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GUEST EDITORIAL

# Environmental land use conflicts and ecosystem services: paper review

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## BACKGROUND, PROBLEM, PURPOSE, METHODOLOGY

The topic of potential conflicts related to land use involving human activities in a watershed is an important matter to be discussed (Pambudi & Pramujo, 2022). The background of this research is that conditions in mountainous watersheds, agricultural land use causes changes in ecosystem services, with trade-offs between crop production and erosion regulation. Watershed management with an environmental concept often faces problems with different interests among stakeholders. Land-use and land-cover conversion by human activities cause changes in ecosystems and their functions. It encourages researchers to map the effective use of land resources in the context of land management, which is a region-specific policy. Land-use conflicts occur when ecologically vulnerable land is used by human activities, resulting in a contravention between two different goals, namely: sustainable conservation and profitable land-use.

Although several studies have initiated the mapping of land-use conflicts between human activities and conservation, the spatial assessment of land-use conflicts on environmental issues and trade-offs of ecosystem services in agricultural areas has not been fully considered. Paper entitled *"Mapping environmental land use conflict potentials and ecosystem services in agricultural watersheds"*, written by Ilkwon Kim & Sebastian Arnhold (2018) in the journal Science of the Total Environment, 630, 827-838 with doi:10.1016/j.scitotenv.2018.02.176. This paper takes a step further to map land use conflicts between agricultural preferences for food crop production and environmental emphasis on erosion regulation.

The purpose of this study is to map land use, with indicators of measuring conflicts in the value of conservation and agricultural development, through scenarios of the level of erosion hazard on agricultural land. This study applies the land suitability index (LSI) and soil potential to estimate and classify the agricultural land capacity. In addition, it assesses two land management scenarios (i.e., reforestation and annual crop cultivation) to classify trade-offs between ecosystem services and to identify the suitability of policy options for the significant reduction of land-use conflicts in agricultural areas. This study provides input to decision-makers regarding watershed conservation efforts that still consider aspects of the economic needs of agricultural land. The objective of the reviewers is to understand how the concept of mapping the potential conflict of land use in the Haean watershed in South Korea can be applied in Indonesia.

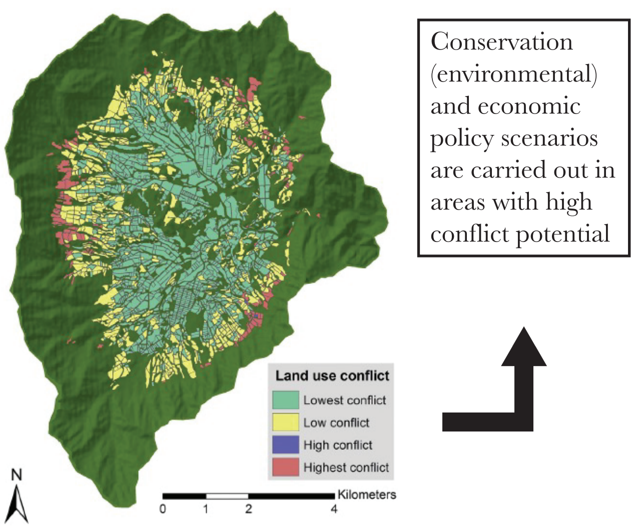
The methodology used is to apply the agricultural land suitability index based on various analytical criteria to estimate the spatial preferences of agricultural activities. To predicting erosion, using the Revised Universal Soil Loss Equation (RUSLE) method and the classification of agricultural land in the watershed is divided into four levels of land use conflict (lowest, low, high, and highest).

## SUMMARY AND FINDINGS

Watersheds (or DAS in Indonesian) are natural ecosystems bounds by ridges with rainwater that falls in the area will flow into rivers which eventually empties into the sea or lake (Pambudi & Kusumanto, 2023; Asdak, 2010; Arsyad 2006; Suripin 2004). In the watershed, there are two areas, namely the water supply area (upstream area) and the water receiving area (downstream area), which are interconnected and affect each other. Halim (2014) stated that the function of the watershed is as a catchment area, water storage, and water distribution area. The low level of formal protection of protected areas is of great concern even though it is significant for sustainable development. Pressures on protected areas and their impacts show great value to communities, both in the surrounding environment and in general (Pambudi, 2020; Cumming, 2016; Watson et al., 2014).

Yi et al. (2018) suggest that with the continued decline of local and global biodiversity and ecosystem services, it is critically important to understand how biodiversity and various ecosystem services interact and how land changes may alter these interactions over time. Land use decisions lead to vulnerability to land-use conflicts. The conflict occurs interpreted as a trade-off between the provision and regulation of ecosystems regarding agricultural practices. Regulatory services (erosion regulation) to improve water quality are significant for residents in downstream areas, while upstream areas focus on procurement services (harvest production). However, trade-offs between ecosystem services in regional agriculture have not been considered in studies of land-use conflicts. In this study, researchers mapped potential land-use conflicts and identified trade-offs between different ecosystem services in agricultural land. The researcher classified agricultural areas according to the conflicted land use environment and extracted the areas with the highest conflict, where agricultural production capacity was low, causing severe land loss. The classification of conflict areas reflects the degree of trade-off between ecosystem services. Land management programs, which strike a balance between different ecosystem services, remain a challenge in the environment. Identification of priority areas with the highest conflict can increase service capacity to reduce losses in service delivery.

Land use conflict is defined as a situation which stakeholders face a conflict of interest (Pambudi & Pramujo, 2022). Land use conflict defines as a situation in which stakeholders face a conflict of interest in their land to use land resources which causes negative effects (Von der Dunk et al., 2011). Kim and Arnhold's research found that soil loss in agricultural areas in the Haean watershed was estimated at 94,504.2 tons/ha/year, and agricultural suitability of 0.873. The results show that the potential for land-use conflicts is highest in steep areas where reforestation can significantly contribute to soil erosion regulation.




Source: Kim & Arnhold, 2018

**Figure 1.** Result of land use conflict analysis in Haean Watershed, South Korea.

The study simulates agricultural land management scenarios with the option of converting the area with the highest level of conflict into the forest as much as 7.5% of the total area (Scenario 1) can reduce land loss by 24.6%. When Scenario 2 is carried out, namely by managing the conversion of paddy fields into annual crops in the highest conflict areas by the community, it can reduce land loss by 19.4% more than the current scenario (business as usual). The result can maximize land management plans by extracting spatial priority issues and land use conflicts -versus- conservation as trade-offs for ecosystem services.

**Table 1.** Comparison of land use composition scenario results.

| Business as Usual (BAU) | Scenario 1 | Scenario 2 |
|---|---|---|
| Soil loss 94,504.2 tons/ha/year | Soil loss 67,702.9 tons/ha/year | Soil loss 75,973.2 tons/ha/year |
| No conversion in agricultural land | Agricultural land converted into a forest | Agricultural land converted into annual crops |
| Communities get optimal economic benefits, but it is not sustainable | Communities did not have economic benefits, but it is environmentally friendly and sustainable | Communities still have economic benefits, and it is environmentally friendly and sustainable |
| High potential conflict (between environmental / conservation and economic interests) | Higher potential for conflict (ignoring economic interests) | The potential for conflict is reduced (still considering economic interests) |

Source: Processed from the results of Kim 7 Arnhold's analysis, 2018

## STRENGTH AND WEAKNESS OF PAPER

The advantage or positive side of this paper is that it has brought up the concept of sustainable development by giving portions to 3 aspects, namely economic, social and environmental. The solution offered from the research results illustrates that there are efforts to reduce potential conflicts between conservation needs and economic and social needs. This study views a larger space than just the environmental aspect as an absolute driver of sustainability, but also other factors, namely the economic. It allows stakeholders to develop the concept of a strategic conservation area as an "ecological and hydrological infrastructure" that becomes a source of ecosystem services, but the aspect of community economic needs is also a concern.

This paper has shown the author's foresight about the effectiveness of policy intervention sites selection, namely to reduce the rate of erosion significantly only need to intervene in areas with the highest potential conflict. It shows that to reduce the erosion rate does not need to change or provide policy interventions in all areas of potential conflict, but only in areas with the highest conflict potential. The mapping of the 3 Scenarios carried out by the author is also sufficient to consider readers to determine or choose the most realistic option, namely by allowing conditions to continue as they are (business as usual), conversion of the highest conflict areas to forests (Scenario 1) and conversion of conflict areas. The highest is an annual plant. Each option provides information on the risk of the resulting erosion rate as well as the economic and environmental benefits that may be obtained by the community.

Mapping the supply and use of ecosystem services discussed in the paper brings together connections/relationships between socio-economic and environmental (conservation) aspects. By showing the risk of existing erosion rates, the authors have offered a sustainable ecosystem approach through environmentally friendly land resource management without ignoring the needs of communities. Protection of natural ecosystems has a better impact if it is in line with economic aspects, especially concerning ensuring a reduction in erosion rates.

Another positive thing that can be taken is that spatial analysis determines areas of potential conflict (lowest, low, high, highest), enabling policymakers and the community to carry out recovery programs/activities more effectively and focused. The accuracy of determining the location of the policy has an impact on cost, time, and energy efficiency.

One of the weaknesses or negative sides of this paper is the lack of empirical data for input factors, which does not adequately reflect local heterogeneity. In addition, this paper has not considered the aspect of calculating population pressure on land. The assumption used by the author when offering the Scenario 2 option (conversion to annual crops) is that the people's livelihoods are horticulture farmers, whereas the existing ones are agriculture/rice farmers. In addition, to estimate the optimal value of each indicator is also needs various input factors that reflect the local heterogeneity of the watershed. Another weakness of this paper is that it still focuses on reducing the rate of erosion option as the point of analysis, not yet touching on accurate economic calculations. Although limited, this research can visualize the macro spatial distribution of erosion rate calculations and crop production potential (economically profitable) that can help formulate agricultural land management policies in water catchment areas.

The concept of spatial planning and land use change is inseparable from watershed management, which considering the balance of upstream and downstream ecosystems within the identical hydrological boundaries (Pambudi, 2019; Arsyad 2006; Suripin 2004). Watershed management is closely related to the ecosystem approach and hydrological regulation where people or humans are a significant element in it.

## CONDITIONS IN INDONESIA

Kim & Arnhold's research (2018) has never been done in Indonesia, but one of the conceptually related studies is the research of Wuryanta & Susanti (2015). Their study conducted at the Keduang Watershed, which is part of the Gajah Mungkur Reservoir Catchment Area, Wonogiri Regency, Central Java. This study assesses the relationship of population/humans to land use upstream, which is prone to erosion. The purpose of the study was to calculate and determine the level of population pressure on agricultural land in the Keduang watershed and each sub-district in the Keduang Sub-watershed. These objectives were obtained by: 1) identifying the area of each sub-district located in the Keduang watershed area; 2) land cover/use analysis, and 3) population analysis which includes population and population growth in each sub-district in the Keduang Sub-watershed.

**ANALISIS SPASIAL TEKANAN PENDUDUK TERHADAP LAHAN PERTANIAN DI SUB DAS KEDUANG, KABUPATEN WONOGIRI, JAWA TENGAH**
**(*Spatial Analysis of Population Pressure on Agricultural Land in Keduang Sub Watershed, Wonogiri District, Central Java*)**

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Diterima 11 Desember 2014, direvisi 5 Agustus 2015, disetujui 24 Agustus 2015

***ABSTRACT***

*Population pressure on agricultural land is one of the important parameters to determine the level of watershed environment quality. High population pressure on agricultural land in a watershed can lead to land degradation and watershed ecosystems damage. The purpose of research is to calculate and determine the level of population pressure on agricultural land in the sub watershed and in each district in the sub watershed by using Geographic Information System (GIS). Population pressure on agricultural land is calculated by using Soemarwoto's formula (1985). The classification of population pressure on agricultural land is based on the Decree of the Directorate General of Land Rehabilitation and Social Forestry (RLPS.) Ministry of Forestry of Indonesia No. P.04/V-SET/2009. The research was conducted in Keduang sub-watershed which is part of water chatchment area of Gajah Mungkur Reservoir in Wonogiri District, Central Java. The results showed that population pressure on agricultural land in Keduang Sub-watershed is categorized as "bad" with the value of 28.978,16. Girimarto, Jatipurno, Jatiroto, Jatisrono and Sidoharjo districts are categorized as "medium", while Jatiyoso, Kismantoro, Ngadirojo, Nguntoronadi, Purwantoro, Slogohimo and Tirtomoyo districts are categorized as "bad" with the value more than 2.*

*Keywords: Population pressure, Keduang Sub-Watershed and Geographic Information System (GIS).*

**ABSTRAK**

Tekanan Penduduk (TP) pada lahan pertanian adalah salah satu parameter penting untuk menentukan tingkat kualitas lingkungan suatu Daerah Aliran Sungai (DAS). Tingginya TP pada lahan pertanian pada suatu DAS dapat mengakibatkan penurunan sumber daya lahan dan kerusakan ekosistem DAS. Tujuan penelitian adalah untuk menghitung dan menentukan tingkat TP pada lahan pertanian pada sub DAS dan masing–masing kecamatan pada sub DAS dengan menggunakan perangkat Sistem Informasi Geografis (SIG). Untuk menghitung TP digunakan rumus Soemarwoto (1985). Klasifikasi TP didasarkan pada SK Ditjen RLPS P.04/V-SET/2009. Penelitian dilaksanakan di Sub DAS Keduang yang merupakan bagian dari Daerah Tangkapan Air (DTA) Waduk Gajah Mungkur Kabupaten Wonogiri, Jawa Tengah. Hasil penelitian menunjukkan Tekanan Penduduk (TP) di Sub DAS Keduang dikategorikan jelek dengan nilai TP = 28.978,16. Wilayah kecamatan di dalam sub DAS Keduang yang tekanan penduduknya dalam kategori sedang adalah Kecamatan Girimarto, Jatipurno, Jatiroto, Jatisrono dan Sidoharjo. Wilayah Kecamatan Jatiyoso, Kismantoro, Ngadirojo, Nguntoronadi, Purwantoro, Slogohimo dan Tirtomoyo memiliki nilai TP > 2 dikategorikan jelek.

Kata kunci: Tekanan Penduduk pada lahan (TP), Sub DAS Keduang dan Sistem Informasi Geografis (SIG).

**I. PENDAHULUAN**

Sub Daerah Aliran Sungai (Sub DAS) Keduang merupakan salah satu Daerah Tangkapan Air (DTA) Waduk Gajah Mungkur di Kabupaten Wonogiri. Berdasarkan hasil penelitian dari JICA (2007), Sub DAS tersebut juga sebagai penyumbang sedimentasi terbesar, yaitu 1.218.580 $m^3$ atau sekitar 38,33% dari total sedimentasi di Waduk Gajah Mungkur. Sedimentasi yang besar sebagai akibat tingginya erosi pada lahan di wilayah Sub DAS Keduang tersebut disebabkan oleh pemanfaatan dan pengelolaan lahan yang tidak sesuai dengan kemampuan dan daya dukung lahan akibat dari peningkatan kebutuhan.

Peningkatan jumlah penduduk terkait erat

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Analisis Spasial Tekanan Penduduk terhadap Lahan Pertanian ..... (Agus Wuryanta & Pranatasari Dyah Susanti)

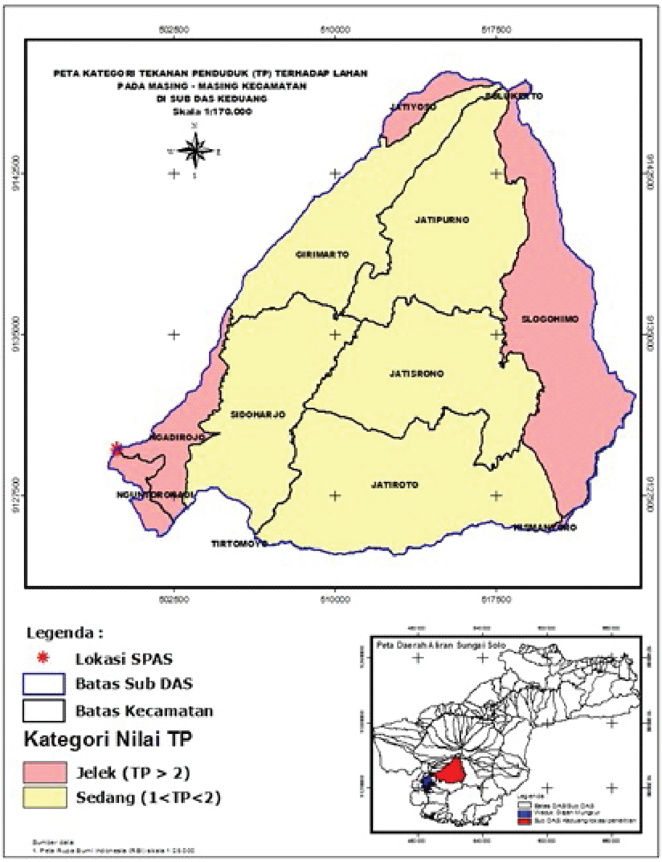
Research by Kim & Arnhold (2018) and Wuryanta & Susanti (2015) emphasizes the concept of human ecology as a core part of their research. The basis of human ecology is the pattern of relationships between society as a community and the surrounding environment.

The increase in population is closely related to the increasing need for land, which can lead to the conversion of agricultural land to non-agricultural land so that it has an impact on ecological changes that lead to environmental degradation (Sartohadi, 2008). In addition, Suputra (2012) suggests that population growth causes land-use problems to become more complex and highly competitive. Land-use change that is not well planned (not taking into account the ability and carrying capacity of the land) can cause various environmental impacts such as erosion, lack of water catchment areas, flooding, river silting, decreased fertility, and land productivity, and others (Harianto, 2002).

**Table 2.** Population pressure (TP) on land in each sub-district in the Keduang Sub-watershed.

| No. | Kecamatan *(Sub District)* | Tekanan Penduduk (TP) *(Population Pressure)* | Klasifikasi *(Classification)* |
|---|---|---|---|
| 1 | Bulukerto | - | - |
| 2 | Girimarto | 1,91 | Sedang |
| 3 | Jatipurno | 1,23 | Sedang |
| 4 | Jatiroto | 1,21 | Sedang |
| 5 | Jatisrono | 1,88 | Sedang |
| 6 | Jatiyoso | 5,15 | Jelek |
| 7 | Kismantoro | 386,95 | Jelek |
| 8 | Ngadirojo | 8,46 | Jelek |
| 9 | Nguntoronadi | 12,25 | Jelek |
| 10 | Purwantoro | 3.719,80 | Jelek |
| 11 | Sidoharjo | 1,26 | Sedang |
| 12 | Slogohimo | 2,37 | Jelek |
| 13 | Tirtomoyo | 2.002,86 | Jelek |
| | Sub DAS *Sub watershed* | 28.978,16 | Jelek |

Source: Analysis results of Wuryanta & Susanti, 2015




Source: Wuryanta & Susanti, 2015

**Figure 2.** Spatial display identification of areas with high population pressure affecting the rate of erosion.

Research conducted by Wuryanta & Susanti (2015) shows spatially the impact of population pressure on land with the recommendation that various conservation efforts and or reduction of population pressure (TP) in the Keduang Sub-watershed of Wonogiri Regency need to be more focused on seven sub-districts, namely: Jatiyoso, Kismantoro, Ngadirojo, Nguntoronadi, Purwantoro, Slogohimo and Tirtomoyo whose level of balance between land area and the population is TP > 2. To get a more accurate TP value in the Keduang Sub-watershed, data collection on the number of residents and farmers recommends being carried out not only in the administrative area but also in the sub-watershed area.

## SIGNIFICANT SOLUTIONS (OPINIONS AND SUGGESTIONS)

The results of this research in the Keduang watershed of Central Java would be better if combined with the research of Kim and Arnhold (2018) in the Haean watershed in South Korea, which relates population pressure to land and mapping areas of potential conflict in conservation and socio-economic policies. Kim and Arnhold's research (2018) will complement the accuracy of erosion predictions associated with human activities. The combination of spatial approaches, watershed, economic, and social concepts with the main point in the human aspect will realize a more integrated and comprehensive view of Mapping Priority Land Use Potentials to Sustainable Agricultural Watersheds.

The phenomenon of the downward trend in environmental quality marked by a high rate of erosion underlies the concept of sustainable development, which is a concept that pays great attention to environmental sustainability in line with social and economic needs. Spatial planning that considering the impact of erosion should begin by identifying areas that naturally must be saved (protected areas) to ensure environmental sustainability, and areas that are naturally prone to disasters in the upstream (prone to natural hazards). Thus, spatial planning must begin with the question: how can watershed conservation be sustainable?.

The paper written by Kim & Arnhold (2018) should be equipped with options for the readiness or response of the rice farming community if they have to convert their land to annual crops. have Recommendations given by the researcher have not considering changes in a community culture that may arise. Another suggestion is the need to present the calculation figures for the design costs, advantages, and disadvantages of each scenario, knowing how economically profitable it is for policymakers and the community if they will carry out these scenarios.

The paper will be more comprehensive if equipped with an analysis of sociological and cultural approaches as a follow-up effort to the results of the spatial mapping done. It is significant because a policy or technical recommendation will not be sustainable without the participation of the community (humans) as the main factor for its success. The reviewer argues, in the future, it is necessary to deepen the science of human ecology to synergize with spatial-technical analysis in non-social science scientific research as carried out by Kim & Arnhold (2018) in the Haean watershed, South Korea, and Wuryani and Susanti (2015) in the Keduang watershed, Indonesia. With the involvement of the human ecological approach, the position and role of human interaction with the environment will become clearer, which also comprehensively examines natural conditions, social organizations, traditions, and the technology that supports them.

## CONCLUSION OF THE REVIEW

Natural resources have a dual role, namely as a capital for economic growth (resource-based economy) and at the same time as a life support system. Until now, natural resources is a highly significant role as the backbone of the human economy and will still be relied on in the medium term. On the other hand, economic policies that favor short-term growth have triggered aggressive, exploitative, and expansive patterns of production and consumption, so that the carrying capacity and function of the environment has declined, even leading to severe conditions. The balance of ecosystems and economy with long-term sustainability targets is currently the concern of many researchers, both in Indonesia and globally. Based on these dual functions, natural resources management must always balance to ensure sustainable development. The principles of a sustainable development application in all sectors and regions are the main prerequisite to be internalized into development policies.

The paper written by Kim & Arnhold (2018) in the Haean River Basin, South Korea, is quite helpful if applied in Indonesia to obtain balanced policy directions between conservation (environmental) and socio-economic needs in sustainable watershed management. This research provides input to decision-makers regarding watershed conservation efforts (enhancing environmental carrying capacity) which considers the alignment with the economic needs of agricultural land. Therefore, it suggested changing the title of the existing paper to "Mapping priority land use potentials to sustainable agricultural watersheds."

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