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# Formation of a Community of Practice in the Watershed Scale, with Integrated Local Environmental Knowledge

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**Abstract:** Rural communities around the world face formidable problems such as resource depletion, environmental degradation and economic decline. While the term 'community' is often used without clear definition or context, it can be viewed as a group of people emerging through social interaction. Through a series of collaborative action toward a shared goal, a community of practice can be formed. This paper proposes a hypothetical framework of integrated local environmental knowledge (ILEK), and applies it to analyze the processes of collaborative actions in the case of the Nishibetsu Watershed in Hokkaido, Japan. The case study identified several phases of actions, all initiated by a group of local residents on a grassroots and voluntary basis. These local resident-initiated collaborative actions had a particular confluence of elements to facilitate gradual strengthening of formal and informal institutions in the watershed scale beyond jurisdictional boundaries, making this a worthy case to study. The local residents used diverse types of knowledge, including livelihood-based technologies and skills of working as a group and with local governments, for establishing and strengthening various institutions for collaborative actions, with such knowledge being used in the manner of tools in a box of bricolage for community formation.

**Keywords:** community; knowledge; collaborative action; watershed; institution

## 1. Introduction

This paper presents an analytical framework of integrated local environmental knowledge (ILEK), and uses it in a case study of community formation processes. We selected the case of a watershed area in northern Japan, where local people have undertaken a series of collaborative action for more than twenty years. In order to address the concerns about the future of dairy production and fisheries as their main livelihoods, local people began to integrate different types of knowledge without any major top-down intervention, and then implemented collaborative actions. The lack of top-down intervention and the almost exclusively grassroots nature make it a rare and worthy example to study. We expect that the case study using our framework will help illustrate how collaborative actions occur to tackle local problems, with integrated and translated knowledge. By combining the conceptual framing with the case study, this paper attempts to identify the types of knowledge that can contribute to collaborative actions. In the next section, we review key concepts that are relevant to the development of the ILEK framework. The third section presents the ILEK framework itself and the analytical procedure using the framework. We also provide an overview of the case study that we conducted.

The fourth section documents a series of collaborative actions we identified, and discusses types of knowledge used as well as purposes of each collaborative action. We conclude with the significance of collaborative action based on ILEK, and utility of the framework for case analyses.

## 2. Conceptual Background

This section reviews key concepts that are highly relevant to the topic discussed in this paper. We grouped these concepts in three broader categories: Collaborative action; community formation and institution; and knowledge to support collaborative action. Clarification of their meanings and contexts lead to the development of the ILEK framework, which is explained in the third section.

### *2.1. Collaborative Action*

Rural communities around the world are facing problems including resource depletion, environmental degradation, and economic decline. These communities tend to be vulnerable to impacts of social and environmental changes [1]. Environmental, social and economic sustainability of rural communities is largely dependent on collaborative action by diverse actors. Research into capabilities and challenges of rural communities, therefore, has and will remain critically important, particularly in the times of rapid global change.

The term 'community' is often used without clear definition or context, however; in the context of community-based natural resource management, a community can be considered as an emerging group of people through social interaction [2,3]. Borrowing the classic statement on 'resources' by Erich Zimmermann ([4] in [5]), it is possible to summarize this characteristic by saying: Communities are not, they become. Community can be formed by a group of people sharing place and/or interest. Another type is a community of practice, comprising 'people who share a concern or a passion for something they do and learn how to do it better as they interact regularly' [6] (p. 1). Such a community, with effective leadership and incentives, tends to engage in collaborative learning and action in various scales. Well-motivated learning, both at individual and social levels, is key to pursuit of sustainability [7]. These dynamic processes of community formation deserve more attention. This paper attempts to contribute to the scholarship on communities of practice, with emphasis on the processes of collaborative action.

Collaborative action is influential in community formation, and has several essential components such as: a group of people, shared interest, common action, and voluntariness [8], as well as self-organization [9]. These components are useful in identifying actions and the nature of those actions. According to Ostrom [10], self-organized collaborative action is likely to emerge, to build mutual trust within the group and to produce joint benefits, where a leader first demonstrates how to produce or increase joint benefits. We adopt all these components in our own interpretation of the term 'collaborative action' but also add joint physical work, or labor, as another influential one. This is why we use the term 'co*labor*ative' action, rather than collective action.

### *2.2. Community Formation and Institution*

This paper focuses on the processes of community formation through a series of collaborative actions. During these processes, knowledge integration is essential in understanding complex issues, and there are examples of drawing indigenous or local knowledge to form global-scale institutions of knowledge systems [11]. However, processes of integrating and translating diverse knowledge bases for promoting action on the ground need further examination. Researchers tend to have a role to play in formalizing and upscaling the integrated knowledge [12], while other actors may also integrate and translate knowledge in ways that are usable by them and other collaborators.

Particularly in rural communities that have serious social–ecological problems such as environmental degradation and economic decline, knowledge can play a critical role in facilitating action against the problems. Such knowledge varies, and includes scientific and livelihood-based types. Institutions such as the UNESCO's World Heritage and Biosphere Reserves, for example, are largely based on scientific knowledge [13–15]. There are other types of experiential knowledge

of indigenous people and natural resource users, as well as specialized knowledge of governmental and non-governmental organizations and private businesses [16]. There might be knowledge that is already existent and potentially effective for solving the problems but not in use yet. The difficulties of identifying the knowledge and the mechanisms limit the potential to draw and accumulate lessons and apply them in other locations and/or institutions.

We regard community formation as a process of institutionalization. Institutions can be defined in different ways. According to North [17], they provide structures to everyday life and shape interactions among humans. As institutions are reinforced, face-to-face interpersonal trust accumulates into institutional trust [18]. Another claim is that institutions are subject to bricolage, as they are constantly reshaped with or without conscious intention to do so [19]. Researchers are increasingly recognizing the needs and benefits of working together with diverse actors for co-production of knowledge, trying to overcome constraints within conventional institutions and disciplines [20]. We look at both formal and informal institutions, acknowledging the nature of institutions as the interplay between externally structured rules and spontaneously developed strategies of a game [21].

### *2.3. Knowledge to Support Collaborative Action*

There are categories of knowledge that are unique to particular local environments. Local ecological knowledge (LEK), for example, is a set of wisdom that people in a specific location possess from their experience of dealing with the natural environment [22,23]. There are cases where indigenous people have passed such local knowledge through many generations, and this is referred to as traditional ecological knowledge (TEK) [24–27]. With TEK and LEK included, there are diverse types of knowledge ranging from indigenous or livelihood-based knowledge to scientific knowledge [28]. Such diverse knowledge is produced and used by people, who represent equally diverse groups such as indigenous communities, natural resource users, governments, non-governmental organizations, for-profit and not-for-profit enterprises, academia, and citizen scientists. The list is not exhaustive, and people often belong to multiple categories. Knowledge integration is more and more important for diverse actors to address complex issues in today's social–ecological systems [29–31].

Interactions between these diverse groups of people help integration of knowledge that is relevant to local contexts, including knowledge on the social–ecological systems, which we call ILEK [32]. The key here is that it is integrated, different from mere pieces of respective knowledge types like scientific ecological knowledge, local ecological knowledge and indigenous ecological knowledge, for example. Because ILEK is produced, modified and used dynamically, the knowledge needs to keep translated to suitable forms and contents [33]. It also includes both tacit and explicit forms of knowledge from experienced skills as well as readily available documents [34]. People who provide knowledge with meanings and forms suitable for collaborative actions are presumed to play a key role. We call them knowledge translators. A local community is often the place where these processes occur. Formation of a community of practice can be considered as an outcome of knowledge integration through collaborative actions. It is difficult, however, to identify the types of knowledge actually used on the ground, and this paper aims to tackle this formidable inquiry.

## 3. Analytical Procedure

This section provides detailed explanation of the ILEK framework itself, our processes and objectives of developing it, the case study we conducted, and the methods of our data collection and analysis using the ILEK framework.

### *3.1. ILEK Framework*

We, mainly the second and last authors, first developed a hypothetical ILEK framework, based on preliminary analyses of narratives collected through interviews with leaders of other inter- and transdisciplinary research projects focusing on global environmental issues. A triangular diagram represents the processes of ILEK (Figure 1). The ILEK processes have roughly two steps. The first step

is co-production of knowledge by multiple actors (at the top of the triangle). These actors include, but not limited to, local residents, natural resource users, government agencies at different levels, non-governmental organizations and private businesses. Categorization of the actors depends on how different interests are represented, and some people belong to two or more categories at the same time. There are also external actors such as researchers and central government agencies, who come from outside but contribute to co-production of knowledge in the local context.

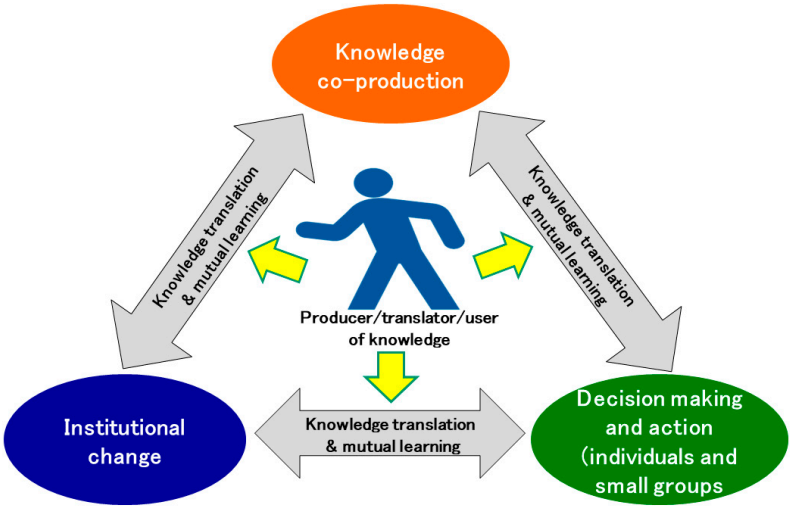


**Figure 1.** Conceptual diagram of integrated local environmental knowledge (ILEK) (Source: Adapted from Sato et al. [33]).

The second step is the distribution and use of co-produced knowledge to influence individuals and society. This second step may have two paths. On one path, the co-produced knowledge first influences decisions and behaviors of individual persons (at the bottom right of the triangle), which eventually accumulate into changes in formal and informal institutions (at the bottom left). This is a clockwise cycle of societal transformations in the ILEK triangle. On the other path, co-produced knowledge directly changes institutions (at the bottom left), and then trickle down gradually to decisions and behaviors of individual persons (at the bottom right). This is a counter-clockwise cycle in the ILEK triangle.

In all these processes, according to the ILEK framework, there are assumedly people who produce, use and translate knowledge. Knowledge translation can be done in multiple directions, such as between science and local knowledge, and between multiple scales such as global, national and local. We applied this framework to the case study in order to identify specific collaborative actions supported by different types of knowledge that help a community of practice to emerge and develop.

### *3.2. Watershed as a Scale of Case Study*

We conducted a case study of a watershed in northern Japan to test the ILEK framework on the ground and examine its appropriateness and suitability for analysis [35]. We chose the watershed case as a spatial scale suitable for studying the dynamic processes of community formation through a series of voluntary and collaborative action. Spontaneous collaborative action can occur in the watershed scale, addressing problems outside the scope of centralized, command-and-control regulations, such as habitat destruction, where joint benefits are large enough and transaction costs are not too large [36]. Much of past research has focused on specific natural resources, making it difficult to define spatial boundaries as 'resource domains' [37]. Nevertheless, a river basin or a watershed has increasingly become a major unit of space to deal with complex human-nature interactions [38].

A watershed as a spatial unit has an obvious characteristic that people within it share benefits and costs related to the same water resource. This characteristic makes it rational to analyze their collaborative action. On the other hand, there are many other resources, ecosystem services and

socioeconomic issues with no direct relation to watershed boundaries, which are also important and necessary. Furthermore, many jurisdictional boundaries are different from watershed boundaries. Jurisdictions are usually more directly relevant to collaborative action of people to address local problems. Our preliminary research found that the case in this paper was a rare example of community formation through collaborative actions beyond jurisdictional boundaries and with no major external intervention [39]. This is why we chose this particular case.

### *3.3. Case Study Site*

The site of our case study is the Nishibetsu Watershed in the eastern part of Hokkaido in northern Japan (Figure 2). The water of the Nishibetsu River originates from Lake Mashu in a closed volcanic crater with no outflowing river. The groundwater systems are the only outlet, through which some of the water penetrates and eventually springs up in the Nijibetsu district of Shibecha Town as the source of the Nishibetsu River. During the winter season, Nijibetsu district is covered with snow at an average temperature below 0 °C but the source water is constantly within the range of 7–10 °C throughout the year, and the upstream part of the river keeps flowing without becoming frozen [40]. After running eastward for approximately 80 km, the Nishibetsu River flows into Nemuro Bay. The total area of the watershed is approximately 450 square km.

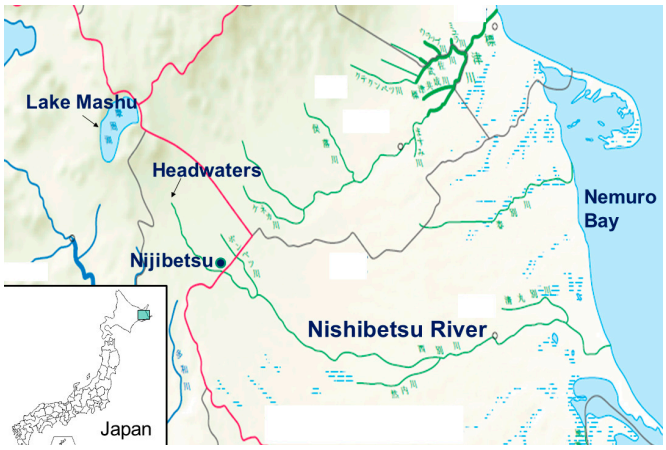


**Figure 2.** Location of the case study site (Source: Base map by the River Department of Hokkaido Prefecture).

Lake Mashu is located in Teshikaga Town, and the Nishibetsu River runs through Shibecha and Betsukai Towns. Therefore, three local governments are involved in governing the watershed. In this paper, the term watershed is used to refer to the broader area, including the original source of the water. The three towns share not only the water resource from the source, but main industries that are dairy production and salmon fisheries. Degradation of riverine and riparian environment in the upper stream has negative impacts upon downstream, which could turn to conflict between the two main industries in the watershed area. When we mention the problems in the watershed, they are not limited to water-related issues but include socioeconomic issues because all the problems are related to each other and not separable to local people.

An upper administrative level is the Prefecture of Hokkaido. Prefectures in Japan are units of local governance, between the national and municipal levels. Hokkaido is one of the 47 prefectures in Japan, and the northernmost one. Hokkaido also has the largest area in Japan, more than five times the area of the second largest prefecture. Hokkaido is divided into fourteen territories governed by corresponding 'Subprefectural Bureaus'. Of the three towns in the watershed, the two upstream towns of Teshikaga and Shibecha belong to Kushiro General Subprefectural Bureau, while Betsukai Town belongs to Nemuro Subprefectural Bureau. At the national level, Hokkaido Regional Development Bureau in the

Ministry of Land, Infrastructure, Transportation and Tourism oversees the overall development policy of Hokkaido.

Archaeological evidence shows that human habitation in the area dates back to approximately ten thousand years ago, and the indigenous Ainu people also appear through their salmon fishing activities in archival records from the eighteenth century, when Hokkaido had been integrated into the Edo regime of Japan [41]. A major demographic change in modern history occurred when a new settlement began in 1929 as part of a national government policy, initially bringing 350 households from other parts of the country to Nijibetsu, the central location in this case study. Since the settlement, main livelihoods in the area have been provided by agriculture and fisheries. The dairy industry is the main sector in the area's agriculture, and salmon is the main fishery resource. A salmon hatchery was constructed in 1890 in Nijibetsu, at the headwaters of the Nishibetsu River. The hatchery has been renovated several times, and still operates actively as a public facility to support the salmon fishing industry. Salmon is one of the popular fish types for human consumption in Japan. People in northern Japan commonly call salmon Akiaji, which literally means in Japanese the 'taste of autumn', because autumn is the season for catching salmon. A large population of salmon returns in autumn to the upstream of its home river for spawning after spending several years in the ocean.

The Nishibetsu Watershed faces a number of problems. One ecological problem is degradation of the river ecosystems. This problem became notable after a national policy of massive agricultural development began in 1973, with large-scale forest clearance. In the survey of water quality in the Nishibetsu River conducted by the Town of Betsukai in the downstream in 2014, Escherichia coli bacteria were detected at higher concentration than the environmental standards in some samples collected at various months of the year [42].

The area also has socioeconomic problems that include a decreasing and aging population. Many rural communities in Japan share this trend as a result of combined factors of insufficient job opportunities, youth emigration to large cities, and low rates of reproduction [43]. The total population in Teshikaga, Shibecha and Betsukai Towns decreased by almost 40% in the 50 years between 1960 and 2010. In the same period, the rate of people at the age of 65 and older in the total population rose from 4% to 25% (Figure 3). This is tied with an economic problem in that the resource-based industries in the area are becoming less sustainable. Jurisdictional boundaries tend to work against collaborative actions by diverse actors in addressing broader-scale problems. A watershed is an example of a broader scale with complicated social–ecological issues that are difficult to deal with at a local jurisdictional scale alone, as evident in this case.

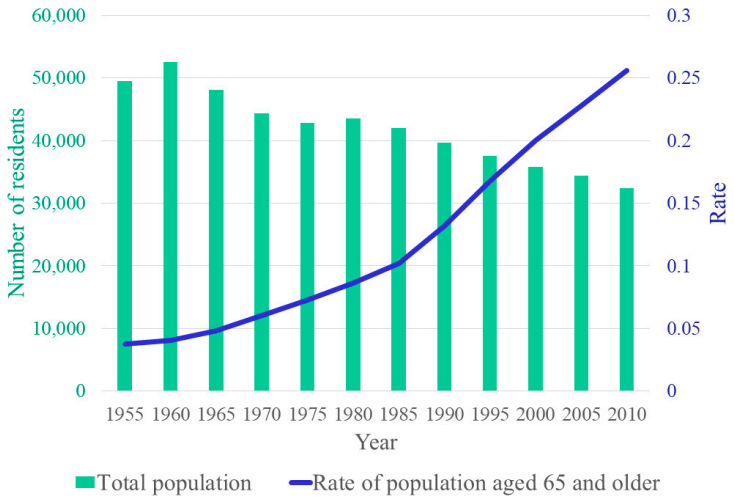


**Figure 3.** Total population and the rate of senior citizens in the three towns of the Nishibetsu Watershed, calculated based on the national census data (Source: Raw data collected from the Prefecture of Hokkaido [44]).

### *3.4. Data Collection and Analysis*

Our data sources were documents, narratives of leaders of the local voluntary organization called Nijibetsu Kor Kamuy Society (discussed in greater detail below) at its meetings and events, semi-structured interviews with these leaders, and the authors' own participatory observation (we consider this term to better explain the method actually used, than the more commonly used 'participant' observation [45]).

The first author visited the case study site seven times in the period from May 2014 to December 2016. The second author visited the site in 2013 to obtain the general understanding of the case. The last author had made a series of regular visits to the site for 14 times from 2010 to 2016 to build trust with major actors, and accumulated narratives and collected data about the collaborative actions from the written documents produced by the Nijibetsu Kor Kamuy Society and their narratives. He was accepted in 2014 as an official member of the Society after engaging in interactions spanning several years. While each of these visits was less than a week long, it captured an important moment of collaborative action such as tree planting events and meetings of the local organization as mentioned in greater detail below.

In parallel to data collection, the first and last authors began and maintained continuous dialogue on our interpretations of the facts of collaborative actions and their relationships with the ILEK framework. We set two criteria in our analysis. One is the types of knowledge produced and/or used for each collaborative action identified. The other is the functions of each action for community formation. We prepared our preliminary findings, and consulted with the leaders of Kor Kamuy Society regarding our preliminary findings. Our consultation had two purposes. One was to make our descriptions and qualitative analyses as accurate as possible (although the authors are responsible for any remaining errors). The other was to use this research itself as a means of collaborative action for mutual learning and knowledge co-production [46]. The local leaders did not choose to become co-authors of this paper, but they have been important collaborators for this study at all its major stages.

## 4. Results and Discussion

This section documents five distinct phases of collaborative action that we identified. This section also discusses what types of knowledge were used in each of these actions, and what were the functions of each action leading to community formation.

### *4.1. Identified Phases of Collaborative Actions*

#### 4.1.1. Action 1: Establishment of a Local Resident Group with an Endemic Owl as Its Icon

The first collaborative action was the establishment of a local resident group, which occurred in the mid-1990s. The person eventually becoming the secretary general of the local organization is a fisherman living near the mouth of the Nishibetsu River. We hereafter call him Mr. S. His main livelihood is salmon set net fishing that he succeeded from his late father. Mr. S also operates a hatchery opened in the late 1980s in the upstream of the watershed for Donaldson trout (*Oncorhynchus mykiss*), a strain of large growing rainbow trout [47,48].

In 1993, Mr. S found at his hatchery the Blakiston's fish owl (*Ketupa blakistoni*), a species listed as a Japanese Natural Monument since 1971 and as 'critically endangered' (IA) in the Japanese Red List. It is a large owl, whose length is close to 70 cm and whose wingspan can reach 180 cm. It feeds on riverine fish such as salmon and trout, and breeds in large tree hollows. The Ainu people have dealt with Blakiston's fish owl with great respect, calling it 'Kotan kor kamuy', which means the 'village guardian god' in their language.

Through a pre-existing network of people both in upstream and downstream communities, Mr. S brought some of those people to his trout hatchery and together they watched the owls hunting trout in his fish pond. They were awed by the bird and understood the reason why the Ainu people had seen holiness in this owl. They decided to initiate voluntary actions for restoring the owl habitats.

In 1994, they established a local voluntary organization called Nijibetsu Kor Kamuy Society, borrowing the Ainu language to express respect for the sacred owl. The Society is not-for profit, and not even registered as a legal person. It is rather a circle of people, who are willing to participate in no more than a few regular events each year, such as the general assembly and tree planting.

The first thing the Society did was to produce nesting boxes and install them on the trees. The then Environment Agency of Japan, which eventually became the Ministry of the Environment, had its nesting boxes already installed in several habitat locations of the Blakiston's fish owl. A non-profit organization had also been active in restoration activities for this critically endangered owl. Science-based knowledge on the Blakiston's fish owl was available from these actors. The local people on the other hand noticed that containers of formic acid, a widely used material in dairy farms to mix with hay, had perfect shape and size for the owl nests. Therefore, the Society acquired several of empty containers at no cost and crafted by hand its original nesting boxes. Those used containers are industrial waste requiring fees for farmers to dispose. This is an example of integrating scientific knowledge with locally available tools and skills without expenditure.

In this first action, values of the healthy watershed environment were visualized using the Blakiston's fish owl as an environmental icon. An environmental icon can represent three things: (1) the biological species itself which has values from environmental perspectives; (2) the characteristic ecosystem in the areas; and (3) the social/cultural/traditional relationships between people and nature. Sato [49] argues that an environmental icon can symbolize ecosystem services that are unique and important to local people, and can contribute to (re)vitalization of local communities.

Iconic animals and plants, however, can sometimes be a source of conflict rather than cooperation. Particularly, wildlife species subject to human harvesting can divide people according to their interests [50]. The local people selected the endangered owl species as a neutral icon to attract people with diverse interests to work together. The membership of the Society ranges from fishers to dairy farmers to pig breeders to the head of a local post office. Together, they aim for sustainable livelihoods in the healthy watershed environment, signified by the Blakiston's fish owl as the environmental icon. The local people applied their own skills and tools, mixed with the scientific knowledge brought by the national government and the environmental organization regarding the Blakiston's fish owl. This is an ongoing process of collaborative creation of ILEK, and the Society's original nesting boxes are one tangible outcome.

#### 4.1.2. Action 2: 100-Year Project of Riparian Forest Restoration

Once the Nijibetsu Kor Kamuy Society was established, it began aiming at broader and deeper impacts. The Society defined three concrete tasks in its actions: installation of nest boxes for the owl, riparian forestation, and cleaning of the river, as related by the current President of the Society, Mr. P, who took over the position after the founding President passed away in 1995. The largest of these three is the action of holding an event to plant riparian trees. Begun in 1994, the event has since been carried out along the river every year on the third Sunday of May. Upon completion of the twenty-third event in May 2016, a total of 75,000 seedlings of native tree species have been planted.

A few hundred people participate in the event every year, coming mostly from the watershed area but also with some outside participants. The event provides participants with new options and opportunities for collaboration and practical learning on the natural environment. Local schools bring students to participate in the event. Some families nail down their name plates as a sign of their own planted trees, saying they look forward to keeping track of the progress in growth of their trees in the future. The event applies a number of locally available skills, tools and human network, based largely on the livelihoods of local people. As many as ten native tree species are selected and planted to restore biodiversity along the river. Local skills in growing seedlings are applied, while also inviting the conventional forestry sector to work together.

Participants are rewarded with local produce. During a short break, locally produced milk is served. After completion of the work, a barbeque party is held to enjoy a variety of fish, meat and

other local delicacies. In this way, participants not only find it a fun event but also learn about the benefits of the diverse ecosystem services in the watershed.

The 100-year reforestation project has outcomes beyond the number of trees planted. It has created new human linkages and enhanced existing ones. It has also provided options and opportunities, which facilitated participants' engagement in conservation practice. All these outcomes have been achieved, with fun memories shared and accumulated year after year. This is a positive and attractive approach, transforming costs such as labor and time into benefits, which include strengthened social ties and mutual trust.

#### 4.1.3. Action 3: Watershed Concerts

In September 1995, the Society organised an event called the Nishibetsu Headwaters Concert, inviting a professional singer sympathetic to the Society's initiatives. As its name suggests, the event was initially held in the upstream part of the watershed. In the following year, it grew into a week-long series of concerts titled the Nishibetsu Watershed Concerts organised by different resident committees in five different districts along the river flow. This series of Concerts were held every May until 2004, contributing to fostering new and expanded networks of local actors in the entire watershed from upstream to river mouth. This series of concerts delivered a clear message on the importance of managing the entire watershed, while providing wider opportunities for actors from different districts along the river to collaborate with and learn from each other.

This third action of the watershed concerts worked similarly with the second action, contributing to enhancing human linkages, but from a slightly different perspective. A particular importance is that the geographical scale of collaborative action was extended to and matched with the watershed scale. The event also developed capacity for all the districts in the watershed to plan and implement collaborative action. While no local government was officially involved, this action by the citizens across town boundaries provided new options of voluntary collaboration, and paved the road for the next series of actions.

#### 4.1.4. Action 4: Creating Collaboration Platform for Three Towns

The next phase is characterized by a series of actions to build more formal institutions than in the 1990s. In April 2000, the Nijibetsu Kor Kamuy Society officially proposed that the Town of Betsukai designate May as the Month of Considering Rivers, which was adopted by the Town in September of the same year to start in 2001. Similarly, in April 2001 the Town of Shibecha designated May as the Month of Forests and Rivers.

The Nijibetsu Kor Kamuy Society proposed a meeting of mayors and local leaders from the three towns along the watershed be held, which came to be realized in August 2001. This served as a venue for the leaders to frankly discuss common matters across the watershed beyond town boundaries. It has since become an annual event, and joined in 2015 by the fourth town of Nakashibetsu, which is located just north of the Nishibetsu Watershed and has common interests in local development on a slightly broader scale.

The Society also organized a workshop titled the Forum on Lake Mashu, Water and the Environment, in collaboration with the three towns to discuss issues related to the watershed environment, inviting guest presenters and local people. Since 2002, the workshop has taken place every year in May or early June, and the location rotates among the three towns in the watershed. This is a formal way to learn together about issues of common interest, including water, forests, wildlife, ecosystems and land use.

Two new organizations were founded in the mid-2000s largely under the initiative of the Society. One was the Coordinating Committee of the Mashu Water System and the Nijibetsu Watershed, established in 2003. The other was the Executive Committee for the Mashu Water and Environmental Conservation, established in 2006 as a result of a restructuring of the organizing committee of the Watershed Concerts following the end of the Concert project in 2005. These organizations have served

as platforms for more formally institutionalized collaborative actions, when compared to the early actions of the 1990s. The annual workshop is jointly hosted by these two organizations and the Society, and supported by the three towns.

This sequence of collaborative actions initiated by a resident group prompted the three towns to work together for watershed management beyond their jurisdictional boundaries. The fourth set of actions established multiple platforms, enabling diverse actors to sit at the same table for discussion and collaboration in more formal manners than the other local actions. These platforms have overlapping members, but their respective origins and purposes differ slightly. This multiplicity provides options suitable for different actions, and opportunities for participants to select and join actions more easily than other institutional forms. Most importantly, these platforms connected the three town governments together to form an institutional base for watershed-scale actions. Through these platforms, the participating parties leaned and shared each other's political or practical priorities. This is an important process of knowledge sharing, which eventually made the Society's philosophy reflected in local policy document (to be discussed in more detail). An established institutional base provides learning opportunities for participants [51]. Described earlier as the counter-clockwise cycle in the ILEK framework, this mechanism of institutional transformation was present in the case of the Nishibetsu Watershed.

#### 4.1.5. Action 5: Water Grass Restoration

The most recent collaborative action is the restoration of water crowfoot (*Ranunculus nipponicus var. submerses*), a water grass in the river that signifies healthy streams, in that it increases the heterogeneity of the water flow patterns and river bed topography. Water crowfoot also provides refuges for fish and supports riverine biodiversity. However, water crowfoot has been seriously degraded due to extensive predation by wild deer and waterfowl in the winter, when other food sources are scarce.

In order to reduce such damage, the Society began experiments in early 2014 to hang fishing nets just above the river surface during the winter season within the bounds of the salmon hatchery in the headwaters. Mr. S had noticed the fishing nets and anchors used in salmon set net fishing would be effective. The river flows are variable and could be rough in times of storms and heavy rains, which could be similar conditions as in the coastal sea. The nets were expected to physically hinder the animals from feeding on the water crowfoot. The Society also used other locally available materials such as anchors for set net fishing and the empty plastic bottles containing formic acid (the same as those used for the owl nests). The methods were modified several times during the experiment in areas in which the damage continued to be observed.

In October 2014, in advance of the second winter of the experiments, the leaders of the Society arranged to organize a meeting under the framework of the Coordinating Committee of the Mashu Water System and the Nijibetsu Watershed. Coupled with a field trip to see the experiment sites, the meeting invited relevant actors to discuss plans and any foreseeable concerns. The Nijibetsu Kor Kamuy Society reported the results of the water crowfoot protection in the previous winter. A visiting researcher who had been monitoring the water crowfoot habitats in the upstream of the Nishibetsu River for twelve years related that the protection nets seemed to have regulated wildlife feeding to some extent, and that without such local actions the plant could be subject to more extensive incidents of damage, possibly to an extent that the plant would no longer maintain the ability to regenerate itself. One concern of the Society had been that the nets covering the surface of the river might be a source of conflict with visitors such as anglers and photographers. At the meeting, a representative from a recreational anglers' association in Hokkaido expressed his understanding of the need for such protectionary measures. Following the discussions, participants unanimously agreed that the experiment would be maintained into the second winter at the existing and new locations near the headwaters.

In this fifth action of the water crowfoot restoration, the values of healthy ecosystems in the watershed have been visualized through the new environmental icon of water crowfoot. However,

this new icon is consistent with the original story symbolized by the Blakiston's fish owl, with the owl at the top of the food chain in the same watershed ecosystems. The water grass is not commonly consumed by humans either, at least in modern times. It has aesthetic and sentimental values for local people, and also practical values for recreational fishers through provision of fish habitats. Underwater photographers find the grass valuable through the diversity of scenery and ecosystems it creates in the water. The non-extractive nature of these environmental icons enable consensus on the actions to be conducted collaboratively. The above mentioned visiting researcher of water crowfoot ecology has provided scientific knowledge to the Society through the Forum and other opportunities. He has been monitoring the water crowfoot for over a decade in the upstream of Nishibetsu River. Local people are working together in this monitoring, where they provide locally available tools, skills and knowledge to adapt the monitoring methods to this particular case. This is another instance of collaborative knowledge creation.

Integrated knowledge and understanding of the complex social–ecological systems helped create a story with appeal to a wide array of people. The meeting on the water crowfoot restoration mentioned in the previous section is one concrete instance of institutions working for collaborative action, with participants' knowledge shared and blended. The collaborative action for restoring the water grass is similar to that of tree planting that started twenty years earlier. The difference is that the institutional robustness of the actor networks increased significantly during the two decades of collaborative actions. Therefore, the new collaborative action, though started in a relatively low-key manner, had the potential to influence local institutions more directly than in earlier actions (counter-clockwise cycle in the ILEK triangle).

The water crowfoot restoration has been enhancing the linkages between diverse actors including local residents, recreational anglers, underwater photographers, bird watchers, conservationists, and researchers. It also provides new opportunities for these actors to work together, in addition to the existing options of collaborative action (Figure 4).

**Figure 4.** (Clockwise from top right) Blakiston's fish owl, tree planting event, water crowfoot, and experiment for water crowfoot restoration (Source: All photographs by the first author).

### *4.2. Findings Based on the ILEK Framework*

#### 4.2.1. Types of Knowledge to Support Collaborative Action

This subsection summarizes the types of knowledge used to promote these collaborative actions, in three categories. We focus mainly on ILEK possessed and used by the Society as the main actor in integration and translation of diverse knowledge.

A first category is knowledge related with the local environment. Scientific knowledge of the Blakiston's fish owl including its population trends and habitat conditions came mainly from the national government, biology researchers and the environmental organization. On the other hand, the local people had their own knowledge that the owls needed more feeding locations and the Donaldson trout hatchery could help reduce the shortage. Mr. S made part of the hatchery uncovered to allow the owls to catch not all but some fish. 'Not all but some' is a kind of knowledge derived from experience. He knew solutions on the ground were often grey, not black or white, meaning that the balance is important. The local people also knew that formic acid containers were readily available and perfectly suitable for the owls' nesting boxes. Combined with the Society member's handcraft skills, free empty containers actually became the nests of the owl. A total of almost thirty chicks in twenty years have been raised in and fledged from the Society's nesting boxes. The nesting box is a tangible product of knowledge integration and translation.

Similar knowledge integration and translation were progressing with water crowfoot, collaborating mainly with the visiting researcher but also groups of different interests including staff of the salmon hatchery. Functions of the water grass in the ecosystem, such as impacts on the water flow and river bed patterns and habitats of insects and fish, were beginning to be understood thoroughly, connected with the values of healthy watershed environment. The mechanisms of severe degradation of water crowfoot in recent winters, as well as the restoration methods, exemplified integrated knowledge.

A second category is knowledge deeply rooted in the livelihoods. Together with the formic acid containers and scientific knowledge of the visiting researcher, the tools were transformed into elaborate methods for the restoration of water crowfoot. Mr. S remarked that people engaged in resource-based industries, such as farmers and fishers, tend to make use of things available without depending too much on capital and external resources. The livelihood knowledge and skills were therefore the primary resources for collaborative actions.

A third and possibly the most important category in this case is the knowledge as to how linkages can be built and enhanced among people of different origins and interests. Mr. S and the members of the Society knew experientially that a common and positive target worked for collaboration, as opposed to pointing the finger at someone for conflicting behaviors. The Blakiston's fish owl was a perfect target, for which people could work together beyond their respective interests. To encourage active participation of people from the entire watershed, the Society allowed small and spontaneous committees in district scales (smaller than towns) to emerge and plan their own concert events. They also knew that having meals and drinks together was very important to strengthen the linkages. These principles were effective not only for linking people but also for sharing the understanding of the food resources provided locally through the resource-based industries, thanks to the clean watershed environment. Another example is that the Society made it clear up front that it would not demand monetary support from the government. This facilitated participation of the town governments in dialogues and collaboration. There were also other groups of people with different interests. The Society organized meetings from early stages to promote dialogues among many actor, which prevented negative reaction from occurring against the collaborative actions. Even though the Society's own actions were limited in scope, it leaders had the knowledge that local governments and other interest groups needed to join the collaborative actions to have greater and broader impacts. This is clearly important knowledge for influencing institutions. Table 1 summarizes the types of knowledge observed in each phase of the collaborative action, and what it did in the processes of community formation.

**Table 1.** Identified action phases with the types of knowledge observed.

| Action Phase | Types of Knowledge | Functions Leading to Community Formation |
| --- | --- | --- |
| 1. Establishment of the local organization | • Scientific knowledge on the owl<br>• Government policy to protect the endangered owl<br>• Local knowledge on the owl as a sacred species by the indigenous people<br>• Local knowledge of the owl's current situation in the watershed<br>• Local and livelihood-related knowledge on available materials and techniques | • Visualization of values to share among diverse actors, using the Blakiston's fish owl as an environmental icon |
| 2. 100-Year Project of Riparian Forest Restoration | • Local knowledge on the importance of joint physical labor and the ways of working with various actors<br>• Local knowledge of the foods as services from the healthy watershed environment<br>• Local knowledge on the importance of sharing meals | • Joint physical labor to enhance the linkages between diverse actors<br>• Deeper understanding of the environment and its benefits |
| 3. Watershed Concerts | • Local knowledge on the importance of self-organized actions, with different approaches adopted by the districts along the river | • Creation and enhancement of the linkages between actors throughout the entire watershed |
| 4. Creating Collaboration Platform for Three Towns | • Local knowledge on the ways of working with governments and also making different government agencies work together with each other<br>• Scientific knowledge on the critical issues in the watershed area presented at the annual forum | • Several platforms formally established for collaboration, adapting to the purposes and structures of actor relationships |
| 5. Water Grass Restoration | • Scientific knowledge on the ecology of water crowfooot<br>• Local and livelihood-related knowledge on the available materials and techniques for restoring the damaged water grass | • New linkages with actors concerned with the underwater environment in the river<br>• New way of visualization of the common values derived from the healthy watershed environment |

The Society's actions in five phases have created and reinforced the values of sound ecosystems over the entire watershed scale, which has and will continue to be the basis for resource-based industries in this area. It is also possible to conclude that the value ultimately (re)discovered and shared among the actors is the sustainability of local livelihoods over the watershed scale. In the processes of societal change, knowledge was translated into motivations for collaborative actions.

This case study showed that the ILEK framework was useful in understanding the mechanisms of societal change. If a particular resource for extractive use were selected as a key target in analysis, such as freshwater, salmon or cows, it would have been difficult to fully understand the mechanisms of collaborative action in this case. While it is true that the water, for example, serves as the basis for a large part of the livelihoods in the entire watershed, looking at this case as merely a water issue trivializes the larger picture of collaborative actions. Therefore, for cases like this, where the true target is broader benefits brought by ecosystems beyond single extractive resources, a framework like the ILEK has greater potential in analysis and design of collaborative actions.

#### 4.2.2. Institutional Change

In this subsection, we discuss the processes of community formation in the case study as an example of institutional change. The Society's original state can be likened to an embryo of a new informal institution. By continuing tree planting and other events every year, however, the Society and its actions gradually strengthened their foundation as a more formal institution. The Society currently has almost eighty members, four times the original number at its establishment, without active solicitation to expand itself at all. The Society itself is not a local community but is a platform guiding collaborative actions in the entire watershed beyond jurisdictions. Its membership is largely in the watershed area, with several people from elsewhere. The only requirement is that any member needs to participate in the annual general meetings and other important events such as tree planting organized by the Society. It does not matter what type of job or origin that a member holds. Only a couple of

people have been expelled by the Society from its membership, simply because they didn't show up at the Society's events at all for a long time.

Mr. P says that some people who had been in conflict on a particular problem can work together through the platform of collaborative actions initiated by the Society because they share positive goals. As planted trees have increased their size, with their rings growing broader every year, the local institution has developed its scale and scope. The increasingly developed institution has provided firmer structure to voluntary actions with less uncertainty, a process exactly concordant with that elucidated in North [17]. This then led to a shift to the counter-clockwise cycle in the ILEK triangle.

Institutional change has occurred in local policy as well, resulting from the sharing and translation of knowledge influenced by cumulative local actions. Such diffusion of knowledge can be attributed to the leaders of the Society playing the role of knowledge translators [16,52]. The most formal evidence of institutional change is an official policy document, and the process can be traced with three sets of texts.

The first text is the Statement of the Establishment of the Nijibetsu Kor Kamuy Society in April 1994, written as an outcome of discussion by the Society's founding members, which reads:

> The Ainu People have paid great respect to the Blakiston's fish owl as a village guardian god 'Kotan Kor Kamuy'. Its admirable style with eyes as if they can see through everything makes it worth being called a god.
>
> The wild field of Nijibetsu was once a hunting ground for the Ainu People, but has been gradually developed since the beginning of the Showa period. Owing to the pioneers' great efforts, it has now become a dairy field with Nishibetsu and Kamuy Mountains as its background lying next to Akan National Park, and blessed with Nishibetsu and other clean rivers and rich forests.
>
> The Blakiston's fish owl once inhabited widely in Hokkaido, but as farm development and river improvement accelerated, its population decreased significantly, leaving only about a hundred individuals barely living in limited areas today. Fortunately, our Nijibetsu area has rivers and hatcheries with abundant fish, as well as remaining forests suitable as the Blakiston's fish owl's habitat. If we do nothing, however, there is a risk of extinction even in this blessed Nijibetsu area.
>
> We are concerned about the current conditions faced by the Blakiston's fish owl, and determined to make every effort to create better environment for the owl's survival.
>
> Therefore, the Nijibetsu Kor Kamuy Society undertakes various activities earnestly for the Blakiston's fish owl without seeking profit or fame (Nijibetsu Kor Kamuy Society [53]; translated from Japanese to English by the first author of this article).
>
> (Note: The Showa period in the Japanese calendar was between 1926 and 1989).

This 1994 Statement shows a philosophy of the Society with the knowledge and perception about the area, which has since been referred to in the Society's activities. Without changing the key message, the Society has made modest elaboration in its other manifested documents. One such example is the Purpose Statement of the Watershed Concerts, which is the second text we look at here. It reads as follows:

> 'Sacred Nishibetsu River originates from Lake Mashu, flows from Nijibetsu in Shibecha Town to Betsukai Town, and finally into Nemuro Bay, serving all of us in the watershed, as well as its industry and culture.
>
> As society develops, however, the flow of the sacred Nishibetsu River has become low and muddy, and the once abundant waterweed in the downstream has disappeared.

> . . . Shall we think of the past, present and future of Nishibetsu River together, while listening to the songs by . . . , a musician who makes concert tours around the country?
>
> We hope that the voices of the village guardian 'Kotan Kor Kamuy' (Blakiston's fish owl) will be heard forever in the Nishibetsu watershed, and that the best salmon and milk in Japan will continue for many generations to come, just like the flow of the river' (Nijibetsu Kor Kamuy Society [53]; translated from Japanese to English by the first author).

The Concert Statement is largely consistent with the earlier written Establishment Statement, but there are a few important additions made on the Concert Statement. One is the names of the locations and towns from the source to the end of Nishibetsu River, clearly mentioned in the first paragraph. The other addition is the emphasis on the main livelihoods with the expression of 'the best salmon and milk in Japan' in the final paragraph. The original idea of establishing the Society was to focus its actions on the Blakiston's fish owl, with other goals remaining implicit. However, the socioeconomic foundation of the watershed area was clarified in the process of building linkages with people in broader districts along the watershed including dairy farmers and fishers.

The third text shows the evolved philosophy of the Society, which has had broader impacts. An ordinance of the Town of Betsukai was enacted in April 2014 regarding the conservation of the riverine environment and appropriate use of rivers. The preamble of the ordinance reads:

> 'In Betsukai Town, such rivers as Nishibetsu originating at the foot of Mt. Nishibetsu . . . have brought many blessings to the land full of green and those of us living in the watershed, and also flown into Nemuro Bay to nurture rich fishery resources.
>
> We must continue to protect the precious rivers and the natural environment for our children and grandchildren, as well as for all the people visiting the watershed.
>
> This ordinance is legislated as a determination to conserve the environment of the rivers flowing through the large Betsukai territory, to aim at appropriate use of the rivers, and to hand over the rivers with many benefits to the next generation' (Betsukai Town Public Office [54]; translated from Japanese to English by the first author).

The fundamental message in the ordinance is similar to that of the Society. This ordinance shares an approach with the Society in that it is both positive and not intended to penalise violators. The process of drafting and passing the ordinance was totally internal to the Town and Council of Betsukai. However, Mr. S was certain that the three town leaders' annual meetings described earlier, as well as the other collaborative actions, served as a platform to share knowledge and perceptions among the parties including the Society and the Town of Betsukai. Therefore, the Society's philosophy had already been shared and readily applicable when the Betsukai leaders were discussing the possibilities of having its own policy statement on the watershed conservation. The similarity of expressions between the Society's statements and the Betsukai ordinance is an indication of knowledge sharing and translation into policy.

Another example of institutional change in local policy was found in the selection of reforestation sites, based on a recently signed memorandum of understanding between the Society and the Town of Shibecha. The Town owns patches of riparian forests with pine trees planted over fifty years ago, and knows that these trees are now reaching an appropriate age for harvesting. Economic incentives in forestry have decreased drastically since the time of those plantations, and the profitability of the pine trees is low today. However, over-aged pine trees would lower their values even further and limit biodiversity of the watershed area. Because the Society had proved its ability to restore riparian forests with native trees, the Town of Shibecha decided to offer their cleared pine forests for the Society's reforestation sites.

## 5. Conclusions

This paper investigated the types of knowledge that promoted collaborative action, including environmental and livelihood-based categories of knowledge. Practical knowledge as to how to link people of diverse interests together was considered key to collaborative action, particularly when such action was initiated at the grassroots level. Setting an appropriate target for visualising and sharing common values among diverse actors, as well as enhancing the linkages of those human networks were critically important. A sequence of combined collaborative actions, though started modestly at the grassroots level, could lead to greater impacts on institutional arrangements, local government policies and actor networks at the watershed level. All of these processes and outcomes contributed community formation in the watershed scale.

The case study found that knowledge-based collaborative actions were in fact undertaken by the local group, and the ILEK framework was useful in understanding the processes in detail. The case study presented in this paper was consistent with the hypothesis of the ILEK framework that collaborative actions would typically begin with knowledge that creates new meanings and values to the most important subject, and visualizes those values. In the case of Nishibetsu Watershed, the new values were found in the residents' own visions for sustainable livelihoods based on natural resources.

New linkages of people, as well as increased options/opportunities, influence individual decisions and behaviours. In the case presented in this paper, this occurred through the variety of events organised every year. Once the institutional foundation becomes strong enough, collaborative actions can influence formal and informal institutions directly. In the case study, such actions took the forms of the town leaders' meetings, public workshops and establishment of the watershed association beyond the jurisdictional boundaries.

The components of collaborative action, namely a group of people, shared interest, common action and voluntariness [8], as well as self-organisation processes, were all in place in the Nishibetsu case. It is worth noting that nobody was forced to take collaborative actions, and that nobody receives monetary compensation for time and labour. The Nijibetsu Kor Kamuy Society is made up of volunteer citizens in a watershed scale and beyond, which is much broader than a town or a generally perceived sense of community of place. Though defined spatially by a watershed, the Society is also a community of interest that has led to collaborative actions. This voluntariness is an important characteristic of collaborative actions in the Nishibetsu case, allowing people in diverse positions to work together for common goals.

The Nishibetsu case was also consistent with Ostrom's [10] suggestion on options presented by leaders for realising joint benefits and mutual benefits as one of the key factors. The leaders of the Nijibetsu Kor Kamuy Society initially designed entertaining events to attract an increasing number of participants and build mutual trust among core members. The single condition that the Society requires of its members is their regular participation in its meetings and events. This simple and strict rule has a rationale. Attendance means not only loyalty but collaborative sharing of situations and thoughts among the participants. We have observed that every single person at regular meetings of the Society gives a brief statement in turns, which is an effective way to update each other on their lives in general, livelihoods, and enthusiasm as well as concerns regarding the collaborative actions of the Society. This itself is one instance of collaborative creation of knowledge on the problems in the watershed area.

The institution of the case study is clearly a type of watershed partnership for collaborative action [8] for addressing the problems that cannot be solved by top-down, command-and-control regulations alone. Because the scope was broader than a single specific resource, the watershed was a reasonable scale for community-based collaborative action in this case. Transaction costs remained low, by making use of already existing livelihood-based networks and skills of working as a group and with local governments. Costs for introducing technologies for specific actions are also kept low, by applying existent technologies from the members' livelihoods. Thus, options and opportunities are provided to new participants, who might not have entered into practice if these options were

not readily available [55]. The Society offers multiple forms of institutions, with such knowledge being used in the manner of tools in a box of bricolage [19]. The case studied in this paper showcased multiple types of knowledge production and integration in different phases of community formation. It is a rare and important example in Japan and possibly in the world, which helps to understand the processes and mechanisms. The ILEK framework is one approach to help identify types and functions of knowledge used in such institutional bricolage for creation and adaptive governance of a community.

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