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Complementary Role of Green and Gray Infrastructures: Evaluation from Disaster Prevention, Environment, and Social and Economic Benefit

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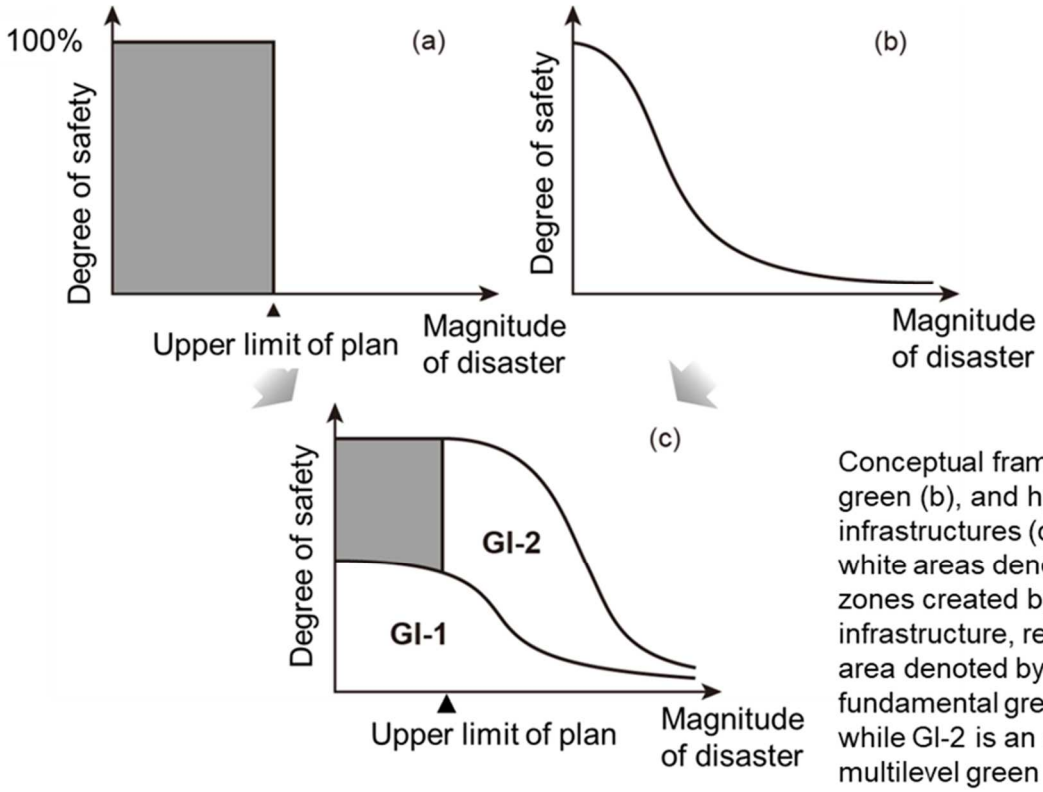
With the advent of an age of depopulation and frequent natural disasters arising from climate change, there is an urgent need to develop a cost-effective disaster prevention system. Hybrid infrastructure (HBI)—the integration of grey and green infrastructure (GI)—is expected to play an important role in disaster prevention and mitigation, environmental conservation and economic progress at the same time. This study has aimed for a comprehensive evaluation of HBI potential, including engineering, ecology and environmental economics, to be conducted by an interdisciplinary collaborative research team, as it indicates the presence of important natural and social conditions for identifying areas with high potential for HBI implementation at the national level.

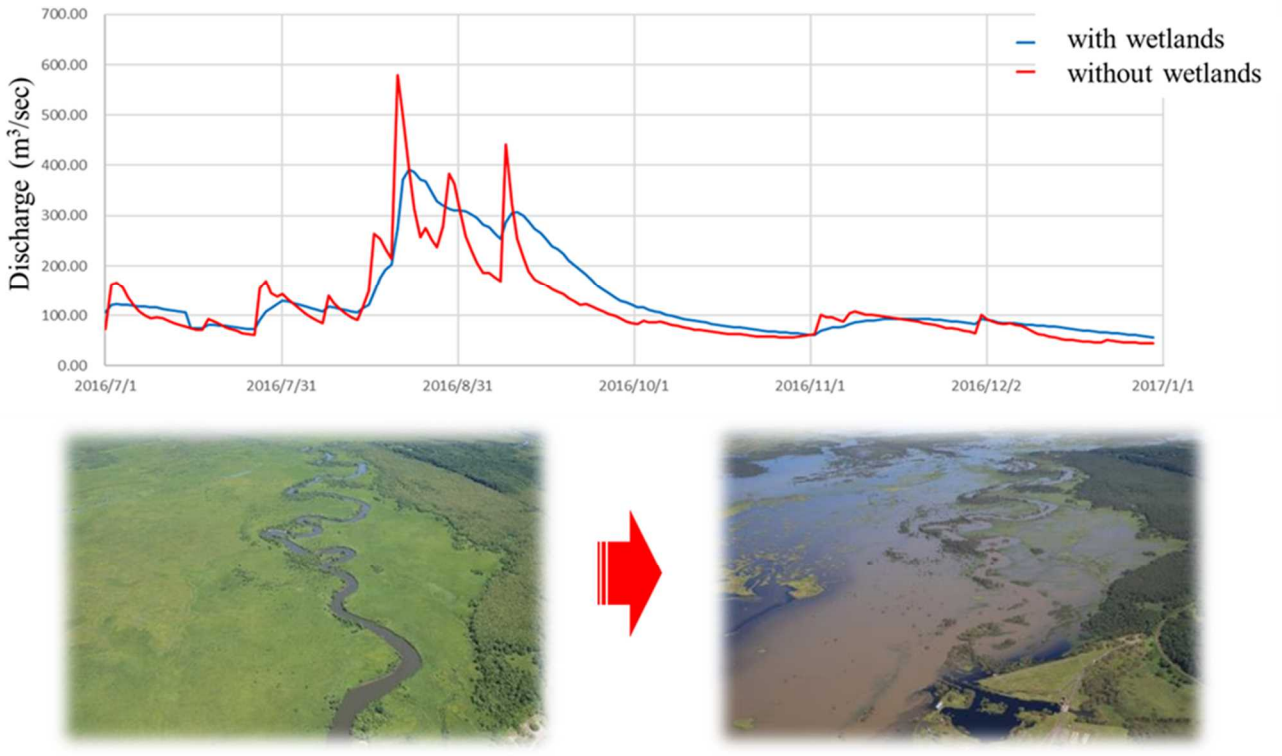
A flood and tsunami simulation model demonstrated that the current configuration of coastal dunes, coastal forests and paddy fields has a sufficient GI functional role for disaster mitigation. We proposed an urban and community development scenario based on a zoning plan to our local government and our approach was found to be directly linked to sustainability and activation of local society because it helped ensure disaster prevention, nature conservation and preservation of the living environment. Comparing species abundance, diversity and composition among various water body types, we confirmed that flood-control basins had the GI function of conserving wetland species diversity. The water retention function provided by Kushiro Wetland National Park also demonstrated a significant role in disaster risk reduction, particularly in the future under the climate change scenario. Our public preference survey showed the importance of knowledge level in linking positive perceptions to GI. A trial in which a sea embankment was covered with sand achieved success in restoring the coastal ecosystem's connectivity as HBI.

Focused on the uncertainty that GI inherently poses, we evaluated the functions and economic benefits of HBI by developing a theoretical model for optimal HBI and an empirical analysis for ascertaining public preferences. According to our analysis, a correlation between costs and benefits, utility in addition to disaster control, respondent attributes, HBI knowledge levels and disaster experience influence HBI preference, providing important parameters for consideration of actual political actions.

Toward HBI implementation in society, we explored the framework and indicators needed to identify high potential areas for HBI at the national level. Using suitable natural conditions and the indicators of social acceptability we identified for implementation, we focused on paddy fields for evaluating areas with HBI potential across the country. Our national survey of public preference showed a correspondence between quality of the natural environment and happiness, indicating that the importance of HBI potential is not only in disaster reduction and ecosystem conservation but also in the quality of local community life.



Conceptual framework of grey (a), green (b), and hybrid infrastructures (c). Shaded and white areas denote the safety zones created by grey and green infrastructure, respectively. The area denoted by GI-1 is the fundamental green infrastructure, while GI-2 is an additional multilevel green infrastructure.



Attenuation of flood peaks by the Kushiro Wetland. Comparison of the simulation results with and without wetland GI (b) in the above figure.

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