# A GIS-Based Analysis Approach for Evaluating Green Infrastructure Plan: A Case Study of Makassar Region

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論 文 名　：A GIS-Based Analysis Approach for Evaluating Green Infrastructure Plan: A Case Study of Makassar Region
（グリーンインフラ計画評価のための GIS 分析：マカッサル地域を事例として）

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## 論　文　内　容　の　要　旨

Indonesia is one of the highest urbanizing countries in Asia and its future will be shaped by its cities. In 2011 the population was 51% at urban area, and the projected to become 85% by 2050. Makassar is the largest city in Eastern Indonesia and part of the Mamminasata Metropolitan Area. Nowadays, over 86% of the Makassar region is occupied for urban uses. The built-up area has expanded far faster than the population, indicating an increasingly lower density of the city. The loss of prime green land has appeared to be a major problem. Moreover, it is located on the coast within an extensive coastal plain which is also subject to flooding every year. Due to the rapid growth of development, Tallo River Area has been becoming inside of urban area. The near future it will be exactly at the middle of the city. The local government proposes to create Tallo River Area where the city can strategically manage urban development in the land that is now undeveloped because it is subject to regular flooding. Nevertheless, it is endorsed in the Mamminasata Spatial Plan (2006) and The Makassar City's Spatial Plan (2012). Therefore, to mitigating flood risks as well as managing the water resources, and increasing nature and green spaces have become more serious concerns. Tallo River Area has a crucial role both in the environmental and development of Makassar City.

Green Infrastructure (GI) is strategically planned and managed networks of natural lands, working landscapes and other open spaces that bring multiple benefits. It is applied to support ecological stability in the landscape by conservation or restoration of ecosystems and their connectivity, and to apply to the management of floods at the local level through the use of natural systems to treat polluted runoff. Geographic Information System (GIS) serves as a good decision support system and tools in environmental issues as well as planning the Green Infrastructure. Thus, the research objectives are divided into two parts: (i) to evaluate prospective Green Infrastructure across Tallo River Area by GIS throughout analyzing the land-use changes, ecological connectivity, and flood disaster risk at the regional scale of Makassar; and (ii) to propose the Green Infrastructure network planning within Tallo River Area at local scale, in accordance with the city's spatial plan where there are gaps or areas of need to put into evaluation network design.

Chapter 1 provides a briefly introduction to the description of the sustainable urban development involving the sustainable and site design, site data and analysis concepts. By the literature reviews, definitions of Green Infrastructure by the Country regions have been discussed. Connectivity is a key element of Green Infrastructure plans, not only within elements of the Green Infrastructure plan itself, but the plan should also create connections between local institutions and people. The goal of a network design is to delineate an interconnected Green Infrastructure system that incorporates both benefits to nature and to people.

Chapter 2, development of grid-mesh based land-use maps from the available topology features have been performed in GIS. Spatial analyses of land-use changes have been evaluated to investigate pattern of transition in the Makassar region, and the details analysis has been simulated to characterize the land-use values change into urban. It is found that about 32% of agricultural fields and 41% of garden fields of 1997 are converted into urban. The increasing phenomenon of urban area has leaded to the existence of the fishpond (13.5%) in Makassar region. In Tallo River Area, mangroves, shrubs, and gardens have been identified as degraded areas and mostly converted into fishponds.

Chapter 3, the Ecological Connectivity Index (ECI) in the Makassar region has been evaluated through the spatial identification of ecological functional areas by different patch size spectrum and development of Barrier Effect Index (BEI) model based on Marulli and Mallarach (2005). The ECI shows a significant decline between 1997 and 2012 due to the loss of agriculture and agroforest mosaics and mangrove forests. Negative changes in connectivity levels have occurred in the former natural-space around the Makassar region, both at West and East part of the city. It is found that the mangrove forest and shrubs field has relatively high impact levels to the ecological connectivity index changes. Furthermore, some areas have been identified in Tallo River Area for the conservation of the potential of ecological connectivity and the restoration of the loss of the vital natural sites.

Chapter 4, a GIS matrix analysis has been conducted to establish spatial vulnerability to flood and risk at local context based on the BNPB (Indonesian National Board for Disaster Management) framework. Based on the available of local statistical data and geospatial information, the Flood Hazard Index (FHI) has been developed. The Flood Vulnerability Index (FVI) is performed in GIS. The FVI study aggregated the local indicators to a single composite index that enable spatial vulnerability representation from various social, physical, economic, and environmental factors. Furthermore, Flood Risk Index (FRI) has been determined to analyze the distribution of risk components at sub-district level. Determination of the FRI level has been calculated by matrix model from the variables of the FHI and FVI. In the vicinity of Tallo River Area, sub-districts of Panaikang, Tamalanrea Indah, and Pampang have been identified as the areas with high potential impacts from flood risks in term of physical and environmental aspects.

Chapter 5, the goal setting by local government has been studied to identify the main objectives in accordance to the city's spatial plan. Identification of key issues for Green Infrastructure plan has been conducted to indicate the potential Green Infrastructure functions in Tallo River Area. Moreover, three spatial themes have been identified that are landscape and biodiversity, flood risk and climate change adaptation, and community and access to greenspace. Analysis element has been conducted for the Green Infrastructure network design model. In particular, the connected landscape biodiversity network has been simulated in GIS to evaluate a patch dispersal distance between existing and planning. Synthesis plan element has also been performed to assess the Green Infrastructure network design model in terms of flood risk factors and other feasibility factors. This assessment leads to the identification of priorities for implementation zones in Tallo River Area.

Chapter 6, the current study results on the evaluation of Green Infrastructure plan has been concluded and the remained research issues have been discussed for future challenges in GIS analysis approach.