Water Infrastructure Sustainable Development

Economies are built on infrastructure, making it a massive part of our society and contributing tremendously to the daily lives and activities of humans who get to live and interact with them for specific and different reasons. However, infrastructure is known to be responsible for social and environmental harm while increasing our vulnerability to natural or manmade disasters (Thacker et al., 2019). Therefore, the context in which I will discuss sustainable development will be the water sector and infrastructure, which falls under the economic type of infrastructure. The primary focus for water infrastructure will be stormwater management, highlighting sustainable management techniques that help keep humans and the environment at large less susceptible to flooding disasters, either present or future.

Sustainable development for water infrastructure, particularly stormwater management, involves mimicking natural processes to manage stormwater runoff to benefit humans and the environment. A practical example is installing decentralized systems within urban cities, such as green infrastructure, to achieve varying purposes. For instance, reducing impervious surfaces caused by urban density (Liu et al. 2014), restoring the ecosystem within cities (Liquete et al. 2015), and reducing the total maximum daily loads (TMDL) discharged into water bodies which prevent the event of combined sewer overflow (CSO), and also for point source treatment of polluted runoff from municipal separate storm sewer systems (MS4) (Clements and Henderson 2020). Furthermore, removing nutrients, sediments, and pollution from stormwater runoff before running into large water bodies to prevent fish kill and feminization of fish and other aquatic animals are some of the quality functions of green infrastructure. Furthermore, while green infrastructure quantity function includes retaining and detaining stormwater runoff for a while before gradually releasing it into the environment, some green infrastructure components include harvesting stormwater water for reuse within facilities or specific purposes, given the system's design.

According to the Environmental Protection Agency (EPA), green infrastructure can be defined according to the *"Water Infrastructure Improvement Act, which defines green infrastructure as the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."* Examples of green infrastructure include but are not limited to rain gardens, bioswales, green roofs, permeable pavements, and retention and detention ponds.

The indicators identified and measurable as a result of the discussed sustainable development in water infrastructure are social and environmental indicators proven by research to positively affect humans and the environment.

Social indicators are measurable by the benefits these systems provide for humans interacting with them, which helps with human health, activities, and security. The presence, exposure, and access to green infrastructure systems have enhanced and supported human health and well-being (Coutts and Hahn 2015). Green Infrastructure can provide various human health benefits that help the human body (cardiovascular health, cortisol patterns, other stress indicators, pregnancy, and birth outcomes), the human mind (attention and mental health), and human behavior (crime reduction, self-regulation, and pro-social behaviors). Given human and nature accessibility and interaction, greenery and green spaces promote outdoor activities within communities where they are available (Suppakittpaisarn, 2017).

Environmental indicators are measurable given the opportunities created by these systems to help not only protect the environment but also help create natural habitats for wildlife animals that make up part of the society, protecting and replanting native and endangered species for vital ecosystem services.

The popularity of green infrastructure is increasing within communities because of the potential it has for urban renewal (Hsu and Chao 2020), resilience to flooding disasters (Green et al. 2021), climate change adaptation (Li et al. 2019), and improving water quality for wildlife or aquatic use (Yang and Li 2013). In addition, the presence, exposure, and access to green infrastructure systems have enhanced and supported human health and well-being (Coutts and Hahn 2015). green infrastructure as they add aesthetic and other functional values to the environment. As stated by (Benedict and McMahon 2012), green infrastructure systems can provide quality air and water, promote diversity and wildlife mobility, and serve as a framework for the healthy operations of the natural environment within a city. For example, preparing for drought by replenishing infiltrated groundwater reserves, reducing urban heat islands using tree planting techniques and green roofs, lowering building energy demands, spending less energy managing water, and protecting the coastal areas (EPA 2021). Green infrastructure can also provide ecosystem services to humans and the environment by supporting, regulating, and providing cultural services (Wallace 2007). To achieve a greater level of ecosystem services in green infrastructure systems, careful consideration and attention should be given to the plants selected for green infrastructure installation (Cameron and Blanuša 2016).

REFERENCES

Benedict, M. A., and McMahon, E. T. (2012). *Green infrastructure: linking landscapes and communities*, Island press.

Cameron, R. W., and Blanuša, T. (2016). "Green infrastructure and ecosystem services–is the devil in the detail?" *Annals of Botany*, 118(3), 377-391.

Clements, J., and Henderson, J. "ECONOMIC FRAMEWORK AND TOOL FOR QUANTIFYING AND MONETIZING THE BENEFITS OF GREEN INFRASTRUCTURE USING A TRIPLE BOTTOM LINE APPROACH." *Proc., National Stormwater Symposium 2020*, Water Environment Federation.

Coutts, C., and Hahn, M. (2015). "Green infrastructure, ecosystem services, and human health." *International journal of environmental research and public health*, 12(8), 9768-9798.

"What is Green Infrastructure." (n.d.). *EPA*, Environmental Protection Agency, <https://www.epa.gov/green-infrastructure/what-green-infrastructure> (Sep. 8, 2022).

Green, D., O'Donnell, E., Johnson, M., Slater, L., Thorne, C., Zheng, S., Stirling, R., Chan, F. K. S., Li, L., and Boothroyd, R. J. (2021). "Green infrastructure: The future of urban flood risk management?" *Wiley Interdisciplinary Reviews-Water*, 8(6).

Hsu, K.-W., and Chao, J.-C. (2020). "Economic valuation of green infrastructure investments in urban renewal: the case of the station district in Taichung, Taiwan." *Environments*, 7(8), 56.

Li, C., Peng, C., Chiang, P.-C., Cai, Y., Wang, X., and Yang, Z. (2019). "Mechanisms and applications of green infrastructure practices for stormwater control: A review." *Journal of Hydrology*, 568, 626-637.

Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., and Zulian, G. (2015). "Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study." *Environmental Science & Policy*, 54, 268-280.

Liu, W., Chen, W., and Peng, C. (2014). "Assessing the effectiveness of green infrastructures on urban flooding reduction: A community scale study." *Ecological Modelling*, 291, 6-14.

Suppakittpaisarn, P., Jiang, X., and Sullivan, W. C. (2017). "Green infrastructure, green stormwater infrastructure, and human health: A review." *Current Landscape Ecology Reports*, 2(4), 96-110.

Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., O'Regan, N., Rozenberg, J., Watkins, G., and Hall, J. W. (2019). "Infrastructure for sustainable development." *Nature Sustainability*, 2(4), 324-331.

Wallace, K. J. (2007). "Classification of ecosystem services: Problems and solutions." *Biological Conservation*, 139(3), 235-246.

Yang, B., and Li, S. (2013). "Green infrastructure design for stormwater runoff and water quality: Empirical evidence from large watershed-scale community developments." *Water*, 5(4), 2038-2057.