Groundwater Preservation Policies for Sustainable Development of Regions

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This paper investigates the structure of the social systems that make it possible to maintain regional groundwater resources, as well as related social dilemmas. In Japan, under the law, groundwater is not assigned to any particular entity, as it is considered a public resource, and there is no centralized authority, which can rule groundwater management. In the Kumamoto region, diverse groups, corporations, and local governments have come together in a multilevel collaboration to establish a local groundwater preservation system that will conduct groundwater recharge. Through field research, we were able to structure, through self-governance, and self-organization, a management system for the protection of the commons, which can overcome numerous policy hurdles. We will discuss whether, in this regard, the results of this systemic framework for governance and management have overcome various social dilemmas. This study advances our understanding of public-private co-management system.

1. Introduction

The surface of the earth is covered by 1.4 billion km^3 of water, of which 97% is seawater and only the remaining 3% freshwater. If we exclude the 70% of freshwater that is frozen in the Arctic and Antarctica, the 88% of remaining water that is suitable for human use is groundwater. Even now, groundwater is considered a precious natural resource, used for drinking water, farming, industry, and other applications. The movement of water—evaporating from land and the oceans and becoming clouds, then later falling as rain and snow, filling rivers, lakes, swamps, groundwater, and even the oceans—is part of the hydrological cycle. Even so, the natural mechanism of recharge that results in groundwater is also affected by the alterations human beings make to the environment. If we are unable to manage our usage through collective action, this shared resource will be vulnerable to destruction. That is to say, our groundwater would soon be depleted, if everyone were to reasonably pursue the consumption of inexpensive personal assets for their individual benefit, and no one would be able to benefit from it. However, if we consider the stock and flow of the natural capacity of groundwater basins[(1)] separately, effectively managing the relationship between the amount of water stored and the rate of recharge, while achieving cyclical balance, we will be able to continue to reap the benefits of our groundwater resources. This is because such natural resources fall into the category of what are called the commons[(2)].

In managing the natural circulation of groundwater, it is necessary to consider the amount of

water, quality of water, and the surrounding environment. Furthermore, when considering policies designed to preserve the groundwater supply, it is also, naturally, vital to achieve a balance between natural mechanisms and societal systems; this is where the primary difficulty in developing policy is encountered. Through this project, we will examine issues, such as "Who does nature belong to? Who does water belong to?" and "Is water a necessity, or a right?", that concern jurisdictional and access rights regarding nature[3], issues regarding the marketability of water, and issues concerning how best to manage the use of water resources so that maximizing their use as a personal resource does not destroy their capability as commons resources to offer benefits to the public. This includes a policy approach concerning the structural feasibility of a preservation/management system to protect a common pool resource (CPR), implemented through regional governing bodies and through field research informed by a diverse collection of scholarly fields, such as policy research, economics, sociology, cultural anthropology, and geology.

The purpose of this paper is to examine the self-governance and self-organizational structure of the various local authorities charged with establishing groundwater management systems in the Kumamoto region. We consider how effective the structural capability and functional mechanisms of these local groundwater management systems are at conserving groundwater resources as a CPR without relying on governmental oversight. In doing so, we discuss the characteristics of the system in Kumamoto, while offering a comparison to Ostrom's vigorous research in the United States.

2. Theoretical arguments

The first issue surrounding groundwater is the issue of the commons, regarding "resources jointly shared and managed by multiple entities, and the management and application of such sharing." This issue is concerned with the various ways in which these CPR can be effectively managed while people utilize them. Garrett Hardin's "The tragedy of the commons" (1968) touched on this issue; with regard to non-personal management and preservation activities, we are unable, due to the open access nature of these resources, to expect that collective action will be an effective form of management, and thus they would seem doomed to fail. There are claims that the compelling influence of government enforcement or privatization is necessary in order to prevent this outcome.[4] On the other hand, these sorts of "tragedies" are uncommon, and there have been numerous research reports such as McCay, concerning successful collective commons resource management promotion efforts with respect to forests, farmlands, fishing waters, groundwater, and irrigation projects; there are claims alleging separate dramatic scenarios, referred to as the "Comedies of the commons", as well. These arguments are based on either the selfishness or altruism of people and also include the question of how society can understand these traits. Various theoretical positions stand in conflict with respect to the issue of how to effectively create order in society: is a Hobbesian world, as described in Leviathan, necessary or can such progression be left to Adam Smith's market theory; in other words are there other alternatives such as communities or others? In this paper, we discuss the possibility

of structuring an alternative management system based on local governing bodies.

Based on the various accumulated CPR research efforts, made by Ostrom and others, regarding fishing waters, irrigation projects, and other applications, arguments have been made concerning what sorts of systems/conditions would invite the free-rider problems, such as scenarios involving a tragedy or collapse of these systems or a comedy-continuation scenario, as well as if a system for resource management could be successfully implemented. Research discussions and case studies concerning game theory, collective action logic, and the feasibility of systems of self-governance/self-organization have been offered.[5] Additionally, there are suggestions, based on the social capital theory put forth by Robert Putnam (1993) and informed by the new institutional approach used in recent years, that ask unanswered questions of how, and for what reasons should, we establish systems designed to overcome the problems of collective action. New perspectives in the commons research, based on the theory of the commons as well as concepts of jurisdictional and environmental governance, have been put forth in recent years, including the ecologically supportive economic activities, known as the concept of regionalism, practiced by the entropy school in Japan since the 1970s and Hirofumi Uzawa's theory of "social common capital" (2000) which introduces the concepts "locality" and "spatiality" with regards to the management of the scarce resources necessary to support peoples' lives and activities. In this paper, we will consider the ways in which local collective management can be structured, including the relationships of people and organizations outside of the collective entity, as a theory of CPR governance.

3. Methodology

The research methodology involves field research concerning the structuring of CPR management systems. It is considered how natural water resources—either found underground or circulated by the natural environment—are allocated legally, organize a discussion of the public and private ownership of water resources, and then scrutinize the efficacy of governance and management by an administrative system based on the self-organization of diverse governing bodies (as opposed to the efficacy of governmental oversight or privatization). The national research council's panel on the study of common property resource management has specified the following 3 viewpoints for consideration:[6]

1. How do multiple levels of management interact and affect performance?
2. What is the effect of group size on the performance of institutional arrangement?
3. What are the roles of different mechanisms for dispute settlement?

4. Analyzing the Kumamoto groundwater basin policy

The policy issues surrounding water are related to the management of critical CPRs that impact the sustainability of regional communities. If the various stakeholders, such as water suppliers, farmers, livestock producers, and manufacturers continue to use large quantities of good quality groundwater at low prices while continuing to plan how to reasonably maximize their use—in other words, if the rate of consumption of this seemingly unlimited groundwater

resource exceeds the rate of recharge—they run the risk of exhaustion, the risk of groundwater pollution from farmers and manufacturers, and the risk of incurring tragedy as land subsidence and the infiltration of seawater inland decreases due to excessive pumping. On the other hand, if we are able to suitably manage groundwater retention in groundwater basins, regional communities as a whole will be able to continue to enjoy the benefits of these sustainable resources.

In the Kumamoto city metropolitan area, the rainfall and water drawn from the Shirakawa river by Ohzu and Kikuyo town, midstream adjacent to Kumamoto city for farming, is contained in the Aso pyroclastic sediment, the Togawa lava, and layers of pebbles in the ground. This water easily permeates through the ground to farmlands and forests, and recharges again underground. Thanks to this mechanism of the hydrological cycle, groundwater is plentiful in the fields of Kumamoto (refer to Figure 1). The people of Kumamoto's towns and villages, including Kumamoto city, have long used these groundwater resources for drinking, farming, livestock cultivation, and manufacturing. Japan benefits from the ample rainfall from the Asian monsoon season,[7] although today most towns rely on surface water from marshes and rivers more than groundwater; this is due to demands for groundwater, caused by the economic development of many towns, exceeding the capacity of groundwater basins, as well as to issues concerning decreased land subsidence from overuse. The Kumamoto region is the only region in Japan with a population exceeding 1 million people that is able to satisfy its demand for water entirely through the use of groundwater. Even in the case of regions blessed by such abundant natural resources, these areas do not have any capacity to utilize surface water. It must be protected the sustainability of these groundwater resources as the lifeline of these regions.

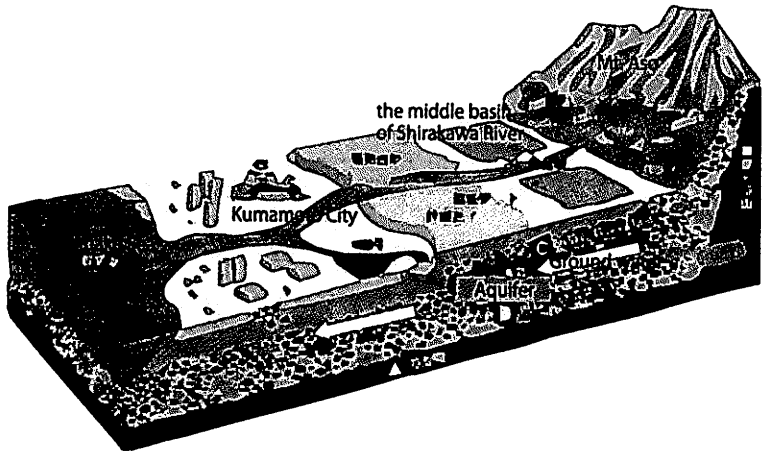

Figure 1 Geological cross section in Kumamoto area (Source : "Kumamoto Water Life")

Sustainable preservation of groundwater resources is a difficult issue, entangled with social dilemmas of how to govern and manage CPRs. Contemporary urbanization and changes in farming methods are creating adverse biases[8] in the water budget cycle, which is comprised of rainfall, ground permeation, recharge, use, runoff, and evaporation. There have been long-term observations of a decline in the level of groundwater in the Kumamoto region aquifer.

Companies and private homes have implemented water-saving measures, factories are planning to introduce recycling technologies, and cities have been able to reduce their consumption of groundwater in recent years.[9] However, the primary cause of the ongoing decrease in groundwater levels has been the subject of long-term research on groundwater conducted by the hydrologists Jun Shimada et al. Their research has clarified that development, urbanization, and changes in farming methods in the midstream Shirakawa river area as well as the groundwater recharge region have all continuously reduced the amount of water able to permeate the land to groundwater basins, which has created an imbalance in the flow of the water.[10] Due to complex causes—such as the fast urban development, the conversion of farmlands to residential spaces, decreases in the number of rice paddy fields due to national acreage reduction policies, greenhouse cultivation, pavement of roads, and improvements made to runoff basins and riverbanks—rainfall discharges into the ocean, with no opportunity for it to seep into the ground. These circumstances can also explain the increase in the amount of water at the mouth of the Shirakawa river.[11]

Additionally, policy constraints, such as the fact that the issues surrounding groundwater preservation in the Kumamoto region exceed the scope of the numerous regional governing bodies (Kumamoto city regulations alone restrict the development of effective groundwater preservation policies) are some of the border transgression issues encountered. Policy boundaries are a basic unit of an important political stratum, and from within this stratum come provisions of policy service and cultural centripetal force. However, it is also a source of unwieldiness, due to the administrative division of natural phenomena. Furthermore, the lack of methods for regulating a society's demand for low-priced groundwater use, changes in the environment due to contemporary urbanization, and changes in farming methods have all become causes for distortion of the hydrological cycle, in addition to making it challenging to develop effective groundwater preservation policies.

In providing conclusions first, paddy field replenishment projects located in the middle basin of the Shirakawa river, such as the efforts of farmers from Ohzu and Kikuyo town to "fill the rice fields with water", have been implemented as part of a "hydrological cycle-based agricultural movement" led by public-private collaboration. Based on knowledge obtained from groundwater research, this method has been used effectively to inject water into the groundwater basin and produce some desired effects. In the middle basin of the Shirakawa river, water is taken from the river and directed into paddy fields through agricultural water channels managed by the land improvement district office. This water is used for rice cultivation throughout the entire area. The water used to fill the paddy fields is transferred from highly permeable farmland (draining paddy fields)[12] to the groundwater pool located in the Kumamoto area. This procedure recharges approximately 90 million m^3 of water as groundwater. Geologically, this area is the ideal place for replenishment to occur: Surface water is injected into aquifers to replenish them. The following factors contributed to the effective recharge of groundwater in the Kumamoto region[13] : (1) Collaboration has occurred with the hydrological cycle-based agricultural council. The council attempts to conduct groundwater recharge using regional

agricultural activities whose decline has been caused by a reduction in rice acreage. (2) A system has been established to overcome cost issues. Corporations and administrative bodies are asked to provide subsidies to farmers. No legal system that addresses groundwater has been established in Japan. Therefore, the legal characteristics of groundwater as public or common water have not been clearly defined. However, the creation of an extended regional groundwater conservation system by a variety of multilayered entities (e.g., local governments, including prefectures, municipalities, corporations, land improvement district offices, agricultural co-operatives, and farmers) appeared to be an effective way to ensure sustainable groundwater management. From the standpoint of the "commons theory", it is interesting to examine a case in which the management system was built by an entire region in response to a social dilemma. In this case, one becomes a free rider who cannot be being held responsible for groundwater recharge, despite that fact that groundwater is shared by various entities.

How did this agreement to cooperate evolve? How did this agreement evolve into the current system? Additionally, what did the main actors intend to achieve with respect to the conservation of the commons? First, based on a number of analyses, this paper attempts to determine who owns water, particularly with respect to the settlement of groundwater ownership issues. Second, this paper examines how a hydrological cycle system that transcends administrative districts' boundaries became actualized.

(1) Who owns groundwater?

Water is required to maintain life. What might occur if people seized this resource and asserted their rights to possess or occupy it? The issue of ownership rights related to nature has been a topic of discussion in sociology and anthropology for many years. These discussions have revealed that issues that involve natural scientific mechanisms that operate during the groundwater cycle, relationships between nature and humans, and issues related to human relationships are interwoven.

Initially, nature (i.e., mountains, fields, rivers, and oceans) was "not owned by anyone". It was considered a free resource unhampered by ownership. Many countries have historically maintained common land (e.g., forests and grasslands), fisheries, and irrigation as common resources. As modernization continued to occur, the establishment of user agreements became increasingly important to prevent competition and conflicts of interest. However, it is ironic that nature became depleted and polluted as the rule known as "ownership" became more stringent. Based on anthropological studies, the world's ownership system can be categorized into four types: open access, private property, communal property, and state property. Yet, the use of traditional resource management methods, such as communal property, dissipated as the modern concept of ownership grew more popular. Anthropological studies have demonstrated how the management of common resources once lost was conducted. However, it is also possible to determine that a relationship in which public use by landowners and private use by residents in the same region occurred simultaneously. They coexisted without excluding one another. Policy science must decide the type of CPR management system that modern society might create.

Japan introduced the French civil code (the Napoleonic code), which was derived from original Roman laws. When Japan first established a legal system as a modern nation, it created a draft of the old civil code that permits the system to recognize public properties (e.g., rivers and flowing water) as a concept of modern ownership. However, Japan underwent a civil code model dispute that centered on whether French civil code or Prussian civil code concepts should be used as references. In 1896, the country adopted the current civil code, which incorporates the legal principles of the Prussian civil code. The Japanese civil code only recognized two types of ownership: state-owned land and private land. The civil code stipulates modern ownership rights. However, the concept of "public ownership" was omitted from the legal system. Gradually, the country began to adopt the concept that states that properties that were not privately owned would be considered state-owned properties. This denies the concept of "public property" that, in Western terms[14], "is accessible to and can be used by anyone". At that time, the decision to place mountains, fields, ocean, and rivers under state ownership was included in a tax reform that collects taxes from users.

With respect to water, the types of water located close to human life (excluding oceans) can be categorized into surface water (e.g., rivers, lakes, and marshes) and groundwater. In Japan, rivers were classified as public water by the old river act, which was enacted in 1896. The act stated, "The flowing water in rivers cannot be used for private purposes". It continued, "exclusive use of flowing water means the use of flowing water is based on licensing". Since ancient times, river improvement and irrigation have been considered significantly important matters. The nation must address these issues to encourage the development of civilization and cities. When Japan enacted the civil code and the river act for the first time as a modern nation, the use of all river water was based on a licensing system, except for water traditionally used for agricultural purposes. The exclusive right to use flowing water by obtaining a license is known as "water rights". River management bodies (i.e., national and local governments) are authorized to determine and issue water use licenses based on their determinations of whether those licenses will enhance the public welfare, as well as on the relationship between the volume of river flow and the amount of water to be extracted from the river. During the middle of the 20th century, individual laws were established to ensure the systematic planning of river improvements and water use (e.g., the development of power resources, water supply, industrial water, and dam construction). In 1969, the new river act was enacted to ensure the systematic management of river improvements and water use under a consistent water system. Additionally, the "environment" was added as an objective of the river act in 1997 in an attempt to establish a comprehensive river system.

As mentioned above, river water was placed under the national government's management. However, groundwater was not included within the scope of that management. The law (article 207 of the civil code) stipulates that land ownership "ranges from the space above and below the land within the limits set forth by the laws and regulations". Groundwater is now considered private property (private water theory). Although legal precedents accumulated throughout the course of trials that involved groundwater and hot springs, the supreme court of

judicature rendered a verdict in 1896. It stated, "The right to use water seeping into the ground exists primitively along with land ownership". Although "public water" was discussed and suggestions were made to limit water pumping to prevent subsidence, to date, Japan has not yet changed its legal position: Groundwater use is fundamentally available for exclusive use by landowners. Therefore, no agreement has been reached as to whether groundwater should be defined as "public water". Currently, groundwater is not fixed to each individually owned land section. Groundwater is clearly recognized as a common resource that possesses fluidity. Yet, from legal perspectives, rules for groundwater use must be devised by adjusting private rights, rather than by actions performed by governments. Under this type of circumstance, transaction costs for negotiations that involve groundwater recharge will be expensive because of the increased numbers of stakeholders, and because of complications that have developed and will continue to develop during negotiation processes. In particular, groundwater recharge has created social dilemmas[15]. It can be difficult to institutionalize a method that will effectively address the paradox that exists between individuality and totality, as well as the free rider problem.

In Kumamoto, local government ordinances, such as the Kumamoto prefectural groundwater conservation ordinance and the Kumamoto city groundwater conservation ordinance, have recognized the characteristics of groundwater as "public water" or "common water" to compensate for legal defects and to ensure the legitimization of the resource management system. In addition, these ordinances stipulated that business owners, administrative bodies, land improvement district offices, farmers, and citizens must collaboratively participate in groundwater conservation and devise methods to ensure its status as a common resource at residents' awareness levels[16]. Rather than including administrative bodies and bureaucratic organizations, these ordinances capitalize on the strengths by which a small community can become an autonomous management body for common resources. The distinctive aspect of this co-management system lies in its nested system structure.

In addition to the fact that groundwater has not been recognized as public water, a challenge exists in the fact that flowing water is managed by governments, such as national and local authorities. At issue is the fact that administrative bodies that manage rivers interpret legal objectives restrictively. They fail to justify the objectives of broad environmental conservation, such as groundwater conservation, as reasons to permit the extraction of river water. All available paddy fields had already been used and groundwater recharge projects had been implemented in the middle basin of the Shirakawa river. Yet, river management personnel raised objections because the utilization of agricultural water by the exercise of traditional water rights[17] was still considered usage other than for intended purposes. Therefore, the groundwater recharge project was approved when a land improvement office provided justifications: The replenishment of paddy fields effectively eliminates pests from the soil. Nutrients contained in river water enrich the soil and contribute to agricultural activities. To maintain the hydrological cycle in the Kumamoto region, it is essential to extend efforts to inject water into aquifers located in other groundwater recharge areas. However, the use of river water for groundwater recharge requires that applicants file license applications with river management personnel to

obtain water rights. In addition, the costs involved to follow procedures required to obtain water right licenses present major obstacles. Different management bodies manage different types of water[18]. Administrative entities are organized based on a vertical hierarchy. These factors have created barriers to community activities that attempt to protect the public's interest in groundwater conservation.

With respect to the conduct of groundwater resource management without reliance on government regulations and management, Ostrom's analytical research on the groundwater basin conservation system employed in the Los Angeles metropolitan area in the U.S. can be used as a reference. Therefore, this paper provides a brief summary of her analytical research[19]. Because the quantity of groundwater and the mechanism used in the hydrological cycle were not clearly understood, water users argued that water resources were still sufficiently available, even though the optimal level of water use restriction had not been determined and was becoming an issue. This exacerbated problems that involved severely declined groundwater levels and saltwater infiltration that developed because of continuous overdraft by pumping race. Based on common law, California water rights state that overlying landowners and water producers who possess appropriative rights can claim exclusive rights to pump water within the limits of groundwater resources. Water producers consist of public and private water companies. A surplus of groundwater resources can be used by individuals on the next priority level as long as they do not negatively affect the benefits of overlying landowners and water producers who possess appropriative rights. However, when the amount of groundwater resources is inadequate, adjustments will be made by the court based on the principle of "first in time, first in right". Thus, acquired rights depend on their history of use.

Under this type of system environment, the scientific measurement of the groundwater basin's capacity is required to restore groundwater to a healthy hydrological cycle as the commons. To protect the individual rights of each groundwater rights holder, private negotiations must be conducted that will encourage stakeholders to accept equal restriction levels. Ultimately, this will achieve sustainable water pumping levels. The principal of "mutual prescription" has been created because of litigation that involved water rights. It has evolved into a legal system that incorporates commercial and market principles by imposing restrictions equally—by sharing the cutback proportionally—and by approving purchases and sales of water rights. As Bates point out, the presence of collective benefits as a result of designing new institutions is itself a second-order collective dilemma[20]. Litigation occurs frequently in the U.S.. Thus, a significant amount of time and money is required to obtain agreements that restrict individuals' water rights among many entities. During these processes, groundwater basins continue to suffer catastrophic damage.

An attempt was made to devise a method based on scientific information to prevent "the tragedy of the commons." Simultaneously, local governments and heavy water users, such as water suppliers, conducted discussions focused on hydrological cycle conservation. Ultimately, the following method was created. First, main stakeholders must agree on a conservation plan in which all groundwater users accept an equal rate of water pumping restriction. Production

levels for producers must be ascertained. The geological structure and inflow levels for a large and complex basin must be determined. Next, the agreement must be submitted to the court to obtain approval for the groundwater conservation plan[21] and to authorize legal enforcement of the content of the conservation plan on parties who do not participate in the agreement. The court must appoint a watermaster to serve as an impartial expert. The watermaster will be responsible for groundwater monitoring. He/she will periodically disclose information based on whether each entity pumps water appropriately. The watermaster will impose official and unofficial penalties on violators. Two-thirds of the watermaster's activity expenses will be provided by water producers. If the level of the watermaster's job performance is considered inadequate, then a request to appoint another watermaster could be filed with the court. Along with negotiations that involve these water rights holders, public organizations, and the court, the water replenishment district was created to conserve groundwater resources by obtaining an agreement from the state legislature and approval from local residents. The establishment of a special tax (taxing power for the new district) was also granted. This institution was not created to place groundwater under government management as public water. Rather, it attempts to monitor the hydrological cycle and share information that might restrict consumption by water producers. This institution promotes groundwater recharge while working collaboratively with other organizations that possess minimum budgets and staff members to encourage the continuous use of private water.

Efforts in groundwater conservation led to many agreements through negotiations not only in the entire region but also among areas that share the groundwater basin. However, the study revealed that neighboring groundwater basins affected one another because of their relationship with river systems, even with bureaucratic boundaries demarcating the entire area. In the west basin, where conservation efforts were informed by lessons from earlier discussions in the Raymond basin, actions were taken to build on the latter's experience and save on negotiation costs and time to achieve effective groundwater conservation; a conservation system that operated at 1/10th of the social cost observed at Raymond basin was developed. Similar discussions occurred at the central basin, which covers a larger area and number of groundwater users. However, the large number of stakeholders and discrepancies in crisis awareness among local areas complicated the agreement process. The groundwater basins in the west basin and central basin were later found to be connected. Districts with different interests formed the central and west basin water replenishment district after strenuous negotiations.

Ostrom focused on a case in which commercialization protected the CPR. She discussed the conditions in which commercialization should occur to maintain and manage CPR, and pointed out that instead of one central governmental authority, a polycentric public-enterprise system can achieve a very sophisticated management system. As for the management of CPR, such as groundwater, an effective management method by stakeholders may exist alongside direct management by the government. However, in some cases, such a system may work effectively and evolve in one area but fail to function in another area. Groundwater resources in the Kumamoto region do not operate under a bureaucratic management or by the conservation logic

that aims to protect private properties through exchanges of lawsuits observed in the United States. Water is seen as a collective property in Kumamoto rather than a commodity. The following section discusses how the region established governance and management of water as a commons while eliminating free riders.

(2) Development of a Trans-Bureaucratic Water Cycle System

Kumamoto city and 10 nearby municipalities share a groundwater basin. They are geographically inseparable with respect to the water resource on which they depend. Abundant groundwater use was historically common, although awareness differed among local municipalities and users in terms of the need to conserve groundwater. Kumamoto city has had a sense of crisis over the quantity and quality of the resource from early on, but studies have shown that conservation efforts by the city alone are insufficient for the effective conservation of groundwater, which cannot be achieved without recharge efforts in midstream areas, such as the area of Shirakawa, a neighboring municipality. Civil groups and researchers started to engage in campaigns for awareness and civil movements to raise an issue over the importance of groundwater; that is, to increase awareness of groundwater as a valuable resource and as a commons that must be managed by the entire region. These pioneering groups intended for such an understanding to be embedded in the community. Meanwhile, areas that had previously engaged in recharge efforts via by-products of their agricultural activities unintentionally brought great benefits to Kumamoto city, although their choice to recharge as a municipal policy was unlikely a rational action under the public choice theory. The issue of securing an external economy was crucial to solving this problem.

Despite persisting issues, the system of groundwater conservation evolved as a result of cooperation between Kumamoto city and neighboring municipalities and the Prefecture, as well as among land improvement districts that manage irrigation, Japan agricultural cooperation (JA), and private companies. As such, why did a policy of conserving groundwater by the prefecture and 11 municipalities become a reality? Modern society is relatively weak in conserving the commons, and public management by the government or division as private properties is often advocated as a means to discard free riders. Neither approach was taken in the case of Kumamoto; instead, multi-layered and diverse local actors created a unique governance system, placing groundwater as a regional common property. The following section discusses the development of this conservation system, while also looking at the history of participation by public administrations and private organizations.

As shown in table 1, Kumamoto prefecture, Kumamoto city, and private companies have developed a city declaration as well as outlines, regulations, plans, and foundations to create a governance framework for groundwater conservation in the Kumamoto region[22]. Kumamoto city, which is dependent on groundwater, took the first initiative for conservation of water resources by declaring that "groundwater is a precious resource to be shared by the region" in a regulation, also considering areas other than the Kumamoto region that depended on groundwater in the prefecture. The city also strengthened regulation of large-scale groundwater

extraction by enforcing measures, such as notification, permission, and reports on the quantity extracted. Policy measures for the conservation of water quality were also devised to mitigate the impact of nitrates used in agriculture and pollution from industrial discharge.

Table-1 Development of management system by public and private organizations

Year	Kumamoto city	Kumamoto prefecture
1976	Declaration of city groundwater conservation	
1977	Enactment of Kumamoto city groundwater regulation	
1978		Enactment of Kumamoto prefectural groundwater regulation
1988	Establishment of groundwater quality conservation outline	
1990	Launch of Kumamoto city water science museum	Enactment of prefectural groundwater quality conservation regulation
1991	Kumamoto city and others establish Kumamoto groundwater foundation	
1992	Establishment of Higo water resources humane foundation by private institutions, including Higo bank	
1994		Development of the first Kumamoto prefecture water resources comprehensive plan
1996	Development of the first comprehensive plan for the conservation and management of groundwater of Kumamoto by the prefecture and Kumamoto city	
2001		Merging of two regulations; enactment of Kumamoto prefecture groundwater conservation regulation
2003	Sony and farmers from midstream of Shirakawa reach an agreement and begin an environmentally neutral project for groundwater recharge.	
2004	Enactment of Kumamoto city groundwater conservation plan. Groundwater recharge project by ponding of uncultivated paddies begins under an agreement with the midstream region of Shirakawa.	
2008	Revision of the Kumamoto city groundwater conservation regulation	Development of the second comprehensive plan for the conservation and management of groundwater of Kumamoto
2009	Development of the Kumamoto city groundwater conservation plan	
2012	Kumamoto groundwater foundation is established, with funding from the prefecture, 11 municipalities in the Kumamoto region, and contributions from the Ohzu-Kikuyo water business association. The foundation engages in groundwater surveys, groundwater quality conservation measures, advancement of groundwater recharge and moderation of its consumption and use, and branding of rice cultivated in the recharge areas	

Despite the formulation and implementation of the existing regulation, the legal definition of groundwater remains unclear[23]. Rivers are managed publicly as public water, but groundwater has been legally interpreted to be under the exclusive rights of landowners. However, control through regulation by local administration was attempted for the following reasons. First, the gravity of the problems, such as land depression caused by excessive extraction in large cities during periods of economic growth, could not be addressed under the condition of free and private consumption of the groundwater basin. Second, a need for management going beyond the administrative boundaries was recognized.

Wasting of groundwater, a resource with properties of the commons, was sufficiently controlled through administrative regulations. However, CPR management continued to face a serious issue regarding measures against the large impact on the mechanism of nature by changes in economic society, such as a decrease in recharge area due to urbanization and changes in the cultivation pattern in agriculture due to adjustment in rice production (50% cut in production area). Constructing rules for groundwater use without being dependent on the government is problematic as negotiations among actors involved over the groundwater recharge entail transaction costs. An increase in stakeholders is an ill-structured policy issue[24] because it convolutes the negotiations over cost burden[25].

The development of a concrete system focusing on recharging groundwater originally began as a result of actions by civil groups and companies[26], before local administrations moved for the regulation. In March 2001, a Non-profit organization "Environmental Network Kumamoto (Kankuma)" submitted an open letter on the "use and conservation of groundwater" as a joint statement with Kumamoto water environment committee to Sony, which built a factory in Kikuyo. The company responded in May, and voiced an intention to disclose the groundwater use plan of the factory and take actions toward groundwater recharge as an enterprise. Sony semiconductor Kyushu environmental strategy division, Kumamoto groundwater study group, and Kankuma evaluated specific methods of recharge, and set the goal of achieving zero environmental load by recharging in the Kikuyo and Ohzu areas the same amount of water as the amount of groundwater used by the factory. After making adjustments with members responsible for the management of farmland upgrade and irrigation in the Ohzu-Kikuyo area, including Oh-kiku land improvement district, Kikuyo town office, and JA, a recharge project based on an agreement with Sony began in 2003[27].

Kumamoto city, which had been considering a similar project, approached Oh-Kiku land improvement district to implement a similar project in 2004. The agreement was imported to the city with the Kumamoto prefectural governor in attendance; the system developed with Sony was in a greatly expanded form using converted paddies. A scheme was developed for private companies to pay subsidies to cooperating farmers based on the area and duration of use of the paddies[28]. The recharge project can be operated from May to October. In 2004, the recharged volume was 300 ha and 873 m^3, and expanded to 629 ha and 1,888 m^3 by 2011. At present, almost all idle paddies in midstream Shirakawa area are used for recharge. Diverse groups, including universities, Kyushu-Okinawa agricultural research center, JA Kikuchi soil analysis

laboratory, Kankuma, and Eco-partner Kumamoto, joined together for groundwater surveys and information exchange to support the structuring and operation of the system.

Public administrations structured the bureaucratic environment through groundwater surveys and creation of regulations, whereas the concretization of groundwater recharge policy in Kumamoto was a product of efforts by civil groups and private companies to improve the environment. Studies on groundwater revealed a mutual relationship in which farm work by farmers in the Shirakawa midstream area brought benefits to Kumamoto city, whereas farmers in areas with poor benefits contributed as part of their farm work without realizing the costs. According to game theory, cases in which self-serving actors take altruistic actions are limited. In a simplistic communality debate, such altruistic actions that maintain the commons is not induced. Such a scheme that exceeds the limits of the prisoner's dilemma game is embedded in this hydrologically cyclic farming project. Participating actors in this groundwater conservation game is not dominated by a one-time prisoner's dilemma game, but rather interpreted as a multi-player and endless "N-person prisoner's dilemma game[29]" where communication is also possible. The scheme of this project is as follows:

① Subsidies are paid by the city and companies to farmers cooperating in the recharge.

② Reduction of transaction cost is attempted through recruitment of partner farmers, confirmation of recharge, payment of subsidies, and unification of conditions for the subsidies by cooperation among members of hydrologically cyclic agricultural practice advancement committee, including the land improvement district and JA[30].

③ Universities, relevant institutions, JA, and civil groups are involved in recharge studies.

④ Regulations and awareness programs for groundwater conservation are coordinated by government institutions, including Kumamoto prefecture and Kumamoto city.

Through this public-private project, various local actors could simultaneously solve the cost burden and cut negotiation cost by earning cooperation from farmers. In advancing this new policy, the prefecture and the city promoted hydrologically cyclical agricultural practices by designating groundwater as a common resource and a source of pride for the Kumamoto region, while also pushing, in parallel, a policy to entrench the value of groundwater as a CPR into local communities through soft approaches, such as awareness and educational programs, civil movement for groundwater recharge, and other campaigns. As a result, rather than viewing themselves as poor beneficiaries, farmers in the Shirakawa midstream area enjoyed both the economic benefit of earning subsidies by cooperating in the recharge, despite practicing unprofitable rice cultivation, and the value in participating in groundwater conservation activities under the awareness that they are local residents that share the groundwater basin of the Kumamoto region. In other words, a local characteristic that recognizes the value of groundwater conservation activities as a CPR was conceived, in which the will to self-govern was shared among the people in the local area to foster the idea of "our groundwater". In an opposite sense, a comprehensive management system for the regional hydrological cycle was

created by altering the culture with respect to water and the perceived framework.

Instead of the government monitoring and performing groundwater management, local rule was created by self-governing and self-organizing entities, as well as local communities that shared the groundwater basin. By keeping the civilian initiatives as a preamble, a scheme was created in which civilians, businessmen, and organizations involved in the water supply secured the financial resources for the ground water conservation project, sharing the cost of 0.3 yen per 1 m^3 of water consumption.[31] This scheme presents yet another hope for overcoming the social dilemma problem. Furthermore, even though the local community is itself is a stratified, wider community consisting of several administrative bodies, it came together as a single local community as around the conservation of the groundwater basin.

In contrast to this is the conservation of groundwater basins and groundwater replenishment in recharge areas in the United States of America, where many enterprises that possess exclusive water rights on groundwater carried out "The water-rights game", "The litigation game", or "The entrepreneurship game" with strategic negotiations and vested interests intended to protect the substantial profits of these enterprises. Groundwater negotiations gradually turned into a "complex polycentric public-enterprise game". Through the negotiations between many regions, it was possible to form a new management system that would avoid destruction. Sure enough, CPR conservation in those regions is achieved through self-governance and self-organization. However, a cultural difference is seen in the formation of the groundwater resource system. The conservation measures of the "commons" that came from the theorization of CPR of the locality in Kumamoto are different from the American case, which is the result of the competitive game between several business entities trying to protect their water resources profits.

5. Conclusions and Future Study

If the basic culture of the society differs, the institutionalization of the conservation of the groundwater CPR (which also differs) becomes effective. Many "commons", which were conserved throughout the world prior to modernization, became exposed to the risk of collapse in modern society. Resource management measures were implemented through one of two methods, namely (a) government management or (b) management by dividing resources into private property. Nevertheless, while creative problem-solving ideas were needed, it was determined that it is possible to create a new CPR management system in areas where local rule can be conceptualized. At times, we can anticipate a flexible and continuous conservation of the "commons" by leveraging regional characteristics and government management.

Regarding the challenges of substantive ground water conservation, the fact that (a) ground water is shared beyond the limits of the administration, and (b) the benefitting regions and those regions that bear the cost of recharging groundwater are different made it difficult to resolve problems. However, it was possible to strengthen the resilience of CPR (groundwater basins) by forming a reimbursement scheme in which multiple entities (people working together on groundwater conservation) participated, including administrative bodies, land improvement districts, business enterprises, farmers, agricultural cooperative bodies, and NPOs. The regional

groundwater conservation initiative of Kumamoto is considered one of the success stories of local management of the "commons"; in 2013, this initiative won the highly prestigious UN award, "WATER FOR LIFE". The progress of scientific research on the evaluation methods for monitoring the groundwater conservation, visualization, etc. was necessary for the formation of these measures. Again, it is considered that the awareness activities of the citizens group and business enterprises, which reframed the knowledge on "commons", were successful in achieving the same.

However, an important challenge that was left out was water quality. An effective means to stop the spread of contamination from the use of agricultural fertilizers, as well as drainage from citizens, has not yet been found. Though research on hard (technical) preventive and decontamination measures is underway, research on soft conservation measures has just started. On the agricultural-measures front, agricultural groups and administrative bodies have started various schemes, including (a) introducing catchy phrases like "Eco-friendly farming" and (b) reforming farming methods to be eco-friendly by minimizing fertilizer and pesticide usage while maintaining profits for the producers. Unfortunately, these schemes have largely not yet become effective due to (a) the difficulty of the farming methods that reduce fertilizer and pesticide usage and (b) the fact that consumers prefer cost-effective products over eco-friendly products. The numerous, low-cost fertilizers customarily used by individual farmers have also become a limiting constraint and can be considered another challenge.[32]

Therefore, an important point is how to change the conditions in which economic costs outweigh the benefits of water quality into conditions more favorable for the environment. The only way to do this is by (a) spreading knowledge about the time it takes for contaminations to spread, due to ground water mobility, and the time required to rehabilitate groundwater, and (b) fostering a culture that is sensitive to water quality. A hint for effective measures comes from the lake Biwa water conservation movement, a successful social movement in which people were encouraged to observe nature and be aware of the movement to use soaps instead of chemical detergents.[33] Furthermore, in Miyakojima island, the fertilizer overdose from sugarcane cultivation was the primary cause of the poor groundwater quality. The measures taken by the government to resolve this issue did not function effectively at all. However, when the sugar factories changed their purchase price to depend on sugar content, instead of sugarcane weight, farmers began devising watering and fertilizing methods that increased the sugar content. As a result, they unintentionally reduced the nitrogen-nitrate concentration in the groundwater.[34] While considering the management measures of the "commons", it would be more effective to flexibly analyze the various possibilities that produce effective results, instead of just controlling the mechanisms by a direct-causal relationship.

Acknowledge

This work was supported in part by CREST program "Sustainable groundwater management system based on regional hydrological cycle", MEXT, Japan.

(This paper was reported at the 2015 International Conference The Asian Association for Public

Administration in January 8th, 2016 in Xi'an Jiaoton University, China, and it was selected as Best paper award.)

Notes

1) A groundwater basin is "a large-scale aquifer or a hydrogeological unit that includes multiple aquifers connected to each other" ("Science of ground water" Ida, Tetsuji, Japanese association of groundwater hydrology, Kodansha, 2009") .
2) Academic terms like the commons, common pool resources, common resources are used when dealing with problems like shared resources. The term CPR is used when indicating resources where (a) the exclusions are weak, (b) there is strong competition for open access, and (c) nobody pays for its conservation. In a broader sense, the expression "commons" is also used when discussing shared natural resources like forests, pastures, fisheries, groundwater, irrigation, etc., and their management. Today, it also covers cultural sphere. "public goods" is a good like air, national defense to which everyone has access but, unlike a CPR, non-rivalry and non-excludability.
3) Tanaka, Shigeyoshi, "Commonality of rivers - To whom does water belong?" Shimizu, Hiroyuki, Hiyama, Tetsuya, Kawamura Noriyuki, 2011, pp. 263-282.
4) Though nationalization was largely carried out in developing countries with the objective of protecting natural resources, it disrupted the existing system for conserving resources and regional activities. Additionally, a weak monitoring system caused further collapse of the commons. Furthermore, the principle of open access elicited competitive consumption.
5) Ostrom et al.'s research was criticized for operating in conjunction with the resource management measures in developing countries that received assistance from huge organizations like the world bank. Therefore, as the various commons were nationalized, new challenges emerged during the process and that led to the research being promoted. (Mitsumata, Gaku, "Revisiting the theory of commons", Makoto Inoue edition, 2008, pp. 45-60.)
6) National Research Council, 2001, p.15.
7) The average annual precipitation in Japan is about 1720 mm. It is 1990 mm in Kumamoto.
8) Kayane, 1992.
9) The total collection of groundwater in 1991 was 240,000,000 m^3, but it decreased to 186,000,000 m^3 in 2006. Although there was a marginal increase in overall water supply, the water supply for building and industrial, agricultural, and aquacultural uses has decreased.
10) Shimada, 2011.
11) In the lower basins of Shirakawa, such as Yotsugibashi, the average flow rate observed was 710 million m^3. However, it was 910 million m^3 from 1980 to 1997, and has increased by 200 million m^3 in 20 years.
12) The daily water reduction rate of paddy fields is as large as 100 mm.
13) There are three important groundwater flows in Kumamoto and the surrounding regions. They are: water that flows to the west, towards the Kumamoto plains from Shirakawa river

basin via spring-water sources like Ezuko lake; water that flows from the foothills of Mt. Kinpozan and the Ueki plateau to the south towards the Kumamoto plains; and water that flows from the Mifune locality in the southeast towards the Kumamoto plains. Currently, groundwater replenishment is carried out only at the Shirakawa river basin.

14) As a result, for example, expressions like "Keep off the State owned land (Public land)" are being recognized and accepted even now.

15) Social dilemma: "The conflict that results when an individual's rational choice in a society is not in agreement with the optimal choice of the society as a whole".

16) Kumamoto prefecture groundwater conservation regulations and Kumamoto city groundwater conservation regulation: Each of the groundwater conservation regulations is an explicit ordinance by itself, mapping the groundwater commons with the recognition of expressions like "common water" (water that has commonality) and "public water" (ground water that is the property of all citizens).

17) In areas where water was being used before the enactment of the river regulation, the customary water rights were approved even after the enactment of the regulation. While the total number of water supplies account for 81%, the supply from rivers is small, at about 29%.

18) The ministry of land, infrastructure, transport and tourism manages rivers only; the ministry of economy, trade and industry manages the industrial water only; the ministry of agriculture, forestry and fisheries manages agricultural water only; the ministry of environment manages land subsidence only. As such, there is no single administrative entity manages all of the water resources.

19) Ostrom, Elenor, 1990, Chapter 4. Here, Ostrom established the institutionalization of groundwater management by negotiations and lawsuits with various organizations, and she has given a detailed analysis on the process for alterations and changes.

20) Bates, R. H. "Contra Constractarianism: Some Reflections on the New Institutionalism", Politics and Society, 16, 1988, pp. 377-401.

21) The case was referred to the division of water resources of the California department of public works. (Ostrom, p. 117).

22) Matoba, Hiroyuki "Creation of a mechanism for regional groundwater management and rules for the self-governing organization". Journal of Grand Water Technology, 201, pp. 13-26. Oshima, Issei, "Current Situation of Water Environment Policies in Kumamoto Prefecture", Journal of Japanese Association of Hydrological Science, Vol. 40, 2010, pp. 135-143. Oshima, Issei, "Administration for Groundwater Management in the Kumamoto Area", Japanese Association of Groundwater Hydrology, Vol. 52.1, 2010, pp. 49-64.

23) Here, government means the country, and the local self-governing organizations.

24) Akiyoshi, Takao, Ito, Shuuichiro, Kitayama, Toshiya, "Foundations of Policy studies", Yuuhikaku, 2011, pp. 64-65.

25) Endo, 2011, pp. 204-221.

26) Retrieved from http://www.kankuma.jp/mondai/chikasui/Sony/Sony-PJ.htm (August 24,

2013).

27) Retrieved from http://www.sony-semiconductor.co.jp/kankyo/kankyo_kanyou (August 24, 2013).

28) A promotion council for farming based on the hydrological cycle was setup locally, with collaboration on the ground water recharge measures through the promotion of paddy field cultivation, and through the multiple functions of paddy fields. The organizing members are Shirakawa river basin-land improvement district, Ohzu town, Kikuyo town, Kumamoto city, JA Ohzu central branch, Kikuyo central branch and Kumamoto city eastern branch. Subsidies are borne by the Kumamoto city and business enterprises. (Sony, Kajitsuren, Kaketsuken (Chemo-Sero-Therapeutic Research Institute), Yamauchi Honten).

29) This situation can be said to be same as that of the assurance game and the game of chicken.

30) For 10a, the subsidy is 11,000 yen (83 euro) for 1 month, 16,500 yen (125 euro) for 2 months, and 22,000 yen (167 euro) for 3 months.

31) Collection of groundwater usage tax is difficult since it is not legally considered public water.

32) Considering the fact that excessive use of fertilizers contaminates the soil and adversely affects the following year's production, the salad onion farmers of the Fukuro district of Minamata city carry out a closely controlled cultivation in which the amount of fertilizer is sufficient for growth and does not remain in the soil after harvesting. This cooperative body encourages farmers to use environmentally friendly farming methods, and provides the strength and cohesion needed to implement production controls that (a) brand products by with strict quality controls and (b) lead to cost savings in district units.

33) The history of the "Lake Biwa soap movement" from the Lake Biwa (Soap) conference is a helpful reference. Retrieved from http://csspcat8.ses.usp.ac.jp/lab/ideken/sOhzuron/pdf/01mikito/01mikito_4.pdf (2011.3.4).

34) Interviews from Miyakojima city government.

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持続可能な地域のための地下水保全政策

上野　眞也

本稿は、地域の地下水資源保全を可能とする社会システムの構造と社会的ジレンマについて論じる。地下水は公共の資源であるが、わが国では法的に公水として位置づけられておらず、政府が中央集権的に地下水を管理・規制することはできない。飲料水や工業用水等凡てを地下水に依存している熊本都市圏では、企業、市民団体、農家の協働により、地下水涵養と保全システムが構築されてきた。フィールドリサーチを通して、諸団体による地下水保全の制度構築のための自己組織化や自治活動が、複数の行政界など種々の社会的ジレンマのハードルを越えて、コモンズとしての地下水を守るガバナンス構築に至ったメカニズムを解明し、コモンズの保全について政府の規制や私有財産化ではないオルタナティブな管理手法が有効であることを明らかにする。この研究は官民パートナーシップによるマネジメントの可能性を探求することにつながる。