Effect of Climate Change on Environmental Flow Components and Physical Habitats

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Abstract-The quantity and timing of runoff are critical components for the water supply, water quality, and ecological interaction of river systems (Poff, et al., 1997). Five components of the flow regime (magnitude, frequency, duration, timing, and rate of change) can directly and indirectly impact an aquatic ecosystem. (Karr, 1991; Poff, et al., 1997). Due to the recent phenomenon of climate change, the timing and pattern of rainfall has changed and affected the flow regime of certain basins. Hence, in this research, the future impact of climate change on the river flow regime and aquatic ecosystem of the Mangyeong River, a medium-sized basin in Korea, has been quantified by analysis of environmental flow components and physical habitat modeling. Consequently, it is predicted that there will be crucial changes in the material conditions related to the river flow regime, and the risk of ecological environmental changes will greatly increase.

Keywords- Climate Change; EFCs; CSI; Environmental Flow Components

I. INTRODUCTION

The function and structure of biological communities related to river ecosystems largely result from changes in the flow regime (Poff and Ward, 1989), flow scale, and frequency. The alteration of annual variations involves possible changes to critical portions of aquatic habitats. Ultimately, river flow is a structural component that indicates the health of an aquatic ecosystem, and long-term changes in river flow can result in major changes to the structure and function of an aquatic ecosystem. In particular, flow regimes have exhibited recent changes as the timing and pattern of rainfall is altered by climate change.

Runoff, which is the critical component of the water cycle, impacts water supply and water use as related to drought disasters, flood control and management, and the environment for maintaining river ecosystems. In particular, five critical components of the flow regime including magnitude, timing, frequency, duration, and the rate of change, are known to impact river ecosystems, both directly and indirectly (Karr, 1991; Poff, et al., 1997). It is very important to analyze and understand the characteristics of a river flow regime in order to examine and predict changes to river ecosystems.

The purpose of this study was to assess the impact of future climate change on flow regime and fish habitat conditions using EFC analysis and physical habitat modeling for the Mangyeong River.

II. METHOD

The object of the study is the Mangyeong River, a representative medium-sized river basin in Korea, with a watershed area of 1,405.6km² and a channel length of 73.9km (Fig. 1). The future rainfall data (2011~2099) were extracted from the resources of six meteorological observatories based on an RCP 8.5 climate change scenario. SLURP, a semi-distributed model, was applied to the Mangyeong River by modeling runoff discharge for rainfall data of a RCP 8.5 scenario (Fig. 2). For changes in flow regimes before and after climate change, indicators of hydrologic alteration (IHA) developed by the Nature Conservancy (USA) were used to calculate the components of environmental flow.

A 2D model was created of approximately 5.5km (Fig. 1) of the primary stream of the Mangyeong River to simulate the physical habitat. Simulation data were used for low flows based on the IHA statistical analysis.

The eel, an economic and endangered species in the Mangyeong River, was chosen for the current study. The HIS (Habitat Suitability Index) of the eel is calculated based on past references and investigative inquiry.
III. RESULTS

Comparative results of the flow duration curve before and after the impact of climate change revealed marked changes in the peak flow for extreme low flows and large floods (Fig. 3). Analytical results regarding the components of environmental flow were used to examine the impact on the water ecosystem and characteristics of the flow regime such as the magnitude, timing, frequency, duration, and rate of change, as listed in Table 1. The extremely low flow condition that is associated with environmental stress and the extinction of many organisms indicate circumstances where the water environment had deteriorated and was shown to increase the duration and frequency of river flow degradation. The conditions for large floods are related to the reorientation of the biological physical architecture and were found to increase the river flow amount and duration. In the case of low flow and its impact on the determination of the area size of aquatic habitats available throughout the year, there was an overall annual increase of approximately 9 percent, with an increase observed in spring and summer and a decrease observed in fall and winter. It appears that the risk of substantial alteration to the ecological environment would greatly increase according to predictions of extreme changes in river flow regime conditions.
The physical habitat of the eel was simulated for low flow conditions according ecological environmental changes, and the Composite Suitability Index (CSI) results are presented in Fig. 4. As the flow increases by approximately 9% as compared to present low flow conditions, the future weighted usable area of the eel appears to decrease by approximately 10%. Additionally, current areas with habitat suitability indicate their continued highly suitability in the future, while areas of low suitability would decline even further in terms of suitability. In the case of the eel, as a migratory fish, simulations for habitats according to its life span must be conducted in order to provide more accurate habitat examinations.

Thus, as changes in environmental flow components before and after climate change are generally large and substantial, it is estimated that this will impact river ecosystem features such as aquatic habitat, flood plains, and biotic communities.

![CSI (Composite Suitability Index) of eel distribution: (left: present, right: future)](image)

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