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Numerical Modeling of a Coastal Lagoon in Japan: Prospects for Sustainable Development in Bangladesh

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Extended Abstract

Coastal areas, vital for both biodiversity and fisheries, are increasingly threatened by climate change, sea level rise, and human activities. In response, Sustainable Development Goal 14 (SDG 14), "Life Below Water," focuses on conserving marine ecosystems and promoting the sustainable use of marine resources. Lake Tofutsu, a coastal lagoon on the Sea of Okhotsk in Japan, exemplifies the abovementioned balance. Recognized for its ecological value under the Ramsar Convention, the lake's brackish water supports biodiversity and serve as a key site for cultivating brackish water clams (Corbicula japonica), a crucial species in Japan's inland fisheries. With natural clam populations declining, sustainable artificial aquaculture in Lake Tofutsu has become increasingly important. To support this, a numerical hydrodynamic model, the Lagoon Environment Pollution Dynamics Model (LEPUM) [1], is being developed. The primary objective of developing this model is to understand the dynamic behavior of water quality parameters and their impact on the lake's ecosystem in the context of climate change and upstream influences, such as sediment deposition. This understanding enables practical solutions for aquaculture management within the lake and helps identify the need for upstream interventions to control excessive sedimentation. Ultimately, this supports the conservation of the lagoon ecosystem in alignment with the SDG.

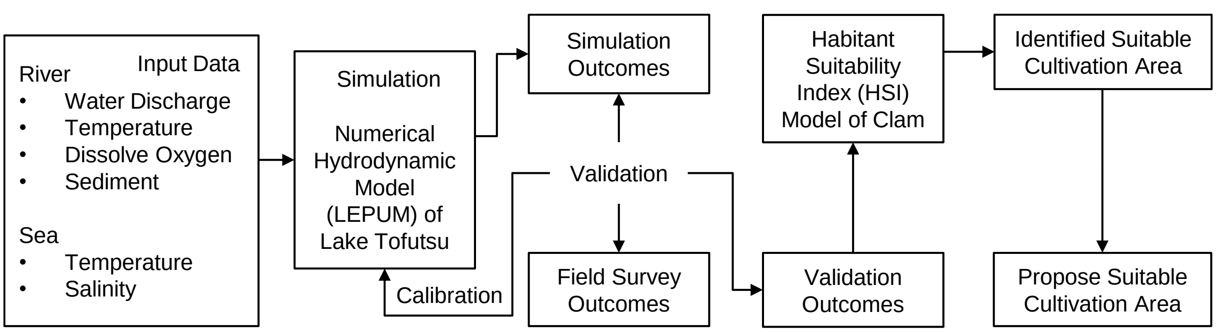

Figure 1: Research method for proposing suitable clam cultivation area.

As shown in Fig. 1, LEPUM simulates salinity, water temperature, and other environmental factors in the lake. The simulated outcomes are validated against real-life data and integrated

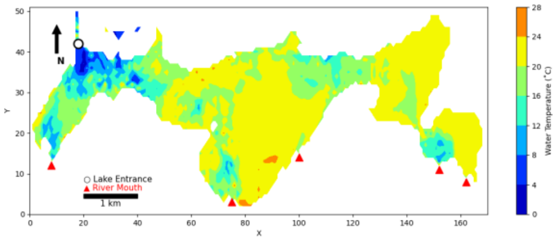

Figure 2: Spatial Distribution of Temperature.

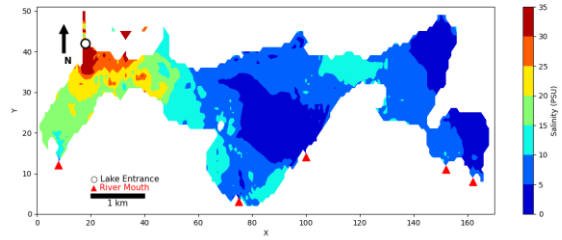

Figure 3: Spatial Distribution of Salinity.

with the Habitat Suitability Index (HSI) model for clams, facilitating the identification of suitable aquaculture areas.

Since lake temperature and salinity are critical for understanding suitable clam habitats, the LEPUM model currently incorporates sea water temperature, river water temperature, and sea water salinity to simulate these conditions in the lake. Additionally, local weather data (wind speed, solar radiation, rainfall, heat flux, tidal action, seasonality, and alike) have been used to establish proper boundary conditions. The simulation results provide the spatial distribution of temperature and salinity within the lake, helping to assess how these inputs influence the lake's environmental conditions. For instance, Figs. 2 and 3 illustrate the water temperature (T, ˚C) and salinity (S, PSU) distributions at surface layer of the lake in May 2017, respectively. T ranges from 5 to 24˚C and S varies between 0 and 30 PSU. This variability means the suitability of clam habitats may change over time due to climate factors given that the optimal T and S for suitable habitation are 23.1-26.5°C and 2-8 PSU [2], respectively. This way, the model provides valuable insight into the spatial variability of suitable habitats across the lake. Furthermore, such model outcomes will be incorporated into the HSI model to pinpoint the best areas.

The findings from this study offer insights into how climate change affects suitable habitats for aquaculture. Bangladesh faces similar challenges, with numerous canals and tidal ponds where saline water from the Bay of Bengal enters. Issues such as fluctuating salinity, water temperature, pH, heavy rainfall, and river siltation cause widespread damage to aquaculture (shrimp, crab, and carp habitats), including breeding ground destruction [3]. As such, this study offers an insightful approach for enhancing the resilience of aquaculture in Bangladesh in the face of climate-related impacts.

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