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Procedia - Social and Behavioral Sciences 227 (2016) 838 – 844

Procedia Social and Behavioral Sciences

CITIES 2015 International Conference, Intelligent Planning Towards Smart Cities, CITIES 2015, 3-4 November 2015, Surabaya, Indonesia

Integrating visibility analysis in rural spatial planning

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Abstract

A product of spatial planning not only describe the structure of general layout of the area, but also must reflect character of the environment, space, culture and tradition with a variety of uniqueness and diversity. This suggests the importance of identifying, classifying, and evaluating process of landscape quality. This paper presents the results of research using the visibility analysis in rural areas Bumiaji, Batu, where the characteristics of the rural mountains feared to be changed, threat natural environment or rural area, and then disrupt rural community activities. The study was conducted on 33 observation viewpoints along the village main road. Visibility analysis using the view shed analysis tools in ArcGIS demonstrate the opportunities to combine methods of visual and spatial analysis that were used to obtain the ecological and aesthetic quality scores. Results of analysis can help stakeholders to understand the relationship between aesthetic and ecological quality in rural spatial planning.

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Keywords: aesthetic-ecological quality; landscape quality; rural spatial planning; viewshed analysis; visibility analysis

1. Introduction

Rural area has a wide range of unique potential and different problems compared to the urban. With the various needs reasons and idealism that are ecological and conservational, rural development should be pinned on the sustainable management of natural resources. Sustainable development has consequences for the balance of the region in a sustainable manner by taking into account local wisdom for the creation of a prosperous society.

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Peer-review under responsibility of the organizing committee of CITIES 2015
doi:10.1016/j.sbspro.2016.06.153

Sustainable Rural Area Development Program (P2KPB) as a special program has been implemented by the Indonesian government since 2012 and ending in 2016 for the first phase. The program is aimed at villages with the criteria of the major issues that are assumed to carry a negative change to the development of rural areas. These issues are (1). Urbanization, (2). Land use, (3). Environmental degradation and the threat of water and energy crisis, (4). Low economic level, and (5). Areas include in Indonesian economic corridors in MP3EI.

There are 75. 410 villages (Statistics of Indonesian Potential Village, 2008) spread throughout Indonesia which require good rural spatial planning and controlling. Sustainable development has required the involvement of community in spatial planning, including the rural sector development. Community involvement in spatial planning in Indonesia has had the legality as stated in the Law of the Republic of Indonesia number 26 of 2007 on Spatial Planning. The legality is especially significant for the rural spatial planning. While on the other hand, the basic ability of rural communities to understand and participate in the process of spatial planning is disproportionately low. The gap confirms at least 2 (two) important things. The first is the need for methods that facilitate people's understanding of a vision of rural spatial planning. The second is the importance of adequate rural resources information (containing data aspects of sustainability). Such information ideally is obtained from a process and a product of rural community activities in their participation to search for and recognize their rural environmental characteristics (Bohnet, 2005).

This paper attempts to demonstrate the visibility analysis as an approach to identify the characteristics of the region in various dimensions (visual-spatial and aesthetic-ecology) in the relations which are more integrated and interdisciplinary (Schirpke, Tasser, & Tappeiner, 2013). These dimensions are very well known in the paradigm of sustainable development planning as strong basic concepts and theories yet they are still very weak in the implementation and empiric level (Ode, Tveit, & Frey, 2008). Therefore, this article also offers a solution to the rural spatial planning stakeholders in communicating the vision of their planning. Control of spatial changes will be easier to do when a vision planning is understood from the beginning. This approach is assumed to be able to bridge the stakeholder difficulty in understanding the relationship between these dimensions.

This paper presents a case study area in Bumiaji district which are assumed to represent the special characteristics of rural areas as referred to in P2KPB. The study area owns the potential of natural scenic beauty of the mountains (Poerwoningsih, & Kakino, 2013) and at the same time possesses a threat of environmental degradation problems in some conservation areas. Analysis of visibility can be an alternative method to resolve these problems and can be applied in the process of rural spatial planning and controlling. This analysis is effectively applied in the case of an area owning the potential of natural resources with the characteristics of mountainous natural landscape as owned by the study area of Bumiaji. This paper is organized into two main sections. The first section in the introduction describes the function of the visibility and analysis capabilities. The second part presents the methods and results of the implementation of the visibility analysis and its implications on rural area spatial planning in the study area.

Visibility Analysis

Visibility analysis determines those portions of the landscape which can be seen. Portions of landscape are including landscape content and composition of available views. As such, visibility studies play a central role in most scenic analyses (Smardon, Palmer, & Felleman, 1986). Visibility aanalysis in the application are often utilized to identify valuable visual resource and a potential threat to visual resources. Information visibility is utilized in the preparation of spatial planning guidelines in order to improve positive visual features or otherwise reduce the negative impact of landscape features (Wu Bishop, Hossain, & Sposito, 2006).

Visibility analysis has been developed as one of the features in some spatial analysis programs, one of them is by ArcGIS. This analysis allows us to identify areas that can be seen at a certain distance from a particular point. To obtain the necessary information, a digital elevation model (DEM) of a contour map from a sample area is needed. By performing control to observation point high position, observation radius and a wide angle of observation, the data area that are visible and non visible can be obtained. These areas can then be converted into the vector data in the form of polygons that are useful in the process of further spatial analysis.

Visibility Analysis Capabilities as Information Providers of Spatial Planning

Spatial planning is currently faced with the challenge of sustainable development issues that integrates social, economic, and ecological aspects. Sustainable development has to be beyond the objective that is not only thinking about physical development, but also optimizing distribution, allocation and land use. In rural spatial planning, the need of 3 (three) integrated sustainability aspects is more urgent to be applied. It is particularly important in rural areas spatial planning to explore information on sustainability aspects as its spatial functions (Ahern, 2005).

Visibility analysis is widely utilized in landscape analysis. In the beginning, this analysis is designed not only to support humans in landscape planning, but also, as in this case study, is expected to connect the visibility evaluation on the aspects of vision and perception (Chamberlain & Meitner, 2013). This analysis is more widely applied in academic research yet it has not been widely implemented in spatial planning practice. Sustainable spatial planning should be able to implement sustainability principles derived from the theory and practice of planning (Ahern, 2005). The complexity of landscape as spatial unit could not be faced only by applying one approach of theory or practice, but rather a collaboration of both. Thus spatial planning urgently requires academics performance to clarify the vision of better planning.

Some studies apply visibility analysis due to a strong impetus to reinforce the relationship between the aesthetic and ecological value on the landscape (Wu et al., 2006; Yamashita, 2011; Schirpke et al., 2013; Ozkan, 2014). Most studies assume that a space entity owns aesthetic and ecological value whose changes can be calculated and predicted. Visibility analysis in this study is utilized to support the assessment, classification and mapping of value to a particular landscape, and even also predicting a landscape situation (Hosni, &Shinozaki, 2009; Schirpke et al., 2013). Results of the assessment can support the preparation of distribution and allocation of land in spatial planning.

Most of the other studies have confidence that the values and aesthetic functions are capable to encourage human motivation to manage the environment. The study was conducted to explore public preferences to changes or landscape spaces for the preparation of vision and perception. Participatory spatial planning (one of the aspects of sustainable planning) starting from planning vision excavation requires adequate planning idea visualization of the technical aspects of information and communication. Visibility analysis helps to explain how these perceptions (visually) has associated with intrinsic elements of the spatial environment. Results of the analysis will help the ordinary people even to understand the complexities of rural space and ultimately succeed in the process of participatory spatial planning.

2. Methodes

Case Study Location

The location study is in Bumiaji District, Batu City, East Java of Indonesia. Bumiaji (covering an area of 12.81 ha) has most of the area are characterized by rural agricultural activities (25% of the total area of Bumiaji) and forest (62% of the total area of Bumiaji), as well as the characteristics of the mountain that serves as a conservation area. The area has been a buffer zone which serves as environmental sustainability of the ecosystem in Batu and surrounding areas. The research analysis unit in the form of observation points located on the main road (about 17 km) of Bumiaji district. The main road is a corridor that passes through several villages in the administrative area of Bumiaji and splits landscape mountainous region which is generally a water catchment area of upstream DAS Brantas.

Results of previous studies indicates the direction of Batu City growth to the north which is characterized by the appearance of buildings and facilities in the main road of Bumiaji. The growth and development of Bumiaji as rural and conservation area has been set in Batu City spatial planning of 2013-2030. Therefore the main road as one of the regional infrastructures requires a growth controlling strategy (Viles, & Rosier, 2001; Jongman, Kulvik, & Kristiansen, 2004). Natural scenic beauty of the mountains as tourism potential and accessibility of agricultural activities allegedly helped trigger the growth (Rosley, Lamit, & Rahman, 2013). Tug of war between the interests of environmental protection and tourism and economic activity will affect the performance of Bumiaji main road corridor landscape. The understanding of Bumiaji rural landscape characteristic in order to develop a vision plan can be traced from the characteristics of Bumiaji main road corridors. These are the reasons why we consider the object and location of this study are worthy to be presented.

Research methods

This study tried to demonstrate the usefulness of visibility analysis in explaining the relationship between several dimensions integratively and interdisciplinary (Schirpke et al., 2013). For this reason a number of 33 (thirty three) viewpoints which own georeferenced information are presented. Viewpoint represents a sample of the entire population viewpoint along the main road of Bumiaji District with a length of about 17 km. Road corridor as space to accommodate movement activity, one of which serves as a visual landscape showcase, connected as a sequence that determines the performance of an environment (Hosni and Shinozaki, 2009; Chamberlain and Meitner, 2013). The viewpoints are generated automatically by the computer that are applied with a distance of 500m on the main road of Bumiaji. Each viewpoint essentially has 2 (two) types of information referred to as visual data and spatial

data. Visual data in the form of observational data captured in an photograph represent an observation point as perceived by the human eye (Sullivan & Lovell, 2006; Kaplan et al., 2006). Spatial data in the form of mapping data in a viewshed map generated from satellite image processing. Both of photographs and viewshed maps are collected on each unit of analysis from a viewpoint.

Analysis of visual data recorded on the photographs in the previous studies have produced the landscape quality score for each unit of analysis. Scoring in the study carried out by expert judgment approach on a number of parameters of the landscape visual aesthetics (Daniel, 2001). This approach is considered adequate for reasons of limited time and resources, and relatively quickly conducted.

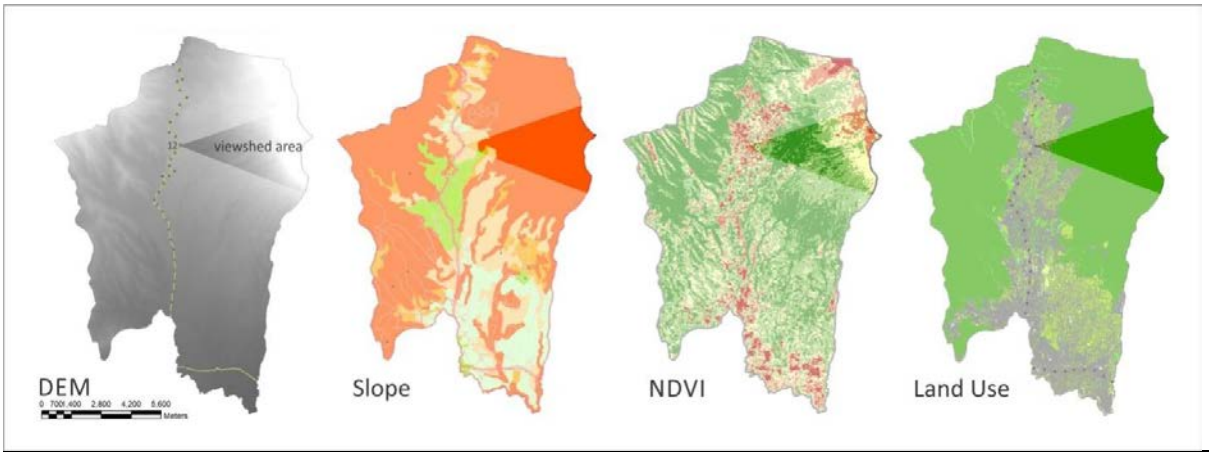

Fig. 1. Overlay analysis based on viewshed area from visibility spatial analysis

Analysis of spatial data used visibility analysis in which we can use viewshed analysis tool from ArcGIS application. This tool generated landscape metric value in the viewshed maps from every viewpoint. This paper presents the landscape metric value of overlay result with the data of slope classification, land use and vegetation density (NDVI). Both types of data were selected in this study because they are relatively easy to obtain yet still own adequate information about the ecological aspects. To simplify the discussion in this paper, in principle, both data are used to measure the complexity and diversity of the landscape, which are two of landscape ecological quality parameters. The data availability and easiness are of the important consideration reason for scope of rural spatial planning in Indonesia.

The discussion is conducted by describing the relationship evidence between visual-spatial dimensions and between aesthetics-ecology dimensions. The description is very necessary in the process of developing a vision of spatial planning. This paper describes some of the results of the analysis and its implications for spatial planning in Bumiaji District.

3. Result and Discussions

Visual analysis toward 33 viewpoints produces scores with scale range of 4 (four) from 8 (eight) visual quality parameters, namely: (1). variation of slope, (2). degree of relief, (3). contrastness of relief, (4) concavity of space, (5). naturalness, (6) the compatibility of land use, (7). contrastness of vegetation, and (8). internal variation of the scene (Litton, 1972; Smardon et al., 1986). Most of these parameters tend to give high ratings to aspects of naturalness compared to aspects of physical development. This is conducted to give emphasis to the vision of Bumiaji District spatial planning that leads to the activities of preservation and conservation of nature. This study intends to convey that the expert judgment assessment method can be utilized for specific reasons accordingly (Krause, 2001), so that the objectivity of the results can be accounted for.

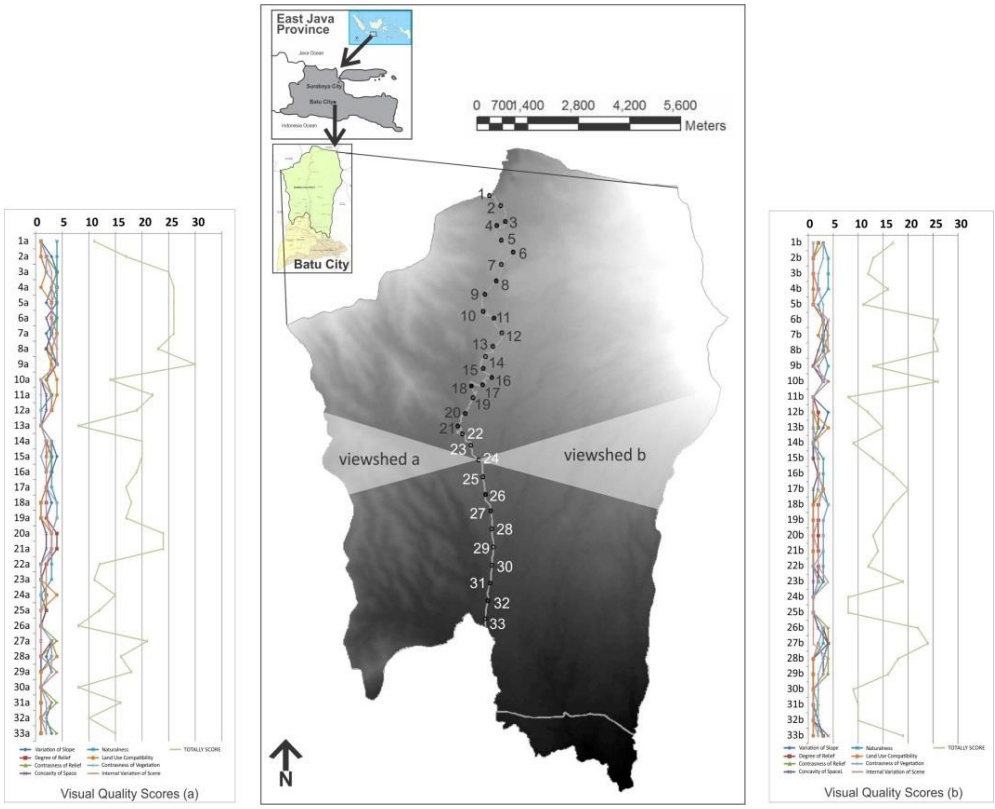

Fig. 2. visual quality score

Mountainous areas as a landscape feature that dominates Bumiaji landscape become a basic consideration in determining the viewshed direction, which refers to the west (viewshed a) and the east (viewshed b). This determination is a response to Bumiaji spatial planning objectives to preserve forests, farms and plantations that are mostly located in mountainous areas. One of the implemented sustainable development principles is preserving the existing landscape identity, protecting the existing elements, space and functions, and not hastily bringing new values (Krause, 2001).

The results of visual analysis showed the tendency of high total value at some points which are in the northern sector (3a, 4a, 5a, 6a, 7a, 9a, 6b, 7b, 8b, and 10b) and low value on points that are in the southern sector (13a, 22a, 23a, 25a, 26a, 30a, 32a, 11b, 14b, 24b, 25b, 30b, 31b and 32b). Differences in these values indicate the naturalness aspect influence toward Bumiaji main road landscape corridor visual quality. Low values at some parameters can be taken into consideration to undergo enhancement efforts. While high values at some parameters can be considered as an effort to preserve or protect.

In principle, visibility analysis helps to explain the function and value associated spatially with the visual value of an observation point. When and at what stage the analysis is going to carry out largely depends on the need for the desired information. For the sake of this article, we present values of some spatial data (slope class, land use, and vegetation density) that correspond to viewshed area at some points. Table 1 is an example of a simple format that can be used to explore the spatial values of any corresponding with the aim of further analysis. The four (4) landscape image that represent the viewpoint with high visual quality score correspond to a high percentage of forest or agriculture area and a high percentage of the size of the area with sharp slope. This indicates that the forest, agriculture and mountain character of landform as the dominant features in Bumiaji District contribute to the visual aesthetic value of rural landscape. This kind of data can be used to influence design decisions relating to the conservation of forest and agricultural land.

Table 1. Example format to confirm the visual and spatial data

	**Viewpoint 3a**		**Slope Classification**		**Land Use**		**Vegetation Density**	
	Y	-7.741843514	Flat	0.00%	Forest	**51.11%**	Very low density	4.70%
	X	112.5327532	Gently Sloping	0.00%	Plantation	0.00%	Low density	3.62%
	Seen Area of Viewshed (ha)	435.22	Moderate Sloping	4.88%	Agriculture	33.01%	Moderate density	28.64%
	Visual Quality Score	25	Steep	**39.26%**	Schrub	0.00%	High density	**50.13%**
			Very steep	**55.86%**	Vacant Land	4.89%	Very high density	12.90%
					Open Space	0.00%		
					Cemetery	0.00%		
					Building	10.98%		
	**Viewpoint 4a**							
	Y	-7.74290668	Flat	0.00%	Forest	10.10%	Very low density	2.01%
	X	112.530655	Gently Sloping	0.00%	Plantation	0.00%	Low density	1.76%
	Seen Area of Viewshed (ha)	683.74	Moderate Sloping	4.04%	Agriculture	**70.50%**	Moderate density	**52.07%**
	Visual Quality Score	26	Steep	2.51%	Schrub	0.00%	High density	34.58%
			Very steep	**93.46%**	Vacant Land	2.90%	Very high density	9.57%
					Open Space	0.00%		
					Cemetery	0.00%		
					Building	16.50%		
	**Viewpoint 6a**							
	Y	-7.749529534	Flat	0.00%	Forest	**44.45%**	Very low density	5.12%
	X	112.5348032	Gently Sloping	0.00%	Plantation	0.00%	Low density	4.34%
	Seen Area of Viewshed (ha)	411.31	Moderate Sloping	2.29%	Agriculture	**55.21%**	Moderate density	37.42%
	Visual Quality Score	26	Steep	0.00%	Schrub	0.00%	High density	**49.71%**
			Very steep	**97.71%**	Vacant Land	0.23%	Very high density	3.42%
					Open Space	0.00%		
					Cemetery	0.00%		
					Building	0.11%		
	**Viewpoint 7a**							
	Y	-7.752562863	Flat	0.00%	Forest	**96.79%**	Very low density	5.76%
	X	112.5317934	Gently Sloping	0.00%	Plantation	0.37%	Low density	4.64%
	Seen Area of Viewshed (ha)	374.77	Moderate Sloping	0.71%	Agriculture	2.84%	Moderate density	38.05%
	Visual Quality Score	26	Steep	0.00%	Schrub	0.00%	High density	**48.35%**
			Very steep	**99.29%**	Vacant Land	0.00%	Very high density	3.21%
					Open Space	0.00%		
					Cemetery	0.00%		
					Building	0.00%		

4. Conclusions

Sustainable rural spatial planning has a different approach to urban spatial planning. Such differences should be reflected in both process and product planning that take account into several things: (1). Ensure the involvement of rural communities in the planning starts from the vision exploration process of planning to decision-making, (2). Prioritize the interests of conservation and preservation of natural resources that rural areas are mostly natural with the ecologically development has significance than mere physical change efforts and (3). Open to different approaches from academic and practitioners to encourage increased public resource that tends to be low.

Visibility analysis has opportunity as an alternative method that can be integrated into rural spatial planning. The analysis has ability to relate perceptional information that has human dimension as a visual assessment to the spatial information that has measured.and ecological dimension. This analysis can be used to facilitate stakeholder in better understanding the complexity of rural space in the stage of rural resource information inventory and also in the stage of further planning analysis.

Acknowledgements

This paper is a part of our process during post graduate study funded by Beasiswa Pendidikan Pascasarjana Dalam Negeri (BPPDN) and also by Penelitian Disertasi Doktor (PDD). So, the authors would like to thank Higher Education General Directorate, Ministry of Education and Culture. Special thanks to Prof. Respati Wikantiyoso, MSA., PhD. and Dr. Ir. Nurhamdoko Boni, MT. for their input as a reviewer in the evaluation process of PDD.

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