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The effects of anthropogenic watershed changes on river water quality — The watershed fragmentation by dams and its impacts in Japan

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(Introduction)

In recent years, biodiversity preservation, environmental impact assessment and river restoration have been recognized as the most important issue for watershed environmental management in Japan. In order to maintain and restore the environmental soundness, we have to evaluate the environmental impact on the river from the aspect of the watershed structural change quantitatively. Moreover, to restore the altered environment based on such evaluations, the watershed planning that is environmentally effective as well as economically efficient is required. To the issues raised above, we conducted a research related environmental impact assessment and its monitoring technology using GIS. For conservation and restoration of watershed environment, efforts to maintain and recover the soundness of multiple interactions (ex. between geographical feature and land cover, food web and riparian environment, material-recycling and hydrological period, etc.), are indispensable. In addition to focus on Ągthe entire watershedĄh is also important in the same way. (Vannote et al. 1980). Mainly after the 17th century, artificial structures in rivers (such as dams) have been constructed a nationwide in Japan (Kameyama et al. 2004, Takahasi 2004). Dams break the river network into smaller segments that controls multiple interactions and isolate wildlife habitat from one another (Morita and Yamamoto 2002. Diffendorfer et al. 1995, Newson and Newson 2000). However, researches on watershed fragmen-

tation by artificial structures have not yet been fully developed in Japan. At present, infrastructures for research such as GIS database do not complete. Furthermore, watershed landscape of Japan is still changing like in many other countries, due to giving high priority to disaster prevention and economic needs over ecosystem conservation.

(Objectives and methodology)

1) GIS database construction: The first objective is to aggregate various data observed by individual research organizations in Japan, and to construct versatile watershed environmental GIS database (ESRI ArcGIS). The integrated GIS data in this research are as follows. River structure:multipurpose dam, river structure for agriculture and main channelized reach. Watershed structure:1/25000 river reach, a main watershed polygon, a sub catchments network polygon. Water environmental data: water quality of major rivers, concentrations of pollutants, water discharge volume, archived historical water quality data, land use and geographical feature data (1km mesh). 2) The spatial analysis of the watershed fragmentation by dams The second objective is to analyze watershed fragmentation by river structure. A new GIS methodology was developed to delineate fragmented areas and to assign fragmented period on individual sub-catchments based on the year of dam construction and its location. This methodology was applied to entire river networks in Japan to grasp the watershed fragmentation. (Kameyama et al. 2004). Furthermore, this watershed fragmentation map was used effectively to evaluate the historical change of watershed. 3) Evaluation of the change of watershed and its impact The final objective is to relate the change of watershed landscape with river water quality. For this propose, we used interannual variability data of sediment loading and nutrient flow in our database. Then we analyzed the spatial distribution pattern of polluted river water and classified the major watershed based on long term trend of water quality. Finally we quantified how the distribution of suspended sediment or nutrient in river network was influenced by anthropogenic change in the watershed (the proportion and distribution of land use, geographical feature of watershed and fragmented situation etc.).

(Conclusion)

The fragmented watersheds by dams are concentrated in mountain regions in Japan (central Honshu, Kyushu and Shikoku regions). The fragmentation rapidly increased especially after the 1950s. Since this agrees the period when demands for electricity power and water resources increased rapidly in Japan. This is considered to be the result of the fact that establishing dam sites in steep slope points is suitable for storage of water. On the other hand, in plain areas, the cause of watershed fragmentation was mainly agricultural dams. Such fragmentations increased gradually throughout centuries. It became clear that about 3% area in Japan had already occurred by the

end of the 16th century, and about 5.5% by the end of the 19th century. As a result of impact assessment based on watershed landscape change, major watershed in Japan was classified into the typical group according to the historical trend of water quality. Additionally, it was suggested that the proportion and distribution of land use and the location of dam were significant to determine the spatial distribution of river water quality in the entire watershed.

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