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Scoring Urban Spaces in an Indonesian City Based on Biodiversity

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Abstract. The effect of inevitable development pressures has implications for natural sites in cities. In response, concepts such as greenways, green networks, green infrastructure and ecological networks emphasize the harmonious possibilities for simultaneous urban development and nature preservation. To proceed, it is important to have knowledge of existing green urban spaces and their potential for inclusion in these concepts. One way to do this is by assessing vegetation structures as a measure of biodiversity.

This paper presents a method for assessing the biodiversity of spaces in Makassar, a developing city in Indonesia. Biodiversity is an indicator that can provide general understanding about the natural state of urban habitats. The Rapid Biodiversity Assessment (RBA), adapted from a UK method and adjusted to comply with the conditions of Makassar, was used. The assessed spaces were first classified into typologies. The assessment produced biodiversity scoring for each space typology in the city. Scores were categorized into 'high', 'medium' and 'low' as a measure of their potential for inclusion in the network concept. The results provide an overview of the biodiversity of various types of space in a developing country city. Such information can be used to judge types of habitat and what must be done for their preservation or restoration. Dominance of vegetation structure is also used to denote utilization of spaces when certain ecosystem services or recreational benefits become the target. Together these form valuable knowledge for the urban planner as well as for government and the local authority.

Keywords: Urban Biodiversity, Urban Landscape, Green Space, Rapid Biodiversity Assessment (Rba), Developing City

1. Introduction

The Population Reference Bureau (PRB) reported world population growth from 2008 to 2009 was an unprecedented rate of 83 million [1]. Although urban areas only cover 3% of the earth's surface, 50% of the world's population live in urbanized spaces [2]. This population pressure drives urban development causing cities to expand and occupy the suburbs, turning these into additional built-up areas. In developing world cities, this urbanization process has been going on for over 20 years. Urbanization presents challenges to ecosystem ecology [3]. Urban development brings disturbances, and constant stresses [4]. It changes and threatens the natural state [5] and is responsible for the fragmentation of urban habitat, mainly through construction of roads and waterways [6], as well as imposing considerable pressures on land use in competition with natural ecosystem components [7].

As a developing country, Indonesia has many cities expanding in response to economic and population growth. Makassar, the biggest city in the eastern part of Indonesia has development problems and needs to preserve the existence and function of natural areas in the city while still developing. In response to this, in the developed world ecological networks and greenways have been established. These concepts, often described as 'ecological infrastructure' or 'green infrastructure', were introduced over two decades ago [8] and are now a reality, or have a place in the considerations of various authorities [9] [10]. In the developed world, the concept has been widely translated into an integrated network of open spaces which serve ecological and environmental functions for the benefit of people and biodiversity. The greenway concept was

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introduced in the United States to connect the city with the countryside, whereas the ecological network initially grew in Europe for conservation purposes [11].

Implementation of network concepts in urban areas requires knowledge about the available spaces in the city. It is preferable to perform spatial assessment thoroughly to identify all available patches and corridors. However, Tzoulas & James [12] confirmed from previous studies that most urban areas have specific habitat types. This suggests that developing a list of common space types is essential for an inventory of potential urban spaces for inclusion in a network. For this research, therefore, the first step was developing a typology of spaces in Makassar [9] consisting of 10 types of patch and 5 types of corridor. This paper describes the method used to assess their biodiversity, as the first stage of the assessment of the urban ecology [12].

2. Methodology

2.1. Rapid biodiversity scoring for urban biodiversity

Urban areas where species, habitat and humans interact [13] are different from natural areas. Even if a city area is still dominated by natural remnants, these are different because of the often intensive human interaction with them. Consequently, a macro scale biodiversity assessment method that includes assessment of built area related to an open space has advantages. A general idea of biodiversity is necessary for comparing the state of urban habitat types. Even for natural sites macro scale and non-detailed assessment is sometimes used to achieve a global non-specific conclusion [14]. One such macro assessment method is the rapid biodiversity assessment (RBA) developed by Tzoulas and James [12]. It combines observation of vascular plants and scoring of biodiversity, is simple and quick to perform, and applies to different locations.

As a very fast growing city, Makassar has characteristics that suggest this method can be adopted to produce useful results, namely:

- The diversity of vegetation is less complicated than for most natural sites in Indonesia
- The method is less intrusive so more acceptable
- A more detailed investigation would be more expensive and therefore not possible to resource
- Coverage by built areas is significant, and this needs to be considered in the assessment method
- There is a shortage of expert ecologists in tropical countries for detailed assessment of their complicated biodiversity [15]
- There is no systematic system for monitoring biodiversity [15], especially in Indonesian urban areas. In 2010, only 20 of over 400 Indonesian regencies have begun to catalogue species in their areas [16].

The simple rapid assessment method developed by Tzoulas and James [12] does not reduce the accuracy of the results for urban patches and corridors. The following table shows differences between the characteristics of several methods of conventional biodiversity assessment and the RBA.

Table 1: Comparison between Conventional Biodiversity Assessment Method and the Rapid Biodiversity Scoring of Tzoulas and James

Conventional method	**Method of Tzoulas and James [12]**
Requires specific expertise in biology-ecology [17]	For people with minimal ecological understanding
Intensive implementation could with much detail [14]	Minimum level of detail as general description is required
Requires significant cost and time [14, 17]	For its simplicity, cost and time are minimal
Observing both animal and plant species [18]	Observing plants as main component of urban habitat
Recording species richness or abundance of species, or indicator species; could be a census or sampling [19, 20]	Recording the diversity of vascular plants
Vegetation structure is taken as main indicator [21]	Observing dominance of vegetation structures
Diverse observations; could be number and detailed description of observed biodiversity elements [22]	Observations produce biodiversity score and possibly description of vegetation structure.
Appropriate for areas with complex biodiversity such as natural sites	More appropriate for urban areas where biodiversity is less complex and detail output is not necessary

2.2. How the tzoulas-james method was carried out in this research

Tzoulas and James [12] used existing habitat types developed from previous research in their UK study. For the Makassar study, the urban habitat type was first established as a typology [9]. Tzoulas and James [12] used a vascular plants list developed from secondary data for the area they sampled, but such a list was not available for Makassar, so the process was reversed and the RBA was used to establish such a list.

The size of the sample is an area considered sufficient to represent the type and structure of vegetation present in the sampling location. After testing, the UK study used a radius of 65 metres. This became 60 metres in Makassar after using aerial photographs to determine a circle size that included most observable different colour densities and surface appearances, assuming these represented different vegetation coverage characteristics, with the proviso this dimension would be reviewed in the field and adjusted as necessary. The number of sampling points was mainly determined by following two principles: together they represent all observed variability in the site and cover at least 10% of the site size. Again, using aerial photographs, this process was simplified by predetermining all sampling points, with any necessary adjustments made on site. Where possible, the sampling circle centre was a specific fixed landmark, such as a tree or built feature. Using GIS, the landmark could also be determined after fixing the sampling circle.

The proportion of land cover relative to the different vegetation structures was estimated through visual observation and recorded on the field work sheet developed earlier. Visual observation of all existing vegetation structures was made from the centre of the circle out to the sampling border. Observation was made in all directions when nothing was blocking the view. If anything obstructed the view, observations were made by walking around the sampling area. The dominance value of each vegetation structure was then recorded. The eight radii defined during the sampling plot determination were then taken to form four transects by combining every two unidirectional lines into a 120-metre long line. These lines were used as the mid line of each transect. Each transect was made into a path 10 metres wide (5 metres either side of the line) where vascular plant identification would be made. Each transect was walked four times to record every vascular plant, including trees, shrubs, grass and ground cover. The dominating vascular plant of each vegetation structure, or the one that stood out visually, was then identified.

2.3. Combining indicators into a biodiversity score

Without comparing the value of each structure, if a vegetation structure was present in the sampling site, one point was added. Areas with less built structure have better potential for greater plant diversity as the built structures reduce the space for natural components. Given the unavailability of a vascular plants list in Makassar, it was not possible to develop a genera list and therefore a list based on field observation was made. However as a significant number of plants could not be identified in the field work, all species of vascular plants found in the sampling locations were recorded and documented. Therefore the vascular plants were recorded on a species-base, not a genus-base. The procedure for addition and subtraction of points with respect to the presence of built structure and recorded vascular plants were as explained by Tzoulas & James [12]. All scores obtained from each step were summed to get the final biodiversity score.

3. Results and Discussion

According to Tzoulas and James [12], larger sites deserve a higher score as the accumulation of scores of more sampling points, and large sites are expected to have more sampling points as they are presumed to have greater biodiversity than smaller sites. However in this study, as the determination of sampling locations was purposively made according to priority, and the main goal was not to assess the biodiversity state of Makassar as a region but to learn something about the biodiversity of each prescribed typology, the different number of sampling points could be indication of a number of factors. Therefore, the average value is used when scoring (table 3) as this study did not survey all sites available in Makassar for each typology.

The RBA method does not provide a quantitative procedure for assessing the ecological viability of the surveyed patches in terms of quality of ecological dynamics and system. This method just provides scores that reflect the biodiversity state regarding to two main factors: vegetation structure and vascular plants diversity. This, however, should represent the general stage of biodiversity as vegetation structure is the main determinant of habitat complexity, and numerous studies indicate that the composition and complexity of habitats could be good indicator of overall biodiversity. Moreover, the structural composition of vegetation can be used in urban habitats as a substitute for their biodiversity assessment [23].

Table 2. Biodiversity Scores of Different Types of Urban Spaces in the City of Makassar

No	Typology Group	No. of sampling points	Biodiversity Score		Categorization approaches					
			Total	Average	*Normal (equal) distribution*			*Standard Deviation*		
					High	Medium	Low	High	Medium	Low
1	Urban farm	11	175	15.91	✓			✓		
2	Wetland	9	132	14.67	✓			✓		
3	Institutional space	14	203	14.50	✓			✓		
4	Empty Field	11	158	14.36	✓			✓		
5	Un-built space	5	67	13.40	✓			✓		
6	Public open/green space	10	131	13.10	✓				✓	
7	Fish pond	3	38	12.67	✓				✓	
8	Stream/canal	1	11	11.00		✓			✓	
9	Public field	1	10	10.00		✓			✓	
10	Secondary road	3	27	9.00		✓				✓
11	Tertiary road	2	18	9.00		✓				✓
12	Inter house space	3	25	8.33		✓				✓
13	Primary road	1	4	4.00			✓			✓
	Total	74	999	11.53						

Vegetation structure could also be analysed for the types of dominating vegetation in space typologies, and for the possibility of linking spaces with similar vegetation types, since these can carry special functions. Dominance of vegetation structure can also be used to denote the possible utilization of certain spaces when particular ecosystem services or recreational benefits are the target.

Application of the method of Tzoulas and James [12] for this study in Makassar was only possible with adjustments (table 3).

Table 3. Adjustments of Rapid Biodiversity Assessment Method in Makassar

Description	RBA by Tzoulas and James [12]	Application for Makassar Study	Comments
List of Vascular plants	Obtained from relevant institution	Developed from the fieldwork	Such a list was not available from either official sources or previous studies
Determination of sampling plot size	Several trials in the field before appropriate representative size was determined	Adjustment based on surface appearance from aerial photograph which was then confirmed by fieldwork visit.	Direct on-site trial not feasible due to limited time and resources
Transect and sampling border set up	Using measuring tape and field marker at the boundary	Using estimation by footsteps and on-site markers for the borders.	This is more to comply with people's physiological behaviour due to sensitive issue regarding land ownership
Number of site visits	Several times per sampling site to record possible changes	Once or twice at most due to limited resources and not necessity for tropical climate	Vegetation structures in tropical climate do not change greatly within short time
Level of vascular plant identification	Listing down to genus	Recording every salient species whether immediately recognisable or not regardless of the genus	This is the result of not having guiding plant list, and having to develop list from the ground up.
Additional score in relation to vascular plants	Points added for existence of each range of vascular plants' genus	Points added for existence of each range of vascular plants' species	Additional score based on species range would tend to give higher score, yet would not change the trend of the scores for the different compared locations

4. Conclusion

The biodiversity assessment implemented in this study is a method adapted from an RBA developed in the UK. In order to make the method applicable to the study location, some adjustments were made for the study location being a tropical, developing city. Biodiversity assessment could provide a way to classify urban spaces in order to identify priorities among available spaces in an urban area. Implementation of urban planning with concerns towards ecology involves many fields and stakeholders, and biodiversity scoring is not the only consideration. Consequently for an urban context, priorities based on biodiversity classification should be overlaid with other priorities such as demography, current land-use, government long-term plans, and other socio-economic issues.

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6. References

[1] Carreiro, M.M., Introduction: The Growth of Cities and Urban Forestry, in *Ecology, Planning, and Management of Urban Forests*, M.M. Carreiro, Y.-C. Song, and J. Wu, Editors. 2008, Springer New York. p. 3-9.

[2] Forman, R.T.T., *Urban Regions: Ecology and Planning Beyond The City*. 2008, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, Sao Paulo, Delhi: Cambridge University Press.

[3] Alberti, M., Urban Patterns And Ecosystem Function, in *Advances in Urban Ecology*. 2008, Springer US. p. 61-92.

[4] Urban, D.L., R.V. O'Neill, and H.H. Shugart, Landscape ecology: A hierarchical perspective can help scientists understand spatial patterns. *BioScience*, 1987. 37: p. 119–127.

[5] Aminzadeh, B. and M. Khansefid, A case study of urban ecological networks and a sustainable city: Tehran's metropolitan area. *Urban Ecosystems*, 2010. **13**(1): p. 23-36.

[6] van der Grift, E. and R. Pouwels, Restoring habitat connectivity across transport corridors: identifying high-priority locations for de-fragmentation with the use of an expert-based model, in *The Ecology of Transportation: Managing Mobility for the Environment*, J. Davenport and J.L. Davenport, Editors. 2006, Springer Netherlands. p. 205-231.

[7] Barnett, G., M. Doherty, and M. Beaty, *Urban greenspace: Connecting people and nature*. CSIRO Sustainable Ecosystem, year unknown.

[8] Hailong, L., L. Dihua, and H. Xili, Review of Ecological Infrastructure: Concept and Development. *City Planning*, 2005.

[9] Iswoyo, H., B. Vale, and M. Bryant. Assessment and optimization of spaces as the basis for an urban ecological network in an Indonesian city. in *The 1st ACIKITA International Confrence of Science and Technology*. 2011. Jakarta: ACIKITA Foundation.

[10] Benedict, M.A. and E.T. McMahon, Green Infrastructure: Smart Conservation for the 21st Century. *Renewable Resources Journal*, 2002. **20**(3): p. 12-17.

[11] Jongman, R. and G. Pungetti, Ecological networks and greenways: Concept, design, implementation. *Studies in Landscape Ecology*. 2004, Cambridge: Cambridge University Press.

[12] Tzoulas, K. and P. James, Making biodiversity measures accessible to non-specialists: an innovative method for rapid assessment of urban biodiversity. *Urban Ecosystems*, 2010. **13**(1): p. 113-127.

[13] Boothby, J., An Ecological Focus for Landscape Planning. *Landscape Research*, 2000. **25**(3): p. 281-289.

[14] Ward, D.F. and M.-C. Larivière, Terrestrial invertebrate surveys and rapid biodiversity assessment in New Zealand: lessons from Australia. *New Zealand Journal of Ecology*, 2004. **28**(1): p. 151-159.

[15] Danielsen, F., et al., A simple system for monitoring biodiversity in protected areas of a developing country. *Biodiversity and Conservation*, 2000. **9**(12).

[16] Simamora, A.P., More than half of RI's biodiversity `unrecorded', in *The Jakarta Post*. 2010: Jakarta.

[17] Oliver, I. and A.J. Beattie, A Possible Method for the Rapid Assessment of Biodiversity - Un método posible para la evaluación rápida de la biodiversidad. *Conservation Biology*, 1993. **7**(3): p. 562-568.

[18] van Jaarsveld, A.S., et al., Biodiversity Assessment and Conservation Strategies. *Science*, 1998. **279**(5359): p. 2106-2108.

[19] Magurran, A.E., *Measuring Biological Diversity*. 2004, Victoria: Blackwell Science Ltd.

[20] Gordon, C., et al., Biodiversity, profitability, and vegetation structure in a Mexican coffee agroecosystem. *Agriculture, Ecosystems & Environment*, 2007. **118**(1–4): p. 256-266.

[21] Schwab, A., et al., Estimating the biodiversity of hay meadows in north-eastern Switzerland on the basis of vegetation structure. *Agriculture, Ecosystems & Environment*, 2002. **93**(1–3): p. 197-209.

[22] Tomei, P. and A. Bertacchi, The Protection Of Biodiversity in Tuscany, in *Nature Conservation*, D. Gafta and J. Akeroyd, Editors. 2006, Springer Berlin Heidelberg. p. 87-89.

[23] Cornelis, J. and M. Hermy, Biodiversity relationships in urban and suburban parks in Flanders. *Landscape and Urban Planning*, 2004. **69**(4): p. 385-401.