Contribution to the session “Integrating Physical, Ecological, and Social Perspectives in Watershed Management Through Green Infrastructure” organized by Futoshi Nakamura

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Research and practice of climate change adaptation using ecosystem functions; the case of the Lake Imba watershed

Recherche et pratique de l'adaptation au changement climatique à l'aide des fonctions des écosystèmes ; le cas du bassin versant du lac Imba

Jun Nishihiro, Yuna Hirano, Kota Tawa, Noe Matsushima, Maki Osaka
Climate Change Adaptation Center, National Institute for Environmental Studies, Japan
nishihiro.jun@nies.go.jp (JN)

RÉSUMÉ

La gestion des écosystèmes à l'échelle des bassins versants permet de répondre efficacement aux risques croissants associés au changement climatique en cours, tels que les inondations, les efflorescences algales nuisibles et le déclin des populations d'animaux sauvages. Une gestion appropriée des écosystèmes nécessite une gouvernance par le biais du partage d'informations et d'une coopération mutuelle entre les chercheurs, les gouvernements, les groupes de citoyens, les habitants et les entreprises. Nous avons mené des recherches sur les fonctions des écosystèmes dans le bassin versant du lac Imba, au Japon. Nous avons ainsi pu clarifier quantitativement les fonctions des zones humides dans le bassin versant, telles que la réduction des risques d'inondation, la purification de la qualité de l'eau et la conservation de la biodiversité. Nous avons également vérifié que ces fonctions peuvent être renforcées par une gestion appropriée de l'écosystème, comme le maintien de l'état humide des rizières abandonnées. Ces dernières années, nous avons travaillé avec de nombreux acteurs pour mettre en place les organisations et les mécanismes de financement nécessaires à la gouvernance des bassins versants. Les leçons apprises ici seront utiles pour la gestion des bassins versants des rivières et des lacs dans d'autres régions du monde.

ABSTRACT

Ecosystem management at the watershed scale is effective in responding to the increasing risks associated with ongoing climate change, such as floods, harmful algal blooms, and declining wildlife populations. Appropriate ecosystem management requires governance through information sharing and mutual cooperation between researchers, governments, citizen groups, residential people, and businesses. We have been conducting research on ecosystem functions in the watershed of Lake Imba, Japan. As a result, we were able to quantitatively clarify the functions of wetlands in the watershed, such as reducing flood risk, purifying water quality, and conserving biodiversity. We also verified that these functions can be strengthened through appropriate ecosystem management such as maintenance of wet condition of abandoned rice fields. In recent years, we have been working with many stakeholders to establish the organizations and funding mechanisms necessary for watershed governance. The lessons learned here will be useful for the management of river and lake watersheds in other regions of the world.

KEYWORDS

natural flood management, nutrient management, biodiversity conservation, abandoned field, watershed governance

gestion naturelle des inondations, gestion des nutriments, conservation de la biodiversité, champs abandonnés, gouvernance des bassins versants

1 NEEDS FOR WATERSHED GOVERNANCE

It is reasonable to plan measures for water-related social issues, such as floods and eutrophication of lakes, at the watershed scale. In Lake Imba (Chiba prefecuture, Japan), as in many lake basins around the world, there is risks of flooding, toxic algal blooms, and biodiversity loss, and these risks are expected to increase with climate change. An approach that utilizes nature as infrastructure (Green Infrastructure), must be effective in addressing these issues. The author and collaborators are conducting research and practice to realize watershed governance utilizing Green infrastructure in collaboration with government, citizens, and private companies.

All of the following elements are essential for the realization of watershed governance: scientific information on ecosystem functions, collaboration among diverse actors, and financial mechanisms. We originally conducted research on ecosystem functions from the perspective of flood control and water quality management, as well as biodiversity in the Lake Imba watershed. Furthermore, from 2023, we have been conducting research and practice to establish collaboration among diverse entities and budget mechanisms.

2 SCIENTIFIC BASIS

2.1 Ecosystem Function and Biodiversity

2.1.1 Flood control

We have been conducting research on natural flood management in the Lake Imba watershed. In rivers flowing into the lake, there are cases where the upstream areas are developed as residential areas, and cases where natural forests and wetlands (often abandoned rice paddies) are left behind. It was clarified that when the wetlands were conserved, the time between heavy rainfall and runoff is about 10 times slower than in the urbanized case, and the amount of runoff is reduced to about 30%. Thus, preserving forests and wetlands in the upper reaches of rivers can help reduce the risk of flooding downstream.

2.1.2 Water quality control

Wetlands in the upper reaches of rivers have been found to help manage water quality. In the Imba watershed, nutrient loading derived from agricultural land has been found to be a major cause of eutrophication in the lake. In areas where there is a lot of crop fields on top of the plateau, the nitrogen concentration of spring water in the valley is excessively high. However, by allowing that spring water to pass through wetlands, nitrogen concentrations can be reduced to less than half (Figure 1, Kato et al. 2024).

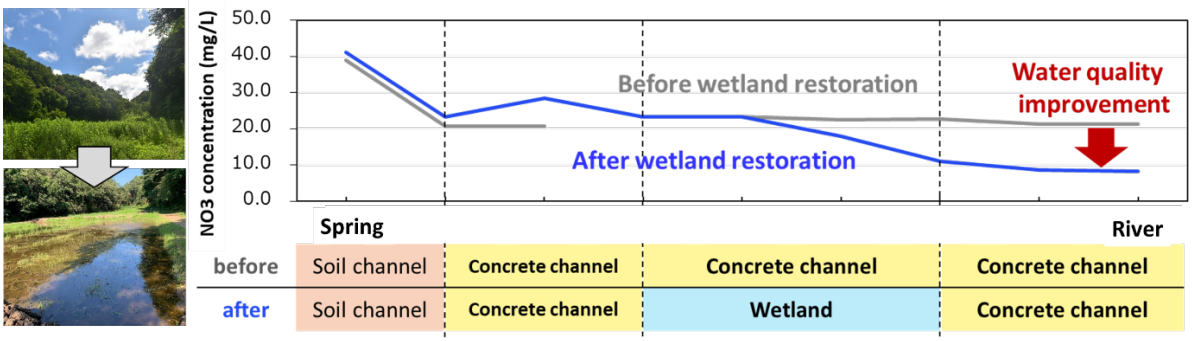

Figure 1. Changes of nitrate ion concentration from spring water to the downstream river. Gray line: before restoration; blue line: after restoration. From Kato *et al*. 2024

2.1.3 Biodiversity

A study analyzing the distribution of endangered species in Chiba Prefecture, where the Lake Imba is located, suggested that a particularly large number of endangered species are distributed in the uppermost valley (called *'yatsu'* in this region) of the river (Kim et al. 2021). Furthermore, where *yatsu* had been restored as wetlands after the soil had become arid, soil seed banks showed the germination of many endangered species (Kato et al. 2024). Thus, *yatsu* are important sites for flood control, water purification, and biodiversity conservation, these functions can be improved through management.

In order to conserve endangered species, it is important to manage at the watershed scale, not just at the local scale where they live. Our research team has shown that in order to conserve organisms dependent on springs of the Lake Imba watershed, it is important to conserve the water infiltration surfaces in the catchment of those springs (Figure 2, Hirano et al. 2022).

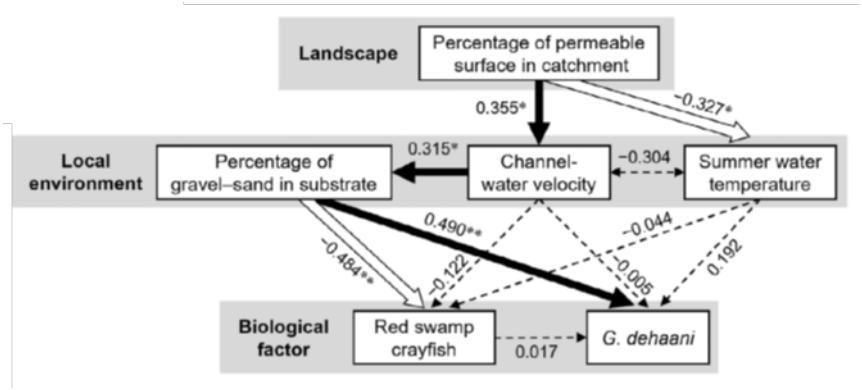

Figure 2. Factors affecting the distributions of Geothelphusa dehaani, a spring dependent freshwater-crab, as determined by path analysis. Numbers indicate path coefficients and asterisks indicate significance (**p < 0.01; *p < 0.05). Solid, outlined, andbroken arrows indicate positive, negative, and insignificant effects, respectively.

2.2 Sharing Scientific Information

Scientific information is published not only as academic papers, but also as handbooks and web GIS for citizens and government officials to utilize. web GIS includes the distribution of functionally important valleys and the status of groundwater (Figure 3). In addition, an organization called "Satoyama Green-infrastructure network" has been established to promote information sharing among citizens, government officials, and researchers at monthly study meetings.

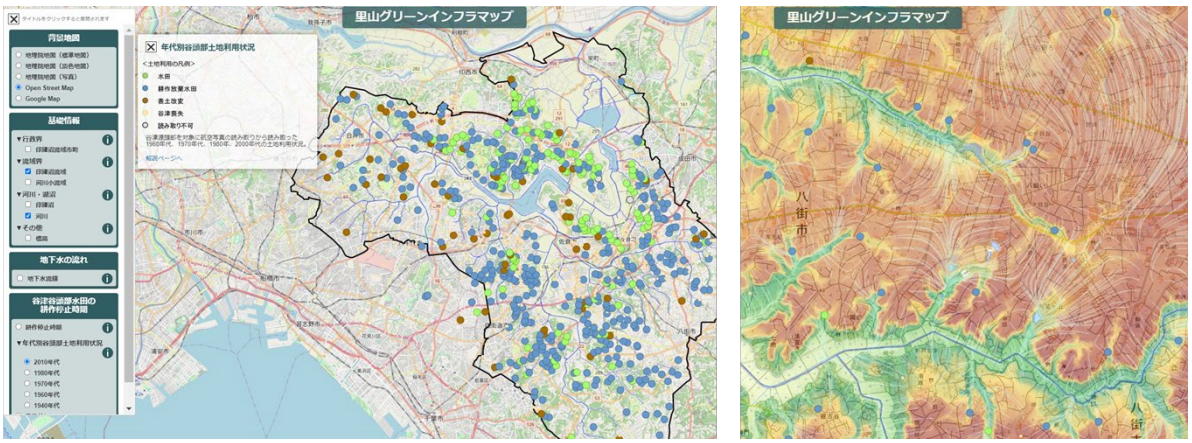

Figure 3. Screen captures of the web GIS focusing on watershed of Lake Imba. Distribution and land use of *'yatsu'* small valleys (left), flow direction of ground water (right).

3 COLLABORATION AND FUNDING MECHANISMS

The Lake Imba watershed includes 13 cities. While scientific information on ecosystem functions and biodiversity needs to be prepared at the watershed scale, implementation of Green infrastructure needs to proceed at the city or more smaller spatial scales. Currently, our research team is in close discussions with several cities to incorporate this information into their administrative plans and to utilize land owned by the cities.

In recent years, many companies have become increasingly interested in managing natural capital, which is having a positive effect on the promotion of watershed governance. Several companies have already begun

cooperating in activities such as improving the ecological functions of abandoned rice paddies (Figure 4, Nishihiro 2024). In promoting such efforts, the role of intermediary support organizations is important to support smooth collaboration among companies, government, and citizen groups. A new corporation started in the Lake Imba watershed, and activities to support collaboration have been initiated. Furthermore, we are planning to establish a new organization (Landscape Management Center) in an area within the watershed to share the future vision of the area among various stakeholders and to function as a system to facilitate the conservation of natural capital by companies such as nature credit. The lessons learned from these efforts will surely be useful in the watershed management of rivers and lakes in other parts of the world.

Fig. 4. An example of wetland restoration in an abandoned paddy field jointly undertaken by employees of a construction company and an NPO.

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