicated.

Socialization. According to SECI model, individuals share and learn from each other's tacit knowledge through daily social interactions including observation and imitation. Experience is crucial, in that tacit knowledge is difficult to be formalized and transferred, and is acquired through shared experience. Mutual trust is often required, and also can be nurtured: in this mode, as individuals start to empathize with each other, and transcend their self-boundaries to intersubjectively know another (Nonaka et al., 2000). In this case study, there is no obvious Socialization promoted as the researcher has no significant shared experience with local stakeholders.

Externalization. Externalization is the process of articulating individual tacit knowledge into explicit knowledge. It happens when metaphor, analogy and model are used in dialogue to create new explicit concepts (Nonaka, 1994). In this case, we found Externalization was facilitated by the *WeValue InSitu* process in which participants (local stakeholders) articulated their shared values into statements and then prioritized and constructed a shared values-based framework of them, representing criteria shared

by the group for decision-making. A sample framework is shown in Figure 4 below for one VDC with their unique, bespoke statements and framework structure. We found mutual trust was cultivated through Externalization and the usability of information (evidenced by data given in Supplementary Table S1) to produce actionable knowledge was enhanced. The shared-values framework was recognized and utilized to be a boundary object (evidenced by data given in Supplementary Table S2) (Wallis et al., 2017), while the researcher who facilitated the process was seen to build capacity to conduct participatory study as a 'Campaigner' (Reed & Rudman, 2023).

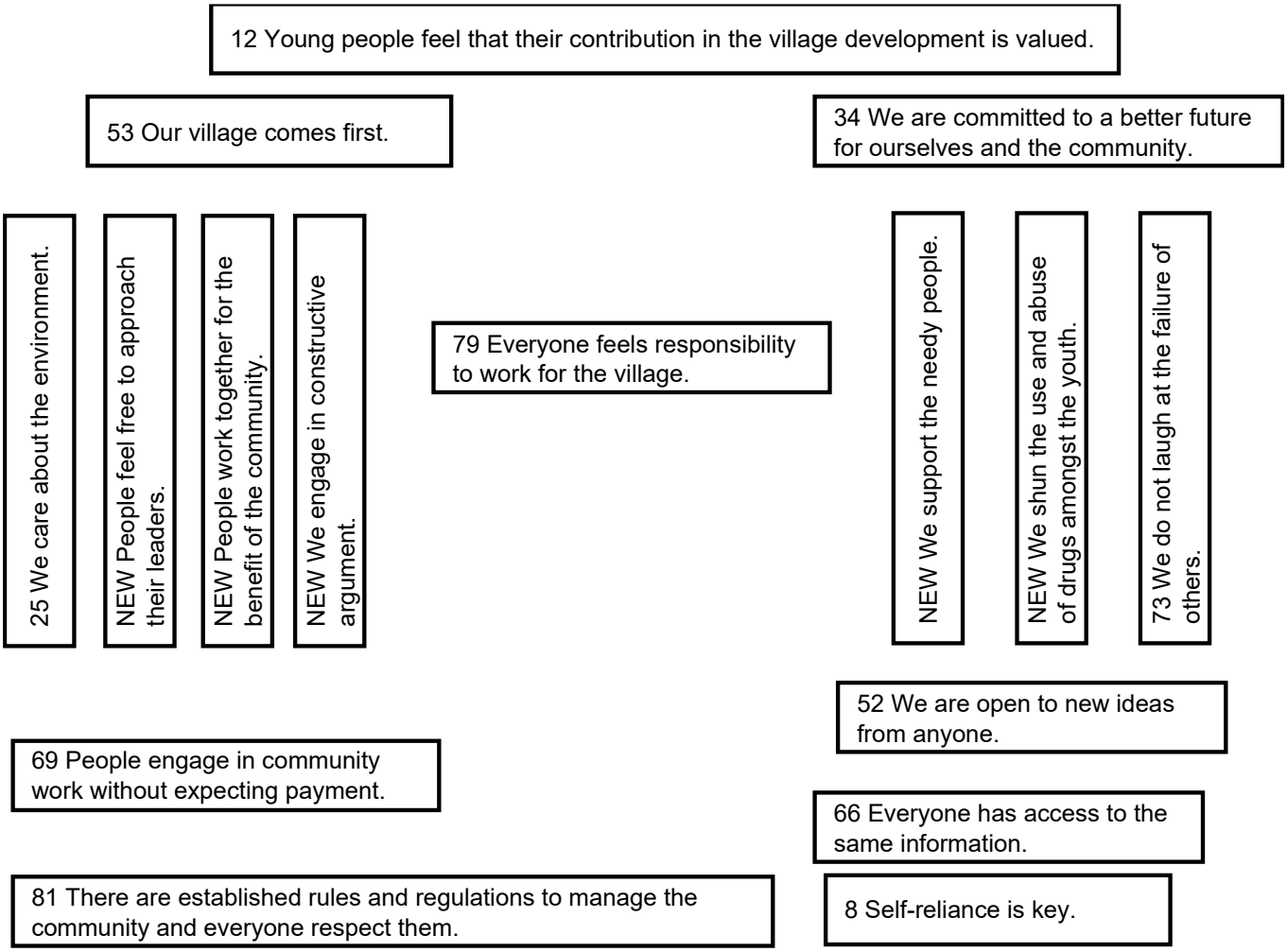

Figure 4. A sample shared-values frameworks developed by the VDC Ta group during the *WeValue InSitu* process.

Combination. In this mode explicit knowledge from different resources are brought together and systematically synthesized to produce more complex explicit knowledge (Nonaka et al., 2000). In this case-study, this mode is found to be facilitated during the (post-*WeValue InSitu*) VRA process. The outcome of Combination here are localized Vulnerability Risk Assessments, including livelihoods activities, climate-related issues, stakeholder involvement and adaptation actions. Participants utilized both explicit knowledge they articulated during *WeValue InSitu* (local shared values), and explicit knowledge provided by the researcher (scientific knowledge of climate change), to create new explicit knowledge. In addition, participants indicated high ownership of the results as they clarified their roles and responsibilities as committee members. In terms of KE, the integration of two types of knowledge was facilitated (evidenced by data given in Supplementary Table S3).

Internalization. In this mode explicit knowledge is converted into tacit knowledge from collective level (group or organization) to individual level, and thus is essential for learning in the traditional sense. When new knowledge is embedded in an individual, their individual tacit knowledge is enlarged and thus learning happens. "Learning by doing" is key for this mode.

In this case, no activities were designed to purposefully promote this mode, for example to contact local stakeholders afterwards to encourage them to utilize their outputs (from the *WeValue InSitu* process of Externalization and from the VRA process of Combination). However, Internalization still did occur, since localized climate change adaptation plans were consequently produced and indeed brought to attention of higher-level authorities on the initiative of the local groups. Local stakeholders were also consequently motivated by the increased relevance and authenticity of their plans to themselves: outcomes seen resulting from Externalization and Combination processes. We therefore are confident to argue this mode was triggered by the process-oriented outcome from previous modes. In KE terminology, the appearance of these consequential actions clearly evidenced that social learning and desired actions took place, which are deemed necessary in KE process.

5. Discussion

Below, we discuss in detail how the framework which emerged from this study is centered around the two new identified linkages informed KE theory building, and we note the key usefulness of the SECI model in this emergence.

5.1. The vertical linkages – a 'Knowledge Foundation' as a unique outcome of the Externalization mode

The mapping shows several KE process-related concepts intertwined with each other in the phase where the *WeValue InSitu* process was facilitated to assist local stakeholders to articulate their values, i.e. Externalization. We argue and label the following set of concepts (i.e. trust, information usability, object boundary, researcher capacity) together form a 'Knowledge Foundation' which provided necessary preparedness for next two KE process-related concepts (knowledge integration; practice and learning) and it is a unique outcome of the Externalization mode. We note there may be sub-sequences within or related contextual concepts, however, outside the scope of this paper.

Trust

In this study, mutual trust at the interface of the researcher and local stakeholders was found to be nurtured during Externalization where intensive engagement happened through dialogue with respect to local shared values. Evidence is found throughout transcriptions of the workshops in terms of participants' rich feedback and deep reflections on their shared values, indicating a high level of openness to the researcher. In addition, some participants subsequently contacted the research to return to assist them further:

"*I believe what you have taught us, even though you were not really teaching but asking questions and listening, is really import. It was important for us to be able to answer your questions. I would say if you had anything that you still want to ask us please do come back*."

KE literature stresses the significant role of trust (Cvitanovic et al., 2021; Stern et al., 2020) as it helps improve salience, credibility and legitimacy of information. Other research emphasizes the importance of participatory action research (e.g. Mapfumo et al., 2013; Meadow et al., 2015). Underlying is the notion of the need to promote relationships founded upon trust between scientists and decision-makers (Cvitanovic et al., 2016) to empower long term collaboration.

Mutual trust is also in SECI model, where it should be established and nurtured in Socialization mode, as it is an essential foundation for the whole spiral of subsequent knowledge creation modes (Nonaka et al., 2000). It is usually hard to achieve in real-life KE settings as it is finance- and time-consuming: people from different interfaces should first come together and socialize themselves through observation and imitation. Our findings indicate it can be efficient and possibly more effective to

achieve this by engaging in the 2-3 hours *WeValue InSitu* process, where Externalization is the goal but because it involves genuine dialogue through meaning-making around local shared values, mutual trust is also established. The goal of knowledge integration in the context of many sustainable challenges (e.g. biodiversity protection, climate change adaptation), could similarly benefit from such effective use of the Externalization mode for relationship building, removing the condition for prior Socialization. This is also a new insight for studies concerning knowledge brokerage and boundary organization which are here proved capable to enable relationship and trust building (Rathwell et al., 2015; Robinson & Wallington, 2012; Wyborn, 2015), particularly concerning the key nodes or necessary conditions to optimize their efficiency (Bednarek et al., 2018; Reinecke, 2015).

Information usability

In our case-study participants reported certain new collaborative capacity built through *WeValue InSitu* process, in their ability to self-identify relevance between local life (driven by local shared values) and potential climate change issues (supported by scientific knowledge), after conversion of their local tacit knowledge into explicit. It thus seems that the quality of knowledge included in the KE process was enhanced by this increased capacity of the knowledge receivers. Their capacities to create, access, interpret and apply scientific knowledge are core to knowledge exchange (Van Kerkhoff & Lebel, 2015).

This effect can be viewed as an increase in the perceived fit of information (Lemos & Morehouse, 2005), occurring within a relatively short period of time compared to normal social interaction. Furthermore, mismatches between tacit and explicit knowledge were reduced, since *WeValue InSitu* meaning-making helped make explicitly articulated some local tacit knowledge, also increasing the usability of information (Lemos et al., 2012). Participants produced actionable knowledge afterwards by making the truthfulness evaluation easier - possibly because, during the process, people organized and articulated values which they based judgement on.

Boundary objects

Boundary objects are considered key components to enable shared understandings and reconfigure focus for the emergence of a knowing system for collaborative partnerships (Wallis et al., 2017). The iterated use of boundary objects by various stakeholders assures information outputs to be salient, credible and legitimate (Cash et al., 2003). In this study we identified that the shared values frameworks constructed in the WeValue Insitu process qualified as boundary objects to mediate communication and shared understanding across boundaries between researchers and local stakeholders. Those shared-values frameworks were later applied by the participants to VRA process where they integrated local and scientific knowledge in a more explicit way. Moreover, these boundary objects were intersubjectively developed with researchers and local stakeholders together, through which researchers as facilitators inevitably involved in the tacit and explicit knowledge translation of the participants. Despite the neutral position of the facilitator taken and absence of value judgments made when participants were collectively meaning-making and -checking shared values, he has enhanced his tacit and explicit understanding of the participants to a certain level, although not as intersubjective as participants, which enables him to better communicate and apply the boundary object in the Combination mode.

According to SECI model, as stated by Nonaka (1994), *"…knowledge creation is a continuous, self-transcending process through which one transcends the boundary of the old self into a new self by acquiring a new context, a new view of the world, and new knowledge"*. Importance of boundary work in increasing knowledge usability has long and widely been advocated in environmental studies (e.g. Hegger et al., 2012; Offermans & Glasbergen, 2015; Van Kerkhoff & Lebel, 2006). However, not enough attention has been paid to understand knowledge processes in which boundaries are dissolved (Lejano & Ingram, 2009). Through the SECI lens, this case-study reveals a vital timing for boundary object formation: when tacit knowledge is articulated into explicit, i.e. Externalization mode. Then, those involved make commitment to become 'one with the group' and transcend their inner-outer-boundaries (Nonaka et al., 2000). Hence, in our Externalization a result is not only the object formation, but also that the people involved can be supported to cross boundaries. This provides a piece of new understanding: that converting tacit knowledge into explicit knowledge (Externalization mode) is more crucial than other modes of knowledge conversion for producing useful boundary objects to

support KE crossing boundaries.

Researcher capacity – From knowledge broker to 'Campaigner'

In this study, the researcher, while facilitating, built up his capacity to engage with local stakeholders by understanding local shared values, and subsequently was able to introduce external scientific knowledge in a more relevant and acceptable manner for local stakeholders. The researcher's interpretation of local implications of general scientific knowledge to stakeholders is then improved, as desired for KE (Reed et al., 2014). We thus argue that that researchers could endeavor to acquire such capacity to facilitate tacit and explicit knowledge conversion. In this case, certified training as facilitator of *WeValue InSitu* process enabled this.

Knowledge broker facilitation of interaction and mutual learning at a multi-faceted interface is increasingly recognized as important for KE (Andrachuk et al., 2021; Cvitanovic et al., 2015b; Maag et al., 2018). Researchers are required to go beyond mere information producing, to become a knowledge broker who tailors interaction strategies to match preferences of target groups (Phillipson et al., 2012; Reed et al., 2014; Young, Nguyen, et al., 2016b), through meaningful interactions which minimize the knowledge gap between researchers and stakeholders (Clark et al., 2019). A corresponding capacity building of researchers is needed (Evans & Cvitanovic, 2018) to socially engage with different stakeholder for better sustainability transformation (Rozance et al., 2020) and further strive to become 'Campaigners' to create impact out of research, into policy making one of whose roles is the "explicit recognition and communication of personal values underpinning research and impact". In this case, while participants are enabled to integrate both local and scientific knowledge in explicit form, the researcher is additionally enabled to interpret and communicate better the scientific knowledge in stakeholders' perspective, to align his communication with the need of users in the behavioral and intellectual sense (Young, Nguyen, et al., 2016b).

In summary, our findings show that the utilization of tacit knowledge leads to the formation to a 'Knowledge Foundation' - consisting of trust, information usability, boundary object and Campaigner-capable researcher – which fulfill part expectations from Phase 0 (Horcea-Mulcu et al, 2022) so to strengthen transdisciplinarity and transformation nurturing. In this case, local stakeholders' tacit knowledge concerning their shared values was converted into explicit knowledge during which the researcher and participants crossed their boundaries to build mutual trust, to form boundary object, and to develop their capacities to increase the information usability and to promote social engagement. Various kinds of knowledge supporting actions for sustainability are tacit (Caniglia et al., 2021) in KE literature. Our findings support the previous argument that tacit knowledge should be appreciate as much as explicit knowledge in forming the knowledge interface between stakeholders from different community of practice (e.g. scientist and manager) which facilitates collaborative learning, shared understanding of key concepts and eco-evolution towards common purpose, intent and action (Roux et al., 2006). Further, we pointed out the necessity to underscore the process where tacit knowledge is utilized. This is in line with the statement from the theory that the mobilization of tacit knowledge is realized through its externalization and amplification (internalization) by facilitating constant interaction between tacit and explicit knowledge. This also implies a knowledge perspective with a focus on the conversion process can be informative for KE theory building. We argue that both the condition of KE and the agents of KE are equipped during this process, therefore, a foundation is built. In the next section, we present our findings on how this Knowledge Foundation support the following process towards KE.

5.2. The horizontal linkages – An informative sequence leading to actual practice

In this section, we present the findings suggesting a specific sequence emerged from the mapping. That is, following the development of the Knowledge Foundation, knowledge integration between local knowledge and scientific knowledge (ending up with a localized climate change adaptation plan) and the actual practice through 'learning by doing', were sequentially realized.

Knowledge integration

Unlike the positivistic stance where researchers are seen as experts to lead the knowledge integration and decision makings, the explicit scientific knowledge regarding climate issues in this study was

introduced by the researcher in a manner that the local stakeholders are encouraged to take a relational subjectivist stance and to identify the relevant risks, resources and actions for their local plans. Some quotations from transcriptions of VRA processes and post-interviews provide supporting evidence of the active integration of local values and scientific information throughout the process. Our findings demonstrate a pathway to tackle the challenge well recognized by the KE literature to integrate local and scientific knowledge. On the local level, it has been recognized to be challenging to consider local and scientific knowledge in parallel to produce user-driven management approaches (Reed et al., 2007). One reason could be that local knowledge held by the stakeholders is mostly in tacit nature which embedded in local people's experience and hard to articulate and rarely formally documented (Raymond et al., 2010). In addition, as advocated by previous literature (Miller et al., 2008), more attention should be paid to different ontological and epistemological perspectives adopted as they shape and influence decisions on types of knowledge being integrated, and ways of knowing being valued in KE process. In this sense, this study becomes more meaningful, given the local knowledge articulated and integrated is local values, which reflect to some extent local perspectives on ontology and epistemology, and consequently improve the quality of KE.

The integration of knowledge in this case happened when explicit local share values and explicit climate change risk information were considered together to produce a systematic plan for local adaptation, i.e. in the Combination mode. Theoretically, this mode is supported by Externalization mode through which tacit knowledge that cannot be easily transferred, communicated and integrated as explicit knowledge is converted/articulated. Without sufficient Externalization, commitment of participants to become one group and personal meanings of tacit knowledge are in absence, which eventually lead to superficial interpretation of existing knowledge without capturing the here-and-now reality (Nonaka, 1994). In this case, what happened after the Combination is that the participants later take their own initiatives without researcher interfering to finalize their own localized climate change adaptation plan and further submit it to the higher-level institutions. This change in action is strong evidence to support that the Combination happened is not superficial but concreate for Internalization. That is to say, the combination of explicit knowledge can still happen but what is created will not be concrete enough to facilitate further modes in a wider social context. This elaboration allows better understanding on the supporting condition for knowledge integration and again underscores the importance of Externalization mode for meaningful KE.

Practice and learning

Although post-event knowledge integration was not purposefully promoted by design in this case, the local participants self-reported that they actively took initiatives afterwards, e.g. forming a new farmer's committee, submitting and presenting their own climate change adaptation plan to the higher-level institution. We view these as evidence of actual practice of the type desired for outcomes of KE.

When viewing this through the SECI lens, we argue that a vital node in promoting social learning through various means for maximize KE output can be the Internalization mode, given that 'learning by doing' is the major way to convert explicit knowledge into tacit knowledge, and amplify both individual and collective knowledge assets according to the theory. On the basis from the knowledge integration from the previous mode, a loop between the active initiatives and learning would then be promoted. Nevertheless, we still need future studies to comprehensively investigate what kinds of learning occur and what roles they play throughout the whole KE process.

5.3. Usefulness of SECI model and Knowledge Creation Theory for KE theory building

Moving beyond specific findings on the linkages, we discuss here the usefulness of the SECI model for theory building for KE process.

Theoretically, several guiding principles of the SECI model match with those of KE process. On the one hand, the central theme of SECI model hinges on the dynamic between different modes of knowledge conversion, especially, on the interchange between tacit and explicit knowledge through externalization and internalization (Nonaka, 1994). Because of the dynamic, multi-level, multi-actor, and iterative nature of organizational Knowledge Creation Theory, the SECI model presents the

conversion of tacit and explicit knowledge as an endless knowledge creation spiral initiating from individual, moving towards higher ontological level to group, organization, across organization, looping back to the individual and starting again. Within each mode, new rounds of SECI spiral can be triggered on different ontological levels as well. It is an iterative and dynamic process with constant reflection involved. On the other hand, the fluid and dynamic nature of KE has to be acknowledged when studied (Fazey et al., 2014; Fazey et al., 2013). Approaches to KE-related research need to recognize and acknowledge knowledge as a complex system wherein individuals' subjectivities play a major role (Evely et al., 2011; Fazey et al., 2014), and thus highlight the iterative learning loops and tacit knowledge management of stakeholders as these sometimes dominate in decision-making compared to scientific knowledge (Contandriopoulos et al., 2010; Dobrow et al., 2004). The five principles for effective KE have an iterative nature that starting from Design and ending with Reflect and Sustain (Reed et al., 2014). In Principle 5, identification of future needs for continuing and sustaining the exchange in the longer-term are required, which lead to a new round of exchange. Moreover, for each principle, different stakeholders on different scales are required to interact and engage for exchanging different types and forms of knowledge.

Moreover, SECI model can provide an informative sequence of knowledge conversion for KE process. As discussed above, some influential concepts from KE field are identified as being reflected in different modes of SECI model. Some of them stand out in one mode while some come across several modes. The adoption of SECI model can thus inform the identification of priorities and relationship among some of the concepts, connecting them in a coherent manner. From the data, a specific learning from this sequence is that when it is time- and effort-consuming to nurture Socialization on the interface between science and practice, well-facilitated Externalization can compensate for it, and further strengthen Combination and Internalization.

Nonetheless, we also strengthen the importance of distinguishing the type of knowledge involved. The type of tacit knowledge externalized in this study was the local values which reflect the local ontology and epistemology to some extent, and therefore reduce the bias, dominating the ways of knowing, and increasing the quality of the desired KE process. According to Raymond et al. (2010), even more categories of tacit knowledge involved in KE are present, including other types of local knowledge and some types of scientific knowledge (e.g., expertise experience). Hence, it is worth incorporating this idea in the interpretation of the work and KE theory building. Specifically, we would call for future studies to exam and test the transferability and generalizability of the framework shown in Figure 3 by replacing the type of knowledge of the inputs and outputs while maintaining the same nature of knowledge. For instance, indigenous knowledge/wisdom with respect to a unique type of know-how could be a salient starting point.

6. Conclusion

Leveraging on the notion of tacit-explicit knowledge conversion, we have contributed towards advances in KE theory by uncovering how key process-related concepts could combine and sequence over time by investigating this particular empirical case. We identified two critical linkages: (1) a 'Knowledge Foundation' platform, where tacit knowledge gets converted into explicit knowledge and enables effective subsequent KE, and (2) a sequential progress of concepts, demonstrating how KE unfolds dynamically towards concreate practice on the ground. Our findings revealed the utility of SECI model for theorizing KE processes, particularly in structuring temporal interdependencies among long-identified concepts. These preliminary findings provide ideas for theory development which has potential to connect greater concepts and thus deserves further investigation.

We argue the utilization of tacit knowledge is critical as it sets up what we have labelled the 'Knowledge Foundation' for later knowledge integration and action promotion. It seems that both the condition and the agents of KE can be equipped through the development of such a Knowledge Foundation. Our findings thus suggest usefulness of the perspective of knowledge as dynamic, and the inclusion of consideration of its tacit and explicit dimensions. These lessons can inform KE process design, and are not restricted to specific contexts, contributing to a new level of theory building, and also to linking KE process to more theoretical bases.

Although not the focus of this study, practical implications can be gained. We highlight how tacit-explicit knowledge conversion through shared-values-crystallization methods like *WeValue InSitu* can promote the bridging of science-practice boundaries and fostering co-creation. This type of contribution is highly sought and deserves further analysis for generalization. Limitations of this work include not systematically reviewing *all* KE concepts, and only focusing on specific process-related concepts for science and practice interfaces. Future study could more systematically follow up on this exploratory work, possibly extending consideration to other interfaces, and levels of governance, and the likely context-transcendence of the findings. By grounding KE theory advancement seeking in knowledge dynamism, we offer a step towards more actionable and time-sensitive theory.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used DeepSeek in order to improve the English language of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Declaration of Interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary Material

Table S1. Data examples from feedback sessions (Day 1 and Day 2) and post-interview sessions indicating participants' capacity building to increase information usability.

VDC Name	Sample quotations
VDC Mo	**(Day 2 feedback session)** **Respondent 1:** I believe we will uphold your teachings; we have learnt how to identify challenges in the village and how to address them and most importantly how to succeed. **(Post-interview)** **Respondent:** The *(WeValue InSitu)* trainings are important for the work of the VDC, since it clarifies the relationship between climate change and the work that the VDC does. When other committees also come to us to request for assistance on related matters we will be able to offer them informed advice. We are able to advice our workforce on how to protect themselves under different weather conditions since we have been experiencing heat waves. We can adjust our working hours in response to the current weather situation so that our people are not adversely affected.
VDC Ma	**(Day 2 feedback session)** **Respondent 1:** … The activities that we developed during the VRA follow the foundation laid by the values framework. For example we have agreed that we are going to do a workshop for our farmers. This is the foundation that we are building on for climate action. The action items out of the workshop will be put into practice which will help us reach our vision as the community.
VDC Sh	**(Day 2 feedback session)** **Respondent 2:** Yesterday we were taking about issues related to how we can develop our village. (…) . Comparing to today, we brought in the issue of climate change and what our village has that can be useful to addressing its impacts on the community. When you look at these two days, they are related, even though we were talking about climate change today we were still addressing village development in relation to fishing and the improvement of agriculture. Attending yesterday's event I can say built my confidence to answer questions related to climate change even though it is not my field. I was able to relate to how it can be addressed through planned development in my village. **Respondent 5:** We talked about caring for the environment and that we wish for everyone to have a responsibility towards the environment. Today we addressed issues of pollution and how this can affect the environment and our health. Now that we have made this connection, the way that we look at this activity of burning charcoal at the poultry farms has changed, it calls for us as the VDC to take action because what we learnt yesterday and today has opened our eyes to this issue.
VDC Ta	**(Day 1 feedback session)** **Respondent 1:** *WeValue InSitu* clarified my role and the how I should execute my plans as well as what is important for the community. **Respondent 2:** *WeValue InSitu* clarified our responsibility, we should be ready to engage in any issue that might be as a result of climate change.

Table S2. Sample quotations from VRA process, Day 2 feedback session, and post-interview session showing participants referring to the shared values frameworks they developed and indicating the frameworks being applied as boundary objects to assist their development of the VR Assessments.

VDC Name	Sample quotations
VDC Mo	**(When discussing issues, livelihoods activities and solutions and barriers related to vulnerabilities identified and solution for farmers)** **Respondent 1:** VDC will provide support to villagers to access these services which are available through the local government. We want our people to be self-sustaining. **Respondent 2:** This was mentioned yesterday in our discussions that it is important for the VDC that people can do things for themselves, we help them become self-sustaining. **(Day 2 feedback session)** **Respondent 2**: This is important for us as it (the framework) advises on how development planning should be carried out. … It is basically our guidelines. **Respondent 1**: It broadened my mind, the ability to establish the important things for the VDC and the community. How work should be built from the foundation, how we work and the vision brought clarity to the importance of planning. It shows the VDC how to develop a way forward. **Respondent 2**: … I do not only understand that I should work for the village but I also understand how I should do this work. I am moving from waiting for things to reach the VDC but now I am going out there to make things happen. **Respondent 3**: I usually just talk about climate change casually without knowing really how it relates to our work. But now I realized the entry points for this discussion and how you should build on the discussion. **(Post-interview)** Respondent: The framework will be adequate to represent our commitments and desires.
VDC Ma	**(Day 2 feedback session)** **Respondent 1:** There is a connection. The activities that we developed during the VRA follow the foundation laid by the Values Framework. **Respondent 3:** I can say the two trainings when they combine, help you build up the essence of a human being. Starting form the foundation, respecting a human being and helping them decide the paths they want to follow in their live. Today we are addressing people's livelihoods but yesterday we were talking about the dignity of a human being. … It helps you clarify the necessary steps and activities to attain our vision, that is, how people can improve their livelihoods, farming and backyard gardens without overly relying on the government. **(Post-interview)** Respondent: The framework was the best. The background, how we work and vision sets a clear description of how work should be done in the village, that is how work should follow. Respondent: The framework shows us where to start in building up projects,

	what actions needs to be taken to achieve our vision. It will even help those who come after us to understand the direction the village wants to take. It gives the VDC direction.
VDC Sh	**(Day 2 feedback session)** **Respondent 6:** The value statements booklet (shared values framework) is useful as I was able to refer to it time and again to clarify my thoughts. **(Post-interview)** Respondent: This *(WeValue InSitu)* framework clarified the VDC's role in the village as well as how community consultation should be undertaken.
VDC Ta	**(Day 2 feedback session)** **Respondent 1:** The structure that you used yesterday in the training has clarified our understanding of how we do work. The training is similar to how the VDC is supposed to conduct its work. The foundation which involves rules and regulations, how we work to ultimately reach our goals showed me the importance of planning from the bottom going up. **(When discussing issues, livelihoods activities and solutions and barriers related to vulnerabilities identified)** **Respondent 1:** The foundation we laid yesterday clarifies for us the most important steps in our work. For example to reach vulnerable people in the society and enroll them for government programmes there are guidelines that the government has set. We have to ensure that these guidelines are followed so that no one is left behind. **Respondent 2**: We agreed yesterday as the VDC that our job is to assist all the people in our village and all the points that we have made today are related to supporting and developing people. While this is important we need to know where to start, so we develop first our roadmap to help us achieve our goal. We start by putting through our requests at the ministry of local government. … **Respondent 1:** I think what you (facilitator) are teaching us is that when people are going through challenges such as flooding, we should all be concerned and go and offer assistance. This is not what is happening currently. People feel like they are being ridiculed when you go to their house to offer help. **Facilitator:** Which statement is aligned to what you just said? **Respondent 1:** We said we help each other in our times of need. I am not trying to take us back but I hope we can change our mindset to live these statements. **Respondent 2**: I think that is something that we need to share with the community that when we come to their houses after disasters it is because we want to help not to ridicule them. **Respondent 3:** I like that we are clarifying these things because sometimes when I raise issues especially about things that we are not supposed to be doing people think that I am radical.

1033 **Table S3. Sample quotations from VRA process, Day 2 feedback session, and post-interview**
1034 **session confirming the integration of two kinds of explicit knowledge.**

VDC Name	Sample quotations
VDC Mo	**(Day 2 feedback session)**
	Respondent 1: I think the VRA is a continuation of what we did with the WV session. The most important thing is to be able to make a connection between the things that are important to us and the challenges of climate change that we are discussing today.
	Respondent 3: This training is important to me because it helps us clarify our starting point, not just the starting point but the things that bring us together. It is a waste of time to be thinking about projects but not knowing the preliminary steps needed to make your projects a reality. We are one team, when one of us brings an idea we must all support it and if it is a good idea make sure it reaches where it is supposed to for action to be taken.
	…
	Respondent 1: I will repeat myself that these teachings broadened our thinking. I feel confident going to the orientation with the district council and I will be able to represent my village well. I believe we will also be able to challenge and interact with our trainers in a productive way. I will be able to support my ideas and thinking.
VDC Ma	**(When mapping out relevant stakeholders and how to benefit from their expertise…)**
	Respondent 3: Some of the stakeholders here like the ministry of agriculture and the social and community development department align well with Statement 27 People understand the value of the environment & We are there for each other during their times of need.
VDC Sh	**(When discussing issues, livelihoods activities and solutions and barriers related to vulnerabilities identified and solution for irrigation agriculture)**
	Respondent 1: This (solution) is about building the capacity of individuals so that they can do things for themselves and become self-sufficient.
	Respondent 2: This (solution) is our vison, but if we are determined, we can achieve it. For example if you want to build a small dam in your farm, you call on the community through "letsema" to assist you. This usually does not take a longtime. You provide food for people.
VDC Ta	**(Day 2 feedback session)**
	Respondent 1: Yesterday (*WeValue InSitu*) we were talking about the building blocks of development in the village. Today (VRA session) you can see that our interventions are closely related to our foundations (of the framework). … The projects that we came up with today, build on our vision (of the framework).
	Respondent 2: … Everything that we discussed from yesterday to today is about people's livelihoods and how the VDC can positively impact them. There has not been a discussion that does not involve people's livelihoods.
	Respondent 1: I think what we have been doing as the VDC is that we have been blindly receiving direction form the district council and we forgot about what our people really want. After this training I think our thinking has been widened. If we can be supported with the projects that we have suggested in response to climate change we can change a lot of people's lives. We can solve the unemployment issue. This is what I

	believe. **Respondent 2:** … the way we came up with our projects is that we also considered our contribution to the project and what we can possibly achieve. We looked within ourselves. I think this kind of planning is useful because it makes you aware of your capabilities.

1035