Creating an RRI model dataset in the Chikuma River Basin for the purpose of evaluating paddy field dam's runoff control

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Due to the impacts of climate change, record-breaking heavy rainfalls exceeding past observations have been occurring and causing severe floods in Japan. The construction of large-scale structural measures, however, that can prevent flood damage increased by climate change in addition to socio-demographic changes such as urbanization and aging of society takes many years.

Therefore, the government of Japan has recently initiated the new policy, 'River Basin Disaster Resilience and Sustainability by All,' which involves residents and stakeholders in the river basin working together as a whole, to mitigate flood damage in addition to existing structural measures. One of the core measures in the new policy is a nature-based solution, utilizing water storage and retention functions of paddy fields and forests to suppress runoff during a heavy rainfall. A paddy field dam is a prospective measure of the solution. Although numerous studies have been conducted to evaluate the effects of paddy field dams, most of them have focused on small watersheds or specific areas of paddy fields, with few cases examining the overall runoff control effects on the entire river basin. Therefore, in this study, we added the function for evaluating paddy field dams to the Rainfall-Runoff-Inundation (RRI) model and created a dataset to assess runoff control by paddy field dams in the Chikuma River Basin.

The RRI model is developed and provided by International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM). The model integrates a runoff model, a river channel model and an inundation model in a basin-wide scale, enabling the prediction of flood phenomena in near real-time.

In this study, we focused on the Chikuma River Basin (upstream of the Nishi-Otaki Dam) in Nagano Prefecture, which was affected by the 2019 East Japan Typhoon. Within the river basin, there are 12 water level and flow rate observation stations, as well as 85 rainfall observation stations including those outside the river basin. The model data for the river basin was created using the Japan Flow Direction Map and MERIT Hydro, and the river basin area is 7,190 km2.

Although land use data includes information on paddy fields, in this study, we used agricultural land polygons created by the Ministry of Agriculture, Forestry and Fisheries. These polygons were visually confirmed and created by examining the shape of farmland from aerial photographs. Since the agricultural land polygons cannot be directly used to create model data in their polygon form, they were converted into grid data with a 3-second resolution, same as other data.

Using data such as agricultural land polygons, we calculated runoff volume using the RRI model. To confirm the effective modeling of paddy field dams in the RRI model, we conducted trial calculations by extracting the areas surrounding the Ame River Watershed from the Chikuma River Basin. The water depth and runoff characteristics of paddy field dams appropriately changed depending on the varied ratio of the drop mouth in the irrigation path, confirming that the functionality of paddy field dams was adequately modeled.

Keywords: Rainfall-Runoff-Inundation (RRI) model, aerial photograph, Chikuma River Basin, paddy field dam, runoff control