Ecological Landscape Assessment of Restored Urban Stream to Guide Adaptive Management

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1. Introduction

Urban stream restoration has increased due to enhanced awareness of ornamental, recreational and public engagement benefits and increased availability of financial resources (Purcell et al., 2002). However, it is not possible to verify the projects outcomes without properly conducting monitoring and assessment (Kondolf, 1995). Particularly in relation to small urban stream projects, the insufficient monitoring due to lack of investment make it difficult to identify the impacts of the restoration project and, consequently, to develop improvement plans. Therefore, to advance the science and practice of ecological restoration, long-term monitoring and the study of the successes and failures of stream restoration projects are required (Klein et al., 2007).

The Banpo Stream, in Seoul, South Korea, had its natural form until the early 1960s, but it was covered due to the urbanization and construction of a complex of apartments (Seoul Historical Compilation Committee, 2000). In 2010, an ecological restoration aimed to solve the bad smell problem due to the polluted water and provide a good environment for the residents (Son, 2010). Since then, a few monitoring reports were released (Seoul Central 50 Plus Center, 2021) but no assessment study has been documented yet.

In South Korea, extreme precipitation phenomena are predicted to occur more frequently according to the Korean Climate Change Assessment Report (Ministry of Environment, 2020). Faced with this, the role of nature-based solutions is being highlighted, and measures that integrate ecological and social functions should be applied in new projects, but also in the adaptive management of prior restorations. Accordingly, comprehending the benefits and weaknesses of previous projects is primordial to present a critical basis for the future development of integrated plans and landscape designs that achieve multiple strategic objectives (Stewart and Neily, 2008).

Thus, this study aims to comprehensively assess the outcomes of the Banpo Stream restoration project with a focus on riparian vegetation quality, to provide a reliable basis for adaptive management and future improvement plans.

2. Methods

2.1 Study Area and Survey Method

The Banpo Stream is the first tributary of the Han River. It originates from Umyeon Mountain in Seocho-gu, passes through Nonhyeon-dong, Seocho-dong, and merges with Sadang Stream, a tributary, to flow into the Han River. The overall width of the river is small, about 10m, with a river extension of 4.8km (coverage section 2.3km) and a basin area of 31.49 km2. In 2010, a total of 2.77km section of Banpo Stream from the intersection of Seoul St. Mary's Hospital to the confluence of the Han River was restored as a natural ecological river. In order to evaluate the results of the ecological restoration and the impact of urbanization on the stream ecosystem, field surveys and mapping analysis were conducted to assess the quality of riparian vegetation.

2.2 Assessment Method

The study area was divided into five sections by identifying changes in the cross-sectional view of river and riparian vegetation, and landscape ecological evaluation was conducted using three indexes: 1. The QBR (Qualitat del Bosc de Libera) index was evaluated on-site based on four components of riparian vegetation: total riparian vegetation cover, vegetation structure, cover quality and channel alterations. The other two indexes were analyzed through mapping work: 2. The RSQI (Riparian Strip Quality Index) analyzes ecological quality by the weighted land cover classification of the stream area, and 3. The NDVI (Normalized Difference Vegetation Index) is used to quantify vegetation by measuring the difference between near-infrared rays that reflect strongly and red light that absorbs strongly. These two indices were analyzed by GIS Software (ArcGIS ver. 10.8) using a 10m resolution satellite image from Sentinel 2 and aerial photographs from Google Earth and Naver Maps.

3. Results and Considerations

Sections 1, 2, 3, and 5 (Table 1) were classified as "bad" due to a lack of vegetation (mainly landscape trees and shrubs), disconnection from surrounding green areas, and a large area of concrete structures. Section 4 was evaluated as the lowest grade due to the part where the entire river embankment is made of concrete. In order to develop an adaptive management proposal, previous studies were reviewed and improvement measures were presented based on Hakui Stream as ecological reference information.

Table 1. Analysis Results and Suggested Adaptive Management Measures to Improve Riparian Vegetation Quality.

	QBR	QBR rating	RSQI	RSQI rating	NDVI	NDVI rating	Final classification*	Purposed adaptive plan
Section 1	10	1	51	2	0,118	2	5 - D	Replacement of the concrete walkway with an elevated walkway that allows plants to grow underneath (in the whole area), as the stream is narrow. Remove concrete structures where possible and actively introduce native plants such as herbs and shrubs.
Section 2	15	1	43	2	0,091	2	5 - D	Remove invasive species (*Humulus japonicus*) and introduce native species (e.g. *Salix integra*).
Section 3	20	1	49	2	0,092	2	5 - D	Introduce native vegetation distributed in galleries and follow the order herbs 〉 shrubs 〉 trees and subtree zone.
Section 4	10	1	35	1	0,069	1	3 - E	Actively introduce vegetation and connect with other areas of the stream to create an ecological (wildlife) corridor.
Section 5	30	2	36	1	0,073	1	4 - D	Increase the number of native species, remove invasive species and strengthen the connection with the surrounding woodland.

* 0-3: E Very bad, 4-6: D Bad, 7-9: C Neutral, 10-12: B Good, 13-15: A Very Good

Additional importance and satisfaction survey will be conducted to understand users' preferences and perceptions of vegetation and general facilities quality, and the results will be further reflected in the adaptive management plan.

4. Conclusion

Currently, river restoration is actively carried out in Korea, but the ecological aspect and natural function of the streams are not considered, limiting habitat creation and reducing the quality of the ecosystem as suggested in this study. Despite the difficulty of restoring streams that have been greatly narrowed due to urbanization such as Banpo Stream, in-depth research should be conducted so that vegetation suitable for water quality and stream buffer can be introduced into the project. It is also necessary to prepare continuous monitoring and adaptive management measures to improve restoration practices.

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