Nature-based solutions and similar concepts on water management

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Abstract. Nature-based solutions (NbS’s) refer to the sustainable management and use of nature for tackling socio-environmental challenges such as, focusing on water issues, water security, flood protection, and water pollutions. This newly emerging concept is conceptually compared, in the aspect of water management, to existing similar solutions with different naming, all of which are based on ecosystem functions. NbS seems significant and meaningful both educationally and understandably, since that it can comprehensively cover and include the existing methodologies and solutions using the services of the natural ecosystem to socio-environmental challenges. However, it seems not entirely different from the broad-meaning of green infra, including Eco-DRR, in the aspect of approaching methodologies in water management. The conceptual and spatial hierarchy of each practice can be expressed in the narrowing order of NbS - (Ecological engineering) - BGI (Blue-green infra) - (CRT, Close-to-river techniques) - GI (Green infra) - LID (Low-impact development).

1. Introduction
Since the late 2000s, the new concept of Nature-based Solutions (NbS’s or simply NbS) has been emerged by the joint endeavors of IUCN (International Union of Conservation of Nature) and WB (World Bank) [1]. This concept was emerged first as an adaptation measure of climate change, to reduce the impact of climate change, protect the species diversity, and enhance the sustainable way of living. Later, this concept has been expanded to manage and utilize the natural ecosystem to tackle socio-environmental issues sustainably. Here, the socio-environmental issues include water security, health, disaster risk, and socio-economic development.

In this study, the definition and significance of NbS are reviewed first, and then the NbS as an overarching and umbrella concept is discussed. Next, it is comparatively assessed with the existing similar concepts, and finally, conclusions are extracted from the discussions. This comparative assessment is focused only on water management.

2. Definition and traits of NbS
NbS is defined as actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits [1]. It has three different types of approaches as human influences or interferences play from zero to a certain degree. Figure 1 shows a schematic representation of the range of NbS approaches [2]. Three main types of NBS are defined, which differ in the level of engineering or
management applied to biodiversity and ecosystems (x-axis), and in the number of services to be delivered, the number of stakeholder groups targeted, and the likely level of maximization of the delivery of targeted services (y-axis).

According to this graph, there are three types of approaches of NbS. Type 1 has the lowest level of human interferences, while type 3 has the largest. Accordingly, type 1 has the most significant number of ecosystem services and stakeholders, while type 3 has the lowest. On the other hand, type 3 has the maximum efficiency of the delivery of key ecosystem services, while type 1 has the lowest. Type 2 represents a managed ecosystem with intermediate human interferences, such as agricultural activities harmonized with the surrounding landscape and green cities.

3. NbS and similar approaches
Since NbS has a broad range of approaches using ecosystem functions and services, it is natural to expect there may already be some concepts similar to it. In actuality, there exist some approaches to tackle the socio-environmental issues using the ecosystem itself or mimicking the natural processes.

Figure 1 A categorization of NbS according to the engineering levels applied to ecosystems and ecosystem services delivery [2]

Figure 2. NbS as an umbrella for ecosystem-related approaches [1]
They are categorized as follows [1]: 1) ecosystem restoration approaches, 2) issue-specific ecosystem-related approaches such as climate adaptation services and eco-DRR (disaster risk reduction), infrastructure-related approaches such as natural and green infra’s, ecosystem-based management approaches such as IWRM (integrated water resources management), and ecosystem protection approaches. As shown in figure 2, those five categories of NbS approaches are all under the umbrella concept of NbS.

Suppose we focus on our attention only to the water issue. In that case, existing concepts similar to NbS may be listed ecological engineering (EE), eco-DRR, green infra (GI), low impact development (LID), and close-to-nature river technologies (CRT).

EE is an academic discipline, not a specific approach of NbS. It can be utilized, therefore, for all of the above five approaches. It is the technology-oriented NbS. It is usually defined as ecosystems’ design for the mutual benefit of humans and nature [3].

Eco-DRR is the ecosystem-based approach to natural disaster risk reduction. It means the sustainable management, conservation, and restoration of the ecosystem to reduce the natural disaster risk while maintaining sustainable and resilient development goals. A typical example of eco-DRR is the coastal forest zone to protect the coastal area from storm surges.

GI is the ”green” nature-made infrastructure in contrast to the human-made grey concrete infrastructure. Starting from a smaller concept of the BMP’s (best management practices) for urban stormwater management in the USA, and expanded to the treatment of urban non-point source pollutants at the begin-of-pipe. However, the use of this term has been developed further in the EU, in the name of blue-green infra (BGI), to the restoration of the water cycle and ecological axis at the built environment and its neighboring suburban areas.

LID is the measure restoring the hydrologic cycle at the development area where surface runoff can be increased due to the expansion of impermeable land surfaces by treating surface runoff as close as possible to the begin-of-pipe areas. Two principles of LID are the conservation of natural landscape as much as possible and minimization of the impervious surfaces by mimicking the natural processes to facilitate infiltration as much as possible at the begin-of-pipe areas. It is specifically used for land development projects.

Last, CRT (Naturnaher Wasserbau in German or close-to-nature river technique in English) is the engineering technologies, originally from German-speaking regions in Europe, to be used mainly for the stream improvement or restoration works. Two prevailing principles of CRT are the use of natural materials such as earth, stone, logs, and living plants and making the stream morphology as close to its original natural figures as possible.

4. Hierarchical considerations of NbS and other similar approaches
As shown in figure 3, NbS and the five similar approaches explained above can be relatively placed in a diagram. In this diagram, NbS can embrace all the existing five approaches. It can cover even EE, since NbS has the non-technical approaches and technical ones, while EE is limited in the technical approaches.

BGI, the expanded version of GI, can be placed in the figure as a subset of NbS. However, many of BGI’s are virtually the same as the categories of 1, 2, and 3 in figure 1. For example, natural infra, such as the well-protected forest playing as a natural reservoir, can be considered a BGI. In many actual figures of BGI, however, are regarded as a subset of NbS. GI, as defined the stormwater-handling practices, is naturally placed within BGI and thus NbS.

LID is finally placed in the inner-most area since most of the LID practices are in the category of GI. CRT is applicable only for the stream works, such as flood-passage improvement or restoration work. As shown in figure 3, it can cover a part of BGI and GI.

The expanded concept of CRT can be best explained with figure 4, adopted from NERC, England. As shown in this figure, the left-most natural river and floodplain can play a natural infrastructure for flood passage in the river and habitat for the riverine ecosystem.
On the other hand, the rightmost grey and hard engineering mean the traditional infrastructural approaches such as a levee, dam, and concrete revetments. In between those two extremes, we can consider the Dutch concept of river management, “Room-for-the-river” [5], providing more space for the river by removal, lowering, and setback of old levees and excavation of river channel and so on. It is expressed as “working with natural processes and natural flood management." Last, the green/soft/bio engineering is the typical CRT such as willow-fascine revetment works and close-to-nature riffles using large boulders.

**Figure 3.** Conceptual diagram for the hierarchy of NbS and similar approaches (from figure 4 [4])

**Figure 4.** Range of the broad-meaning of green infra within a context of river management [6]
5. Conclusions
Major conclusions obtained from this study can be summarized as follows:
- NbS has its significance in the perspective of overarching the existing similar concepts based on natural processes. It is especially meaningful in the aspect of education and persuasiveness.
- NbS is not much different from the present concept of BGI, except that it can cover the restoration and protection approaches of the ecosystem beyond the normal scope of BGI.
- The hierarchy of NbS and existing concepts can be arranged from the broader set to smaller subset as NbS – (EE) – BGI – (CRT) – GI – LID, where the EE and CRT are parenthesized since EE is the academic discipline and CRT is applicable only to river works.

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