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Original Research Article

Defining rural–urban interfaces for understanding ecohydrological processes in West Java, Indonesia: Part I. Development of methodology to delineate peri-urban areas

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A B S T R A C T

Urbanisation within global economic and socio-political settings has created rural–urban interfaces, or peri-urban areas, where ecosystem interactions are complex. It is now recognised that the rural–urban interface dichotomy in the current planning and management approaches does not adequately account for the rural–urban interface linkages, particularly for potential emerging conflicts in land and water demands and uses. Using the Cirebon Metropolitan Region (CMR), West Java, Indonesia as a case study, Part I of this two-part article aims to develop a suitable methodology for peri-urban delineation. We used a total of 11 social, economic and spatial variables directly or indirectly related to ecohydrology. Multivariate, univariate and multiple univariate data analysis techniques were used for defining regional rural–urban interfaces. Based on these analyses, eight regional classifications of rural–urban interfaces were proposed and evaluated based on different spatial classification methods and clustering techniques. The results of classification were mapped by integrating both Geographic Information System (GIS) and statistical methods. The study indicates that with the variable included, the multiple univariate clusters using Jenks natural breaks and scoring provides more accurate rural–urban definitions for peri-urban delineation. The proposed methodology provides a suitable framework for delineation of peri-urban areas needed for quantifying ecohydrological state in urbanising landscapes.

1. Introduction

Rural and urban developments increasingly overlap creating irregular forms of environment that cannot be defined within the current rural–urban interface dichotomy. Urbanisation has created mixed rural–urban interface landscapes, identified as "peri-urban", with distinctive features of the loss of rural characteristics and a lack of urban characteristics (Allen, 2003). In the context of metropolitan regions, emerging zones of intense economic activities in the intersection between rural areas and cities are known as "*desakota*" zones, drawing on the Bahasa Indonesia words for town and village (McGee and Shaharudin, 2016). Currently, peri-urban areas are not recognised as integral part of the functional activities of urban growth suggesting the need of formulation of peri-urban policies to make cities are liveable and sustainable while they are secure in terms of biodiversity and ecosystem services (Maheshwari et al., 2016). However, many issues still remain concerning the indicators and

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thresholds for distinguishing urban, peri-urban, and rural areas (Iaquinta and Drescher, 2000). In the metropolitan context, understanding rural–urban interface linkages is even complicated as a rural area on the metropolitan inner or outer boundary of a city or the land in the space between rural and metropolitan boundary may be deemed peri-urban (Buxton and Choy, 2007). To date, the dynamics of the rural–urban interface combined with no clear boundary definition of peri-urban has become a challenge for developing effective, consistent and integrated planning and management of regional areas for liveability and sustainability.

Several new classification systems have been proposed in the global context to describe human settlement structures beyond the rural–urban interface dichotomy (Coombes and Raybould, 2001; Dünckmann, 2009; Hugo et al., 2001; Öğdül, 2010; Camaioni et al., 2013; Wandl et al., 2014) but the definitions are diverse. It is impractical to propose a universal standard as different processes of peri-urban development. For instance, peri-urbanisation in developing countries is linked with rural urbanisation, rural–urban migration, and a mixture of agricultural and non-agricultural activities while peri-urbanisation in developed countries is related to urban wellbeing and welfare (Woltjer, 2014). The increasing movement of population to urban centres brings a number of critical challenges affecting peri-urban areas from urban expansions, such as poor sanitation facilities and public health (Singh and Maheshwari, 2014). Further, in developing countries, population increase is taking place in the growing urban and peri-urban areas that has resulted in serious water pressures, poor water management and severe non-point source pollution (Akissa, 2001). However, current rural–urban interface classifications still focus on spatial planning purposes with little recognition of ecohydrological aspects.

Ecohydrological consideration in planning of new urban areas provides an opportunity to cope with the global changes of urbanisation and climate and to create systemic solutions of problems that are integrative and interdisciplinary in nature around water, people, and the environment (Wagner and Zalewski, 2009; Zalewski and Wagner, 2008; Zalewski et al., 2008; Sohel, 2015). In particular, Ecohydrological considerations can allow transdisciplinary framework for understanding the problem and implementing the solutions that will enhance environmental sustainability (Zalewski, 2011), including near and within urban areas (Janauer, 2005). Three methodological principles are proposed from ecohydrology point of view for sustainable water ecosystem and societies covering information for understanding structure, states and relationship; knowledge for understanding pattern and processes; and wisdom for using information and knowledge for problem solving (Zalewski et al., 2009, 2010; Wagner and Zalewski, 2012; Zalewski, 2002, 2011):

1. Hydrology – quantification of hydrological cycle analysis from the perspective of socio-economic, spatial, and temporal dynamics with respect to the various forms of human impact;
2. Ecology – analysis the distribution of various types of interacting organisms living together in a habitat (biocenoses) and their potential to enhance the resilience and carrying capacity of ecosystem services for society;
3. Ecotechnology – using dual regulation (biota to control hydrological processes and vice versa), integration of various types of biological and hydrological regulations to improve water quality, biodiversity and freshwater resources, and harmonisation of ecohydrological measures with necessary hydrotechnical solutions such as irrigation systems, reservoir/dam, and sewage treatment plant.

Various physical and social landscapes in metropolitan regions can influence water availability, water and energy consumption rates and stormwater generation. In fact, there is progressing degradation of water and urban–peri-urban ecosystem resources on a global scale that is affecting rural–urban liveability and sustainability. Planning and managing rural–urban interface environment for sustainable water use and liveability will need the efforts in quantifying and qualifying the process, identification of threats, and development of solutions considering the perspective of socio-economic and spatial-temporal dynamics with respect to various forms of human impact. The approach for defining rural–urban interface in this study is related to the first principle as it implies the quantification of the processess related to hydrology-biota interplay. The main aim of Part I of the two part article is to develop methodology to delineate peri-urban areas through multivariate, univariate, and multiple univariate clusters analysis. Part II of this article is focussed on evaluating the delineation methodology for rural–urban interfaces in the context of ecohydrology and quantifying the ecohydrological state of a given area.

2. The study area

The study area is located in the development zone of Cirebon Metropolitan Region (CMR) in Indonesia. This is a new metropolitan region proposed by the West Java Province, located in the north-eastern part of West Java. Specifically, the CMR is situated between latitude 6°30′ and 7°44′ S and longitude 108°03′ and 108°48′ E. Five local governments at district level are involved in CMR – Cirebon Municipality, Cirebon Regency, Kuningan Regency, Majalengka Regency and Indramayu Regency (Fig. 1).

The centre of the metropolitan region is Cirebon Municipality, a medium size city with a total population around 300,000 inhabitants. The boundary area of the study covers 45 sub-districts, and 483 villages with a population of around 1.6 million people. More than 50% of the population of CMR live in the lowland areas, concentrated in the Cirebon City and Cirebon District. In particular, three out of five political boundaries (Cirebon City, Cirebon and Indramayu Districts) are situated in the coastal area (north coast of Java) while the rest (Kuningan and Majalengka Districts) are situated in inland area. To fulfil urban water needs, the Cirebon District and City are largely dependent on water supply from Kuningan District. Flooding and drought disasters are major challenges of water management in the CMR. The rapid change of land use and climate predicted to occur in the future may