Green infrastructure concept in supporting rural development

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Abstract. Infrastructure is not only needed to push the development but also able to protect rural natural environment in which its ecosystem functions as life support. The challenge is that development activities should not change rural natural landscape. Green infrastructure which have multifunctional capacity offer the concept of environmental conservation while promote development activities based on natural resources. This paper aims at analyzing whether the concept of green infrastructure could support rural development as well as conserve the rural environment. Ciemas rural area is chosen as rural development location which begin to develop tourism activities. This study used a qualitative descriptive method, based on literature survey, on-site visual observation and survey of relevant official institutions. Based on demography statistic, geomorphology, vegetation cover and land use map data, this study identify socio-ecological linkages across Ciemas rural area and the prospect of development activities and propose green infrastructure types at rural landscape scale as a result. This paper conclude that green infrastructure concept could be implemented and protect Ciemas natural environment effectively as well as provide welfare to Ciemas community.

1. Introduction

Infrastructure development is absolutely necessary especially in the effort to enhance development activities of a rural region. Infrastructure could ease community activities and increase community welfare [1]. However, infrastructure is not only needed to push the development but also able to protect rural natural environment in which its ecosystem functions as life support. The challenge is that development activities should not change its natural landscape. Many of built infrastructure in Indonesia are grey infrastructure. Grey infrastructure, such as transportation or water management infrastructures, has only a single function [2]. On the other hand, green infrastructure which have multifunctional capacity [3] and provide multiple benefits for wildlife and human recreation [4] offer the concept of environmental conservation while promoting development activities based on natural resources. Multifunctionality showed that green infrastructure has multiple functions and provide benefits to the same spatial area [2].

Green infrastructure have been applied in many developing countries [5], especially in urban environment [3,6]. Green infrastructure concept have the capacities to address environmental problems such as water shortages and flooding [7], air quality deterioration [8], or damage due to climate change and development [9,10]. Green infrastructure is actually an ecological technology application [11], so that it gives ecosystem opportunity to recover if damage happened. Green infrastructure have a spectrum functions which provide ecosystem services benefits of social, economy and environmental nature [12]. The green infrastructure concept is rarely applied in Indonesia [13]. Although most rural areas have...
already looked green, they still need to be planned cautiously because of their natural resource abundance.

By definition, green infrastructure is an interconnected network of greenspace that conserves natural ecosystem values and functions and provides associated benefits to human populations [5]. This paper aims at analyzing whether the concept of green infrastructure could support rural development as well as conserve the rural environment. Ciemas rural area is chosen as rural development location which begin to develop tourism activities. Ciemas rural area administratively belong to Ciemas district located in southern part of Sukabumi regency. This area has the potential of both biological and non-biological natural resources, such as historic geological sites. All of the natural resources in Ciemas rural areas are used to meet life necessity of local inhabitants as well as community of the surrounding the area. In the process of utilizing the natural resources to meet the living needs, the community needs to be supported with the provision of infrastructure so that the resources can be used effectively. A study of green infrastructure concept for rural development for Ciemas rural areas in Sukabumi regency is therefore needed to support the community.

2. Methods
To analyze the implementation of green infrastructure concept, this study utilizes qualitative method which use interpretative approach to spatial phenomena [6]. The analysis is based on literature survey, on-site visual observation and survey of relevant official institutions. The literature survey examines green infrastructure concept with regard to general application in spatial planning as well as other earlier studies in the area. The on-site visual observation covers areas that have ecologically sensitive as well as beautiful scenery. While the official institutions surveys look for spatial maps, policy and statistical population data.

Based on demography statistic of Ciemas rural area, this study analyses the prospect of development activities. From the geomorphology, vegetation cover and land use map data, this study identify socio-ecological linkages across Ciemas rural area and several ecologically sensitive and good scenery areas as conservation area. Through map overlay with the development prospect, green infrastructure concept is applied to Ciemas rural area. Several green infrastructure types at rural landscape scale are proposed.

3. Results and discussion
Ciemas district administratively has 9 (nine) villages with an area 31,316 ha, located in the western part of Sukabumi Regency, which is directly adjacent to the Indian Ocean. Each village has different morphological characteristics, covering the highlands areas to the low lands areas which are located in coastal areas and has bays and several small islands. The Ciemas rural area is drained by 2 (two) large rivers, that is the Ciletuh river and the Cimarinjung river and there are some other streams dispersed on the low land area. In coastal area, mangrove ecosystems can be still found.

Activities that can be developed in this rural area are dry land agriculture, wetland agriculture, plantations, fisheries, and tourism. Until now, main community activities depend on agricultural sector. Although rural community has not completely ready to be able to participate in tourism activities [14], tourism potential is very promising prospect. Tourism activities can be developed in the form of natural tourism and marine tourism. There are cliff landscapes or ravines known as the Ciletuh Geopark tourism icon. This unique landscape separate lowland area with hill area and go along up to 8 villages, starting from Girimukti village to Mandrajaya village and forming the letter U. That morphological shape of the Ciletuh bay resembles the shape of an amphitheater in the form of a plain surrounded by high cliffs open to the west, as can be seen in figure 1. This area was developed into the Ciletuh geopark tourist area, which is one of the activities that can provide a multiplier to other community activities.

Other tourist attractions developed in the Ciemas rural area are natural attractions which are supported by the presence of the waterfalls which are found on the walls surrounding the amphitheater. Those waterfalls pervade from south to north, which consist of Puncak Manik, Tengah, Awang, Cikaret, Cikanteh, Ngelai, Sodong, and Cimarinjung waterfalls. One of them can be seen in figure 2. In addition to being tourist attraction, these waterfalls also supply of raw water for the development of wetland
agricultural activities undertaken by the community. Natural resources in the Ciemas rural area have the potential for the prospect of developing community activities, including agricultural activities in wetlands, fisheries, and tourism, where activities undertaken by the community can provide prospects for other development in the area, that is trade and service activities.

![Figure 1. Ciletuh mega amphitheater as a geo-landscape.](image1)

![Figure 2. Awang waterfall as natural attraction.](image2)

There are several socio-ecological linkages that can be identified. In supporting the development of Ciemas rural area, there have already existed grey infrastructure in the form of road networks, docks, clean water, irrigation, electricity networks, telecommunications networks. The Ciemas rural area is currently only accessible by land transportation, namely through the City of Sukabumi and Pelabuhanratu. The routes are Sukabumi City - Jampang Tengah - Ciemas or via Pelabuhanratu to Ciemas road, with good quality roads and all routes take more less 2-3 hours. Existing sea transportation can only be used for capture fisheries activities. It cannot be utilized as a transportation route for people.

Most of Ciemas community which have cultural tradition work as farmer in rice field and forest area, also as fisherman. Their settlement area located alongside local and collector road as well as along seashore. They work really having connection with nature in the way that nature as source of their livelihood and give them many other benefits. Rivers and several streams have been used as water source for irrigation. There is irrigation network, both technical and semi-technical irrigation, with a total discharge of 2,340 liter/second, which can irrigate 3,241 ha of agricultural wetland (see table 1).

![Table 1. Irrigation area in Ciemas district.](image3)

| No | Type of irrigation network | Authority | Irrigation Area Coverage | Irrigation Area (Ha) | Debit (lt/second) |
|----|---------------------------|-----------|--------------------------|----------------------|------------------|
| 1  | Technical                 | Central   | Ciletuh                  | 1,369                | *                |
| 2  | Govt.                     | Cikanteh 1| 132                      | 119                  | 165              |
| 3  | Districts                 | Cikanteh 2| 620                      | 558                  | 775              |
| 4  | Semi Technical            | Cicerug   | 76                       | 68.40                | 95               |
| 5  |                           | Ciporeang | 100                      | 90                   | 125              |
| 6  |                           | Rancalutung| 151                   | 135.90              | 188.75           |
| 7  |                           | Nempel   | 150                      | 135                  | 187.50           |
| 8  |                           | Cikalong | 161                      | 144.90              | 201.25           |
| 9  |                           | Cibenda  | 102                      | 91.80                | 127.50           |
| 10 |                           | Cimarinjung| 230         | 207                  | 287.50           |
| 11 |                           | Cirambutan| 150                    | 135                  | 187.50           |
|    | Total                     |           | 3,241                    | 1,685*               | 2,340*           |

Source: Water resources management agency, Sukabumi regency – 2017.

Natural Resources and the existing grey infrastructure in the Ciemas rural area have already a positive impact on increasing community activity. This can be seen with the irrigation network with a discharge of 2.34 liter/second can increase rice production by 13.52% in the period of 2016 - 2019, meaning that the average production growth rate increased by 6.76% / year. With the opening of the Ciletuh Geopark
tourist area, provide enormous opportunities for the Ciemas rural area for more advanced development, which can take advantage of development opportunities and increase other activities. In 2019 there is an increase in the number of tourists visiting the Ciemas rural area, based on the results of interviews conducted with the Tourism Office Sukabumi District, information are obtained about the number of tourists visiting Sukabumi in the first quarter of 713,617 people, 32,512 people from foreign tourists and 681,105 people from domestic tourists, while in the second quarter the number of foreigners was 29,066 people and from domestic tourists were 1,250,379 people. Agricultural and tourism activities need good water quality along the years. Green infrastructure can be planned to include the application of water self-purification and natural rain water collection system as ecological technology [11], which can be integrated with Ciletuh and Cimarinjung river as major sources of natural water supply.

The potential of natural resources in the Ciemas rural area is suitable to be developed into community activities so as to increase community welfare. This can be seen from the analysis of the suitability of the land designation by conducting a superimpose analysis of land conditions and land morphology. The developed land includes areas that have potential land to be developed (see table 2).

| No. | Village       | Potential Land (ha) |
|-----|---------------|---------------------|
| 1   | Cibenda       | 575.61              |
| 2   | Ciwaru        | 564.95              |
| 3   | Taman Jaya    | 716.4               |
| 4   | Mekar Jaya    | 1091.814            |
| 5   | Ciemas        | 361.02              |
| 6   | Girimukti     | 67.05               |
| 7   | Mandra Jaya   | 1574.646            |
| 8   | Mekarsakti    | 667.686             |
| 9   | Sidamulya     | 1838.946            |

Source: Analysis results.

In line with the increase in population in 2035 it is predicted to number 59,180 people, requiring 14,086.36 tons/year of food (assuming the consumption standard is 0.1241292 tons / capita / year). Therefore, for the future development of the Ciemas rural area, it is necessary to develop infrastructure that supports agricultural activities, such as: the development of irrigation networks, agricultural production processing facilities, markets and others. Meanwhile, to support the development of tourism activities in meeting the needs of tourists in the Ciemas rural area, tourism supporting infrastructure is needed, such as culinary facilities, tourist information centers, guest houses, road networks, dock improvements and others. Both agricultural and tourism activities will produce wastewater and sewage. These could be managed with engineering measure [15], such as that has been implemented for use in green infrastructure [11]. The picture of all socio-ecological linkages can be seen in figure 3.

There is a fairly strong relationship between community activities and the availability of infrastructure. This means that all infrastructure in supporting rural development which use natural resources has a positive impact on the community development. Development of green infrastructure to support rural community activities can improve environmental sustainability, because green infrastructure can make existing natural resources well managed and provide added value to the rural society. Ciemas has a unique landscape namely Geopark Ciletuh. It is a geology site, which has been designated as National Geopark. Since Geopark Ciletuh has been proposed as tourist destination as well as protected area, therefore conservation principle and eco-tourism should be become a choice. This means Ciemas rural development should provide green infrastructure plan integrated with plan for grey infrastructure. Moreover, implementation of green and grey infrastructure should hold balance principle which support sustainable development [16]. Green infrastructure would be a key to sustainability [15] since the concept promote more efficient and sustainable land use and development design [3].
Future green infrastructure for Ciemas rural development create networks of multifunctional green space in rural environment. Networks called as corridors whereas green spaces called as hubs which act as an anchor for variety of natural processes and function as origin or destination for wildlife. Corridors take account of system flows such as stream and river while hubs in rural landscape scale could be reserves, native landscapes and working lands. There are Cipeucang nature reserve, Cikepuh wildlife, Ciwaru rice field, Ciletuh and Cimarinjung river can be determined as hubs. Meanwhile, several streams act as corridors. How those hubs and corridor are connected can be seen in figure 4.

![Figure 3. Socio-ecological linkages across Ciemas rural area.](image1)
![Figure 4. Future green infrastructure for rural development.](image2)

4. Conclusion
Infrastructure development in a system become a supporting of activities in a rural area. Infrastructure is a means as well as a catalyst in a development. Infrastructure availability will increase public access to resources so as to enhance efficiency and productivity. Therefore, it is important that a good planned infrastructure system could be employed to support rural development. The green infrastructure offers more environmentally sound concept and several ecological technologies can give more sustainable solutions.

Other green infrastructure provides ecological, economy and social benefits that support sustainable development. However, to implement green infrastructure, there will be need for collaboration among stakeholders. They could be from local communities, local government of Sukabumi regency, West Java provincial government, Geology institution, the Natural resources conservation agency of West Java, Geopark management board, Tourism board of Sukabumi Regency.

Indonesia has not much implementing the concept of green infrastructure in the planning of rural and urban areas. The fact that Indonesia has many rural areas in the spectrum of diverse landscape, their environments should be constantly looked after. Green infrastructure concept is a promising concept and the concept could procedurally be applied into the regional and local planning document. For the Ciemas case, green infrastructure could be substantially adopted. This will contribute to practical rural planning. To implement green infrastructure concept in a village scale, a more detailed study is therefore needed.

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