Chapter 12
Local Knowledge on Water Use and Water-Related Ecosystem Services in Lowland, Midland, and Upland Villages in Mindanao, Philippines

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Abstract We explore local knowledge on water in lowland, midland, and upland villages in the Libungan-Alamada Watershed in Mindanao, Philippines. Specifically, we investigated local knowledge on water use and other natural benefits derived by the villages from their water sources (i.e., river and spring) or water-related ecosystem services (WES). We implemented a two-stage participatory exercise in each village that engaged diverse residents to collaboratively identify how they use water and other WES they obtain from their water sources. Results of our participatory exercise indicate the richness of local knowledge on water, reflecting that their water sources do not only supply water for domestic and agricultural use but also WES that shape the very social-ecological dynamics of their village. Villagers' local knowledge captures how the water sources are a complex biome of several water-dependent ecological units (e.g., trees and shrubs that form riparian forest strips) that all contribute natural benefits for subsistence, livelihood, and cultural identities of each village. We found similarities in local knowledge across all villages, especially on traditional WES that have intergenerationally supported the basic needs (e.g., food) of their village. More importantly, we found several unique local knowledge for each village, demonstrating place-based specificity of local knowledge based on biophysical (i.e., elevation) and socio-cultural variations.

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In particular, we found local knowledge among Indigenous communities in the upland village to mirror their traditional heritage. We discuss that our findings can strengthen the need for engagement, recognition, and documentation of local knowledge for more sustainable, resilient, and equitable water management.

Keywords Upland · Watershed · River · Indigenous · Participatory

12.1 Introduction

Water sources provide various benefits to local communities including water supply for domestic and agricultural use, as well as other natural benefits or water-related ecosystem services (WES) (Gao et al., 2017; Sahle et al., 2019; Shaad et al., 2022). WES are natural benefits that are generated because of the unique ecosystem structures, compositions, and functions (i.e., biomes) that are closely dependent on water sources, especially in freshwater sources such as rivers, lakes, and springs (Chang & Bonnette, 2016; Pettinotti et al., 2018). WES can be the provision of the very supply of water, other provisioning services or material benefits such as meat from the animals in the water source, regulating services or ecological function benefits such as the erosion mitigation of riparian forests, cultural services or non-material benefits such as the recreational value of water sources, and supporting services or benefits that support the generation of other benefits (e.g., photosynthesis) (Millennium Ecosystem Assessment, 2005; Brauman et al., 2007).

Sustainable, resilient, and equitable water management should therefore consider not only the water supply in water sources but also other WES these provide. Understanding local knowledge on water, especially WES, can serve as a significant first step to having more holistic perspectives that can better guide more comprehensive and inclusive water management actions and decisions (Kanyama-Phiri et al., 2017; Ramirez et al., 2019; Cebrián-Piqueras et al., 2020; Moore & Nesterova, 2020). Local knowledge is the knowledge held by a specific group of people about their local ecosystems and has been generated as local communities interact with their natural environment (Olsson & Folke, 2001; Raymond et al., 2010; UNESCO, 2021). Water management that effectively considers local knowledge is better understood, accepted, perceived as fair, and legitimized by communities (Titilola, 1990; Kozar et al., 2020; Cebrián-Piqueras et al., 2020).

It is under this rationale that we explore local knowledge on WES among three elevation distinct villages—lowland, midland, and upland—in a watershed in Mindanao Islands, Philippines. Analyzing the variances of local knowledge on WES across different elevations provides a more nuanced understanding of how biophysical factors influence WES perception and the consequent knowledge this articulated perception reproduces. In this research undertaking, we thus ask the following research questions:

(a) How does each village use water? What are the other natural benefits or WES does each village acquire from water sources?

(b) How does varying elevation, including related socio-cultural factors, influence local knowledge on water use and WES?

By answering these questions, we aim to expand our understanding of water sources as suppliers of WES while providing empirical information on similarities and differences in local knowledge across distinct villages. Comparing villages will provide key insights on how we can further engage local knowledge in informing water management, specifically how we can consider synergies and trade-offs in actions and decisions from one place to another. Our study likewise contributes to the limited comparative literature documenting local knowledge that are relevant and useful for water management (Camacho et al., 2015; Landicho et al., 2021).

12.2 Methodology

12.2.1 Case Study

We use the Libungan-Alamada Watershed (7°19′40.2″N, 124°30′57.4″E) in Cotabato Province, Mindanao, Philippines, as our case study. The whole Watershed is around 52,000 ha, which serves as the primary source of water supply for domestic and agricultural use of 6 municipalities in the province or around 142,000 families. Two of these municipalities have villages that are directly living within the Watershed. The Watershed is also a government-designated production-protection site, which means that villages that are directly within it are legally allowed to implement sustainable forms of agriculture. In particular, the Watershed has been characterized as an "agroforestry landscape" because most of the families on the site practice different forms of agroforestry systems (i.e., integration of perennials in crop and/or livestock production) (Neyra-Cabatac et al., 2012; Galang & Vaughter, 2020). Water supply of the Watershed originates from two major water sources: (1) the river and its tributaries and (2) springs.

To answer our research questions and implement our methods, we selected three elevation-distinct but adjacent villages in the Municipality of Libungan. The Municipality is one of the two municipalities whose several of its villages are directly living in the Watershed. These three villages we explored are the following:

Ulamian (Lowland Village) This village is in the lower, plain-to-hilly lands portion of the Watershed. Families mostly practice bi-annual cash crop-based agroforestry systems (i.e., two harvest cycles in a year). Among the most common agroforestry system practices is the integration of rice production with fruit trees (e.g., coconuts) as shelterbelts. It also has a strong poultry and swine industry, as well as a relatively well-built dirt road networks that allow better transportation in and out of the village. Thus, many families also rely on non-agricultural sources of income such as employment in government and market sectors, entrepreneurial activities, and service offerings in the nearby urban centers. Accessible and efficient transportation is a crucial factor that explains why among the three case study villages, Ulamian has the best access to social services usually found in urban centers, especially educational and health centers. The village likewise has access to processed tap water.

Demapaco (Midland Village) This village is in the middle, sloping-hilly lands portion of the Watershed. Families mostly practice multi-story farming of fruit trees (e.g., mangoes) integrated with irregular cash crop farming (i.e., vegetables and corn). Multi-story farms are also important spaces for small-scale ruminant production (i.e., goats and beef cattle). Unlike the lower village, families here are much less involved in non-agricultural sources of income. It is interesting to note that this community has a high percentage of families with at least one overseas Filipino workers (OFW) member or someone who works and remits money from abroad. Remittances from OFWs play a critical role in ensuring more reliable cash in-flow for the families, compensating for the irregular income from multi-story farming and cash cropping. Like the lowland village, this village also has access to processed tap water.

Sinapangan (Upland Village) This village is in the upper, plateau-like portion of the Watershed. The village has one of the highest population proportions of *Erumanen ne Menuvu* in the whole of the Watershed. The *Menuvu* is an Indigenous group in Southern Philippines, and the *Erumanen ne Menuvu* is a particular Indigenous *Menuvu* subgroup that has traditionally inhabited that Watershed (Neyra-Cabatac et al., 2012). Families mostly practice slash-and-burn agriculture and cash crop-based agroforestry farming (i.e., upland varieties of rice, corn, and beans with perennial legumes). Livestock production, especially of small ruminants (e.g., goats), is also present. Hunting wild meat and gathering wild vegetables in the rich hilly forests of the village are important sources of food for their subsistence. The village relies on income from tourism-related services as the village serves as the entry to the Watershed's hiking trail. Indigenous peoples sell souvenir items, serve as local hike guides, and prepare/sell local delicacies to tourists. Unlike the lower villages, this village has the least transportation network, which is only accessible through one main dirt road that only big trucks or single motorcycles can pass through. During the rainy season, the roads can be completely impassable to vehicles, and the village only becomes accessible by walking. Among the three, this village is the only one with no access to processed tap water.

12.2.2 Participatory Exercise to Scope Local Knowledge

We have implemented a participatory exercise in each of the three villages that aimed to solicit their local knowledge on water and WES. Specifically, our exercise identified the water use and other WES that each village obtains from the river and springs within their village. We invited 15–21 diverse residents of each village to participate in the exercise, including representatives from local farming associations, women's groups, elderly and youth organizations, and community councils. Each participant was carefully co-selected with village leaders to represent as much diversity of local knowledge. Meanwhile, all village exercises were spaced 1 day apart during the rainy season (i.e., August) to reduce seasonality bias that might affect local knowledge of water (Buhyoff & Wellman, 1979). Each exercise lasted for around 3 h, all held in the mornings. Described below are the key activities of the exercise.

Water Source-Specific Water Use and WES Participants were placed into subgroups, such that each subgroup is assigned a specific water source (either the village's river or spring). The differentiation between river and spring is associated with their potential varying biomes. Water in rivers flows continuously downstream, while water in springs is confined within a particular space. Prior to the exercise, we took photos of these two water sources as located in their village (i.e., each village has distinct sets of photos). We provided these photos to each subgroup to help facilitate their thinking process. Termed as "photo-elicitation," photographs can serve as better stimuli and guidance for respondents than oral or written discussions alone (Harper, 2002). Each subgroup was then given 30–45 min to discuss and list down, in their respective village languages (i.e., each village speaks a distinct language), the various water uses and other WES they know from the water source, through either their own experience or personal observation of other villagers.

Village Consensus of Water Use and WES Each subgroup then presented their preliminary list of water use and other WES from river/spring to the rest of the group. After the presentation, we facilitated an open group discussion to ask for comments and further additions of water use and/or WES that were not captured in the preliminary lists. Once everyone agreed that we have exhausted all possible answers, we then finalized the list of water use and WES for each water source. Before we ended the exercise, all participants were asked to check and verbally validate the results that we just co-produced, which is a process also termed as transactional validity (Caretta & Pérez, 2019). We, as the facilitators, took a passive role all throughout the process to ensure that the lists solely reflect the local knowledge held by the participants.

12.2.3 Analyzing the Outputs of Participatory Exercise

We aggregated the water use and WES identified for the river and spring in each village because we wanted to consider both water sources as a single unit of analysis to represent our case. We then cleaned out the aggregated list in each village to remove close duplicates or fused highly related ones. We also translated all entries into English, closely coordinating with local experts to review and confirm our translations. Using the framework of the Millennium Ecosystem Assessment (2005), we categorized and counted the water use and WES from each aggregated list as provisioning (i.e., material benefits), regulating (i.e., non-material benefits that support ecosystem functions), or cultural (i.e., non-material benefits that support socio-cultural functions) ES. All identified water uses for drinking, domestic, or agricultural purposes were classified as provisioning WES because these are tangible and direct benefits obtained by the village (Sahle et al., 2019).

12.2.4 Probing Exercise Results

We conducted follow-up interviews with select participants to gather more information that would substantiate the results of our exercise. We have also reviewed relevant reports and other documents, as well as conducted observations of the villages.

12.3 Results

12.3.1 Understanding Water Sources as a Complex Biome

Results of our participatory exercise show that local knowledge is tied not only with water use for various purposes but also with other WES that benefit the villages. Specifically, local knowledge on WES spans provisioning (Fig. 12.1), regulating (Fig. 12.2), and cultural (Fig. 12.3) dimensions associated with various ecological units of the water sources (i.e., rivers/springs). These ecological units closely interact in both structure and function to depend on these water sources, forming a vibrant river/spring biome. These components include:

(a) Trees such as native timber trees (e.g., *Ficus* sp.) and some fruit trees which form thin strips of riparian forests
(b) Perennial shrubs and grasses (e.g., *Bambusa* sp.)
(c) Fish (e.g., *Ambassis* sp.) and other water-based animals such as reptiles, mollusks, and amphibians
(d) Small rodents, avian, and other air- and land-based animals that depend on the ecological dynamics provided by the river and spring

These ecological units can be unique in these water sources, especially that many of these are dependent on water supply. For example, some flora can only be found in areas where there is continuous supply of water. Some animal species mainly thrive in the ecological food web that directly consumes water-based animals (Pettinotti et al., 2018; Sahle et al., 2019). These biomes do provide not only material benefits or provisioning services (e.g., tree branches as fuelwood) but also non-material or regulating/cultural services. For example, villagers know that trees and their canopies improve the overall microclimate in their watershed. Our results feature the complexity of local knowledge on water among local villagers—capturing not only the usage of water supply per se but also the benefits that the whole river/spring biomes provide for their subsistence, livelihoods, and wellbeing. We

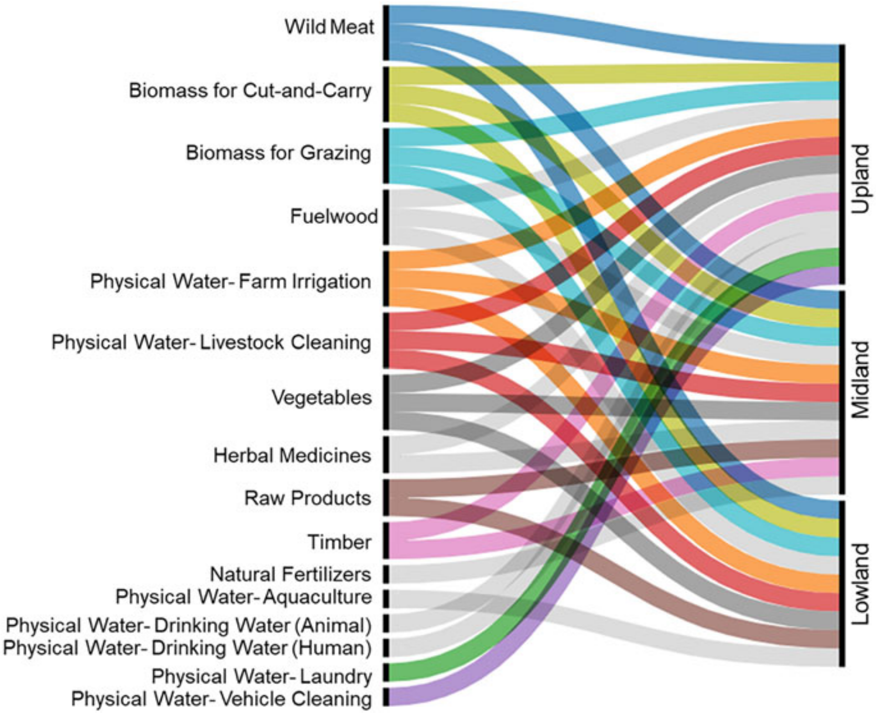

Fig. 12.1 Provisioning WES known by each village

further discuss local knowledge on these WES in the succeeding cross-cutting and case-specific results.

12.3.2 Cross-Cutting Local Knowledge on Water Use and WES

Despite differences in elevation, our results show how there are several similarities across local knowledge on water use and WES. Similarities are particularly evident in local knowledge on provisioning services including wild meat from the animals, cut-and-carry/grazing biomass for livestock feedstuff from trees and perennial shrubs/grasses, fuelwood from fallen branches of trees, and vegetables that are mostly native plants growing beside the rivers (e.g., *Diplazium* sp.). This group of provisioning services is also what Galang and Vaughter (2020) termed as "traditional ES" or the WES that translate as basic needs that rural communities require to persist intergenerationally. This echoed during follow-up interviews in which villagers mentioned how "nature," in this context the rivers/spring biomes, are essential for their wellbeing since they were children. How their parents and/or grandparents

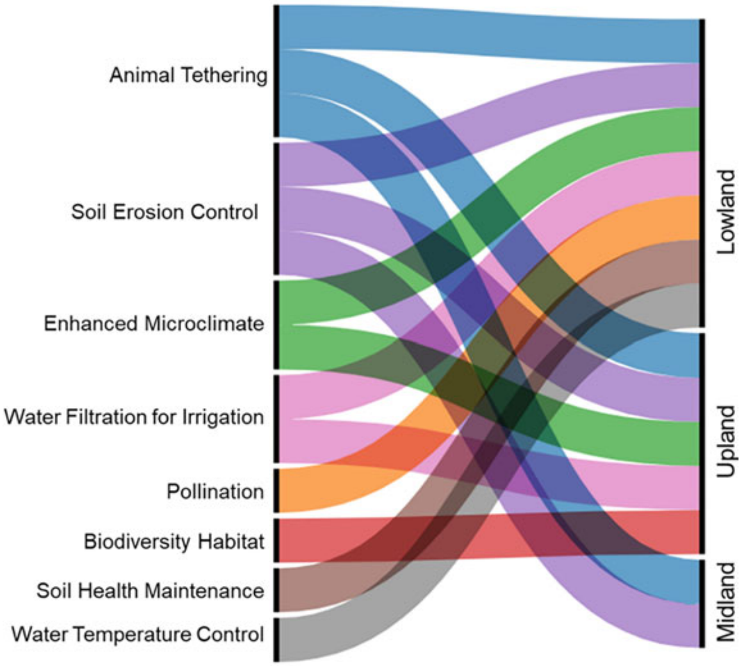

Fig. 12.2 Regulating WES known by each village

operated their daily lives for subsistence, as far as villagers can remember, has been greatly influenced by the availability and access to natural resources, including those obtained from water sources. Eventually, such local knowledge on how to utilize trees, shrubs, and grasses around water sources has been transferred intergenerationally from the elderly to young ones.

Water use for farm irrigation and livestock cleaning is also common across the three villages, reflecting their dependence on crop farming and livestock raising livelihoods. Villagers use the water for their crops and for livestock purposes, including directly washing them as in the case of large ruminants (e.g., cattle) or washing the animal pens for smaller livestock (e.g., swine). Also related to livestock production is the cross-cutting local knowledge on regulating service of trees for animal tethering. The combined effects of the canopies of trees and the cooling effect from the water source provide an ideal place for animals to be tethered onto (Calub, 2003). Villagers shared in the follow-up interviews that livestock raising requires them to spend more than half of their daylight life in the water sources to keep an eye on their livestock. For them, it is essential that their livestock grazes in cool areas to maximize their growth and development, hence higher cash returns when sold.

Another cross-cutting regulating service is soil erosion control by perennial shrubs and grasses. Villagers discussed with us that the extensive rooting of shrubs and grasses keeps soil beside water sources intact. Villagers explain that most of

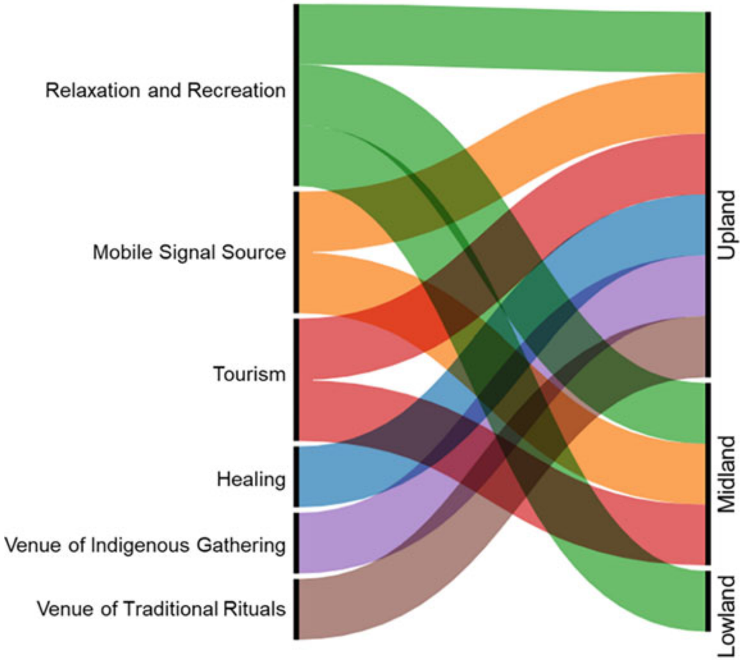

Fig. 12.3 Cultural WES known by each village

them do not let their livestock graze on grasses beside the water source because they know that these are important to avoid eroding soils.

Among the three, local knowledge on cultural WES is the least similar with only relaxation and recreational value of the water sources being common across the villages. Rivers and springs are important for swimming and strolling with friends and/or families, especially during the summer. It was also identified as an ideal site for family gatherings, picnics, and special occasions (e.g., birthdays). Our follow-up interviews further showed that for the villagers, "being with the water" (e.g., swimming, standing beside it, looking at it) can be very therapeutic both physically and mentally. It was not our intention in this study to capture individual differences among participants; however, we observed that there are very apparent distinct differences on the idea of the recreational value of water sources. A major example for this in our case study is how our youth participants have credited water sources as a site for courtship. Young couples in the villages usually walk through and spend time beside rivers or springs.

12.3.3 Specific Case of the Lowland Village

Local knowledge among lowland villagers centers on regulating services provided by the water sources. They associate trees and shrubs along the river with the ecological regulatory benefits that help their cash crop-based farming. Because most farming families divert the water from the rivers to irrigate their farms, they attribute the trees and shrubs along the river to keep the water cool, filtered from trash and other pollutants, and cleaned from eroding soil. All these regulating services assure that the quality of water supply that enters their farms is optimal for their cash crops. Villagers share that this is significant during the summer when increased water temperature could cause damage to crops, especially affecting the germination of crop seeds. In our follow-up interviews, the villagers also shared that these regulating services reduce the anticipated labor efforts and expenses for cropland preparation because they do not have to remove eroded soil, trash, and other pollutants for the next farming cycle.

In addition to these, they also know that trees and shrubs are important habitat for pollinators of their crops. Villagers recognize, for example, that many pollinating insects (e.g., bees) live among the flora around water sources. Another unique regulating service in this village that is also related to crop farming is soil health maintenance or good health of soil in croplands. Villagers understand that the water diverted from the river to irrigate their croplands contains soil organic matter that is rich in nutrients for their croplands.

Lowland villagers also have a unique local knowledge of water use for aquaculture production. Some of them practice small-scale pond-fish farming (esp. *Oreochromis* sp.) in which small ponds are created beside rivers. Small earthen canals connect the river to divert water into the ponds. Our field observations also tell us that the ponds are being used by some villagers for duck production. Among the three, the lowland villagers associate water sources with the least cultural WES or only for their recreational value. A specific interesting theme on the recreational value of water that we heard during the exercise is how water sources were closely associated by participants as a "children's playground" which included activities such as paper boat raising.

12.3.4 Specific Case of the Upland Village

Upland village's local knowledge highlights their subsistence and cultural dependence on water sources. This can be attributed to their high Indigenous peoples population whose lives and livelihoods have traditionally relied on their surrounding environment. This human-nature interdependence is particularly apparent as the upland villagers have the most local knowledge on water use and provisioning WES. Unlike the lowland and midland villagers who depend on processed tap water for drinking, this village directly obtains drinking water (for human and animal) from the water sources, especially from springs. In our interviews, villagers share that it is an essential part of their daily lives to go fetch drinking water. Our further probing shows that this is mostly an activity done twice a day, dawn and dusk, by young members of the household. The dependence on springs as drinking water source is further exacerbated by the fact that they are the only village in our case study that have no access to processed tap water, which is the drinking water source for the other villages.

Important water uses also include laundry and vehicle cleaning, with the latter becoming important during rainy season when dirt roads become extremely muddy. As trivial as it may sound, upland villagers value this water use for vehicle cleaning because owning a vehicle, mostly motorcycles, required them to save up for years before owning one. Having these vehicles, for them, is their only way to have better access in urban centers, especially if they want to send their children for further education or access more advanced health care for severe illnesses. Hence, the contribution of water to the maintenance of the vehicles against wear and tear has been an important local knowledge theme for the village.

These daily interactions with water sources can also explain why upland villagers have unique local knowledge on the role of water sources as biodiversity habitat or as a physical space hosting varied animals and plants. In our exercise, villagers particularly pointed out that there are some avian species that they observe to be present only in their village and not with other villages when they go downstream. An Indigenous participant has also shared how their traditional oral stories and epics are tied to the diversity of flora and fauna of nature, including creatures that dwell in rivers and springs.

Upland villagers also have local knowledge of timber value of some trees along the water sources. In our observations, most of the houses in the village are all made of wood. They emphasized, however, that their community does not allow cutting of timber trees for commercial selling as that goes against their tribal agreements. Cutting of timber trees along water sources will only be allowed upon consensus of the tribe.

Another major local knowledge for them concerns herbal medicines from the trees, shrubs, and grasses. This local knowledge is a major source of cultural pride for the Indigenous peoples, sharing that their great ancestors have left them the "legacy to heal." Probed further about the intergenerational knowledge transfer about herbal medicines, villagers share that when they were children, their parents would already teach them the medicinal value of every plant species from nature. Until now, they have made sure that their children and grandchildren are knowledgeable about this. Coupled with the poor transportation network, many of the villagers have minimally availed or accessed health services from the urban centers—further reinforcing the necessity to use available resources even for health purpose.

The healing value of water is also a unique local knowledge of cultural service among upland villagers. Upland villagers believe that water from the river and spring has healing properties for physical illnesses. Villagers would go to the river/spring to take "healing baths" or praying for cure/treatment while in the water. Related to this is their local knowledge of the water sources as important sites of Indigenous gatherings, especially those that involve life decisions (e.g., weddings). Indigenous villagers shared how water is the embodiment of the flow of life and that rivers/springs are their "portals to life." It is also in this purview that several traditional rituals are done along the water source. Rituals are also implemented for cutting timber trees, requiring animal sacrifices to appease any elementals living in those trees.

They informed us that parts of the water sources, especially some springs in more thickly forested part of the watershed, are restricted for non-Indigenous peoples as these are sacred, housing certain water gods and other elementals that bless/curse them. One of the villagers say that their gods decide whether there would be water for them in the coming planting cycle.

12.3.5 Specific Case of the Midland Village

The pattern of local knowledge among midland villagers is less apparent, which may be credited to the village being located in between lowland and upland villages. It is the only village that has no distinct local knowledge on both water use and across all WES categories. An exemption to this is their unique local knowledge on the natural fertilizer value of fallen tree parts, especially leguminous trees present in the riparian strips (e.g., *Leucaena* sp.). Villagers share that they would collect branches, leaves, or fruits from the trees and use them as natural fertilizer for their home gardens. In our observations, numerous families in the midland village practice home gardens mostly to augment the less regular harvests that they acquire from their multi-story farms. There were also mentions of community-development activities that introduced participants on organic agriculture, which could be a factor on the emergence of this local knowledge in the village.

However, midland villagers share more local knowledge with upland villagers than those with the lowland. For example, the local knowledge of the herbal medicinal value of plants around the water sources is also present. Various propositions can explain the prevalence of such local knowledge including knowledge exchange with Indigenous upland villagers through simple interactions, transactions (e.g., trading), or even intermarriage.

As in the case of upland village, local knowledge on the role of river/spring as an important source of mobile signal is also highlighted in midland village. Villagers explained that they would go to the river/spring to call/text or connect to the mobile internet because it is a relatively open area, hence receiving better mobile signal connection. Another shared local knowledge on the cultural service is the role of the water sources for tourism. While tourism for upland villagers is associated with the waterfall in one of its springs that serves as a popular stopover among watershed hikers, midland villagers' tourism is associated more with the river. A community resort was once present (dilapidated just before this study was conducted) in the village.

12.4 Discussion

12.4.1 Engaging Local Knowledge on Water Management

Our results highlight how local knowledge captures the complexity of water sources not only for water uses but also for other WES that shape the social-ecological dynamics of the villages. Such validates that the water sources are whole ecosystems that should be valued not only for the water that they provide but to also consider the other benefits that the community derives from it. Hence, our study further reinforces the need to engage and mainstream local knowledge in any decisions and actions in water management.

Sustainable and equitable management of natural resources, including water sources, requires that diverse local actors are genuinely included in the agenda planning and implementation (Kozar et al., 2020). Usual scientific approaches (e.g., remote sensing, modelling) that inform water management should be coupled with participatory approaches that can integrate local knowledge (Ramirez et al., 2019). Lack of local knowledge inputs in policy processes can fail to capture the complex nature of water sources, mostly focusing only on the supply capacities of water sources and very minimally including other WES (Palomo, 2017). Actions and decisions that fail to address the holistic nature of water sources can result in significant trade-offs that may jeopardize the wellbeing of the villages that depend on these WES. Hence, integrating local knowledge in these policy processes improves the credibility, saliency, legitimacy, social acceptance, and relevance of decisions and actions made (Bennett, 2016). Integrating local knowledge can allow for better co-management of programs and co-ownership of outcomes—better guiding the conservation, sustainability, and resilience of natural resources (Cebrián-Piqueras et al., 2020).

Local knowledge can also reflect the desires and interests of local actors (Paing et al., 2022). Engaging and mainstreaming local knowledge is essential for watersheds that have villages living directly within them. These watershed-located villages have high and direct stakes in maintaining the watershed's ecological capacity to provide water and other benefits not only for them but also to other villages outside the watershed. It is imperative that watershed-located villages, such as those in our case study, be actively part of the policy processes to ensure that their interests in provisioning, regulating, and cultural benefits are not compromised while addressing the interests of surrounding villages for regular supply of water. For example, policies that aim to ban animal grazing around water sources for the intention of protecting tree saplings will greatly affect livestock livelihoods, which is a significant economic activity for all villages.

Our results have also highlighted the rich local knowledge among Indigenous peoples of our upland village case. We can treat such local knowledge as "traditional knowledge" which has been culturally accumulated by the *Erumanen ne Menuvu* for millennia of living with their nature, including the water sources. Proactively accounting such traditional knowledge in water management can protect the cultural identity and legacies of the Indigenous peoples (Nelson et al., 2019).

Engaging local knowledge is central to Integrated Water Resources Management (IWRM), which is a popular holistic management approach that promotes coordinated efforts in the development and management of water, land, and related resources. IWRM hopes to maximize equitable social and economic welfare without compromising the sustainability of critical ecosystems such as watersheds (WWAP et al., 2009). The Philippines has already been applying IWRM through the Integrated River Basin Management (IRBM) approach and operationalized through River Basin Offices (RBOs). Our case study, the Libungan-Alamada Watershed, is also oversight by an RBO; however, the lack of documentation by the local RBO for the specific portion of the watershed has hindered us from further exploring the roles and influences of the RBO in engaging diverse knowledge. Nonetheless, the experiences of other RBOs confirm the benefits of engaging inter-sectoral, interagency, and public participation coupled with strong policy, regulatory, and institutional frameworks in the success of water resources management. However, there remains the challenge of accounting for the traditional knowledge of Indigenous peoples (Almaden, 2017).

12.4.2 Recognizing Differences in Local Knowledge Toward Water and the Factors Shaping Them

Our study highlights that local knowledge on water is place-based, meaning that knowledge is highly dependent on context of the place. We showed how differences in elevation can serve as an underlying factor that shapes land use (i.e., agricultural systems), socio-cultural dynamics (i.e., access to social services), and community priorities (i.e., subsistence and livelihoods). In turn, all these factors were key to the local knowledge each village has. Thus, while our case study villages are in the same watershed, we found several local knowledge on water use and WES that are unique to each elevation distinct village. Our results, thus, provide empirical proof for the need to tailor water management plans to the biophysical and socio-cultural specificities of the place.

Our findings support current understanding of local knowledge as one that evolves and adapts through time, being strongly knitted with the beliefs and practices of the place (Cassin & Ochoa-Tocachi, 2021). Local knowledge on WES is closely linked to proximity and relative access to water source, as well as socioeconomic and cultural factors of the place (Chang & Bonnette, 2016; Ramirez et al., 2019). Place-based specificity of knowledge strongly justifies our earlier discussion for the need for diverse local actors to be involved in water management, especially to closely consider the impacts of actions and decisions across scales. Recognizing the differences in local knowledge in each place could provide important insights into the potential synergies and trade-offs of actions in decisions from one place to another. This is important in water sources, especially rivers like in our case study, because of its transboundary nature. Issues in upland villages, for example, also have repercussions among lowland villages. Or lowland villages may benefit from good management among upland villages. This cross-scalar interdependence is exhibited in our case study where in the upland villagers' strong cultural ties with nature have sustainably managed their river, directly benefiting not only their community but also the villages downstream.

The need to consider cross-scalar interdependence is also essential for situations where there are villages that are living directly within critical landscapes such as a watershed. Our case study villages, for example, have essential roles to become environmental stewards to maintain the ecological integrity of the watershed to supply water and deliver other WES (e.g., flood mitigation) to the tens of thousands of families living outside the landscape. Trade-offs and synergies of water management actions and decisions in a single village will not only be limited to its adjacent villages but can have rippling effects in larger social-ecological systems. Hence, looking at differences in local knowledge across varying villages can be a practical step that can dissect such cross-scalar interdependencies within and outside the watershed.

Moreover, the differences in elevation and other biophysical aspects are closely intertwined with the differences in socio-cultural contexts. In other words, local knowledge on ES is a social representation of how communities connect with and understand with their natural environment (Nelson et al., 2019; Cebrián-Piqueras et al., 2020). For example, local knowledge in our upland village case study is strongly influenced by the cultural identity and traditional heritage of its long-standing inhabitants, the *Erumanen ne Menuvu.* Local knowledge of nature among Indigenous communities, particularly that which relates to water, has been attributed to their ways of life that aim to maintain harmony with nature. Such local knowledge on nature shapes their ethics, ceremonies, and norms and even customary governance structures (e.g., who can access sacred parts of the water sources) (Magni, 2017; Moore & Nesterova, 2020; Sangha et al., 2018). This shows how it is important to understand local knowledge on water as a product not just of biophysical differences but of variations in the very social-ecological dynamics of the place.

12.4.3 Continually Documenting Local Knowledge on Water

Our study strengthens the need to document the rich local knowledge on water, both its use and the related WES that water sources provide. Documentation has two main contributions: (1) protecting local knowledge and the community identity tied with it and (2) sensing changes in the social-ecological state of water sources.

First, we have shown in and discussed from our findings the place-based specificity of local knowledge, showcasing how they represent the social-ecological interrelationships in the communities. As major changes in societies and lifestyles interrupt the retention of local ecological knowledge (LEK) (Aswani et al., 2018), documenting local knowledge has been increasingly recognized as a way to guarantee the social, cultural, and economic interests of Indigenous peoples and local communities (WIPO, 2017). Thus, protecting local knowledge is also a way to protect this community identity including the social ties and cultural heritage. This is particularly important for communities with Indigenous cultures, such as our upland village case, that has a long intergenerational transmission of local and Indigenous knowledge. In the Philippines, protecting local knowledge is upheld by the 1987 Philippine Constitution and institutionalized by the Indigenous Peoples Rights Act (Republic Act No. 8371), which both recognize, protect, and promote the rights of Indigenous cultural communities/Indigenous peoples.

Second, documenting local knowledge can be a simple yet effective approach to sense the changes in the social-ecological state of water sources. Specifically, LEK can detect extreme events and record significant changes (Moller et al., 2004). Ramirez et al. (2019) proved that local knowledge on watershed landscapes is evidence-based and complements scientific knowledge (e.g., satellite imageries and fragmentation analyses) to address and understand landscape changes and declining quality of ES. Systematic monitoring using advanced tools and techniques can be costly for these villages. Documentation, through community-based methods such as our participatory exercise, can serve as an alternative while capturing more nuanced perspectives on the state of water resources. Changes in local knowledge on water use and WES, either loss or gain, across repeated documentation can signal that there might be significant social-ecological changes in water sources that are worthy of further investigation. While our study did not explicitly assess changes in local knowledge, our probing with the villagers tells us that they have not recently encountered some previously known WES, thus having only a few villagers who have local knowledge about them. A big example of this from our case study was the practice of betel nut-chewing, a practice of combining and wrapping areca nut with betel leaf as a form of stimulant among rural communities. We were informed that areca nut plants were abundant around springs in the watershed in the early days. However, the loss of areca nuts because of various factors including illegal felling have also resulted to the loss of the practice, thus also the loss of local knowledge.

Finally, the significance of local knowledge on predicting changes in the social-ecological state of water resources becomes more instrumental considering the increasing pressures from climate change impacts and other emerging environmental challenges, which threaten the integrity of water sources to provide WES. Based on Chang and Bonnette's (2016) review, climate change impacts on the distribution and quality of water at spatial and temporal scales will affect provisioning, regulating, and cultural WES relative to the extent of changes and adaptive capacity of the ecosystem and local community. In complement, documenting the trends in local knowledge and practices on WES may provide evidence of how local communities manage water resources over time (Quevedo et al., 2021; Cassin & Ochoa-Tocachi, 2021).

12.5 Conclusions

We show the richness of local knowledge of both water use and WES among three villages of a watershed in the Philippines. Understanding local knowledge showed us that the water sources in the villages provide more than just water for domestic or agricultural use. In fact, exploring local knowledge tells us that the WES that are generated by the complex interaction of various ecological units (e.g., trees and shrubs in riparian strips, flora, and fauna) closely rely on water sources. These WES do not only support subsistence and livelihoods of the village but also contribute to the shaping of the villages' culture and way of living. We found similarities of local knowledge across the three villages, especially on traditional WES that have provided basic needs and allowed persistence of the villages. We also found differences in local knowledge, many of which represent the unique water use and WES that each village obtains from water sources. We find that this unique local knowledge is grounded in existing differences not only in the biophysical aspect (i.e., elevation) but also from inherent socio-cultural variations across the villages.

We discuss that such rich local knowledge should be actively engaged in water management, especially when designing and implementing actions and decisions. Engagement captures the complexity of these water sources not just in supplying water but in rendering other benefits. This should be coupled with recognition of place-based specificity of local knowledge. Understanding the differences in local knowledge across places, as driven by both biophysical and socio-cultural variations, can help water managers explore the potential trade-offs and synergies that actions/decisions can have across places. Finally, we discuss the importance of the documentation of such local knowledge to protect the cultural heritage of the villages, especially those inhabited by Indigenous communities. Documentation can also provide the community with a better sense of the social-ecological changes in their water sources.

Our study's findings are empirical contributions on how we should tap local knowledge in understanding the complexity of water resources. The recognition and application of local knowledge remain paramount in designing and implementing place-based water-related interventions, activities, and programs suited to the context of the community they aim to cater to. Further, our study's participatory approach can be adopted by water managers to address our call for more active engagement, recognition, and documentation of local knowledge for more sustainable and equitable water management. Ultimately, such participatory approach lends voice to communities in forging development within their own terms, placing their needs and desires front and center. This has become more crucial than ever given the urgency of environmental challenges these communities face—from climate change, biodiversity loss, to land desertification—that threatens not only the very supply of water but to the very wellbeing of humanity.

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