The impact of the characteristics of riverbanks settlements on the sustainability of Kali Pepe Surakarta

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Abstract. Surakarta City is one of the cities in Indonesia that has experienced the effects of urbanization and rapid development. This is evident from the slums along the banks of the Kali Pepe. This river intersects the city of Solo and stretches for about five kilometers from Sangkrah Village to Gilingan Village. This river used to have an important role in accommodating urban mobility. In 2016, Kali Pepe received attention for its pedestrian segments, parks, and riverbank development. This study describes the settlement characteristics along the riverbanks in relation to the sustainability of the Kali Pepe. Descriptive-qualitative methods accompanied by in-depth interviews were used to collect data. Moreover, the study exploration of field conditions was recorded in the form of sketches and photographs. The results of the study show two prominent potentials from the characteristics of the Kali Pepe riverbanks in relation to its sustainability, i.e., (1) nature characteristics that can be developed through integrated water transportation tourism; (2) The emergence of home-industry that is backed by the potential of employment in the informal sector and accommodated riverbank tourism.

1. Introduction

One impact of the current high rate of urbanization is the increase in the need for human settlements. This leads to the formation of unplanned settlements and slums. Population growth can cause social, economic, and cultural changes in cities. Such conditions can lead to a competition for land, causing the formation of slums on the remaining pieces of land in urban areas. Slum settlements are not only caused by newcomers who cannot afford the price of urban land. It is also caused by the deterioration of old settlements into slums.

Slum settlements are settlements that are not suitable for habitation due to the high building density and the low quality of buildings as well as facilities and infrastructure that do not meet minimum standards. Some other the characteristics of the slum settlements are that majority of the inhabitants are low-income households; the livelihoods of slum dwellers are in the informal sector; the environment, settlements, houses, facilities, and infrastructure are sub-standard; the public facilities are inadequate, flood-prone, and the environment can pose physical and non-physical threats for the inhabitants.
The largest slum settlement in the city of Surakarta is located along the banks of the Kali Pepe, which spans approximately five kilometers from Sangkrah Urban Village to Gilingan Urban Village. Kali Pepe is a meeting point of two rivers; Kali Pepe and Bengawan Solo. The river plays a big role in the city’s mobility for transporting goods that supply markets and for human transportation. It is the main trade artery for various ethnicities. In 2016, a restructuring program for the pedestrian walks, parks and the construction of a concrete canal lining for the Kali Pepe were planned. Kali Pepe has an interesting dynamic development environment after the waterfront environmental arrangement which began in 2016 and is planned to be completed in 2018 in line with the government's efforts to restore the image of the city in this case to accommodate waterfront city tourism.

Research related to settlements built in urban areas that are normally illegal for development has mushroomed. Areas along riverbanks are normally prohibited for development. Research on riverbanks identified the problem of settlements in the city of Bandung. These areas do not fulfill the need for adequate housing; low-income communities have limited access to housing; the quality of housing and settlements is declining; and there is no integrated development of facilities and utilities in the area. This research aimed to find out the quality of the slums and provide recommendations for the improvement of the settlements along the Cikapundung [1]. This was reaffirmed by Bintarsih's research on the development of waste banks for communities in the Cikapundung River [2]. This research recommended governments and institutions/social organizations to implement a continuous program that increases the awareness of local communities of effective waste management. Both studies complement each other in providing solutions for settlement improvement on the riverbanks [2].

Another study that has been carried out on riverbank settlements is the study on the characteristics of Kampung Beting in Pontianak [3]. Kampung Beting was formed spontaneously due to the socio-economic conditions of the area. The area is characterized by ethnic plurality, which is the absence of customary rules that generally shape the social environment of traditional settlements. Changes in settlements occur under the influence of changes in networks, lifestyles, which ultimately changes the overall ecological elements of settlements. Another study was conducted that analyzed the sustainability of riverbank settlements of the Kahayan River in Palangkaraya City. The research discovered that there were two types of settlements, namely: (1) Lanting houses (informal settlements) and (2) Stilt houses, which form formal settlements with land certificates [4].

A study on the characteristics of slum areas in Semarang found that the environmental conditions were unsuitable for living and did not meet the standards for settlements [5]. Furthermore, research on the banks of the Palembang Musi River identified the spontaneous settlement process in the area. The study identified the legality of settlements in terms of the place of origin of the residents, the process of acquiring land, the house construction activities, the characteristics of activities, and the tendency of displacement of habitable places [6]. The various studies mentioned above highlighted that the characteristics of riverbank settlements are influenced by several factors, which are, among others, by nature, the origin of residents, the behavior of people, occupancy and condition of facilities and infrastructure. In contrast to the before mentioned studies, this study examines the characteristics of the settlements in the Kali Pepe using the Doxiadis’ five elements of the settlement in order to determine its sustainability.

### 1.1. Elements of settlements

The term settlement refers to dwellings intended for humans. As such, settlements are built with the purpose of meeting humans’ needs for living space. Broadly speaking, the term settlement also implies an understanding of human interactions and interactions between humans and society as well as human-nature interactions. A settlement comprises two elements [7]:

- The content: humans who live in the settlement (individuals and social groups);
- The container: the physical place where humans live which includes natural and man-made elements.
1.2. Settlement systems by Doxiadis

A system is used to show a "phenomenon" that has a clear and well-known structure. The system is defined as a collection of elements that mutually interact and collaborate to achieve certain goals in a complex environment. The settlement system is made up of five elements, i.e., nature, Anthropos, society, shells, and networks. These elements are a comprehensive unit rather than a collection of parts.

Good settlements can provide happiness and safety and vice versa, a settlement is considered bad if it can no longer fulfill human needs. The settlement system includes [7]:

- **Nature**: sub-elements of the natural environment include geography, topography, land, water, plants, animals, climate/weather, wind, and sun.
- **Anthropos**: human needs must be well-considered, among others, biological needs (space, air, food); sensory regulation; stimulus from the environment through the senses and the need for the perception of the environment; and emotional needs. Physical development marginalizes moral values and there are reciprocal links between quality of life and quality of the environment (Figure 3).
- **Society**: elements of the society include composition and population density, social stratification and cultural patterns, economic development, education, health, law and administration (Figure 4).
- **Shells**: covers housing, social facilities, economic facilities, government facilities, industry, and transportation centers.
- **Networks**: this element includes water and power supply systems, transportation, communication, and wastewater disposal.

Human needs for space receive the most attention in ekistics. Spatial requirements include individual space for various activities and functions as well as more complex spaces for socio-economic activities. Doxiadis argued that space is needed to provide the possibility of interaction between humans and regions.
1.3. Sustainable development
The Minister of Population and the Environment in the year 2010 has outlined several environmental policies in relation to sustainable development as follows.

- Reviving economic growth, which has a direct relationship with community welfare. The indicator of community welfare is income per capita. In developing countries, the minimum growth of national income is 5% per year.
- Changing the quality of growth. This is associated with conserving natural resources, improving income distribution, and resilience to various economic crises.
- Meeting basic human needs. This includes food, shelter, clothing, energy, water, and sanitation, which must be able to meet minimum standards for economically weak groups.
- Ensuring a sustainable population. A population that can support sustainable development is stable and in accordance with the carrying capacity of its environment. To ensure a sustainable population, high population growth rates (> 2% per year), as is the case in most developing countries, must decline towards a growth rate of zero.

Sustainable development refers to actions that can preserve their natural environment. Sustainable development has the following characteristics.

- It preserves the functions and capabilities of ecosystems, directly as well as indirectly.
- It utilizes natural resources through technology that does not damage the environment.
- It provides opportunities for other sectors and activities to develop in each region, within the same timeframe and at different time periods on an ongoing basis.
- It enhances and preserves ecosystem functions to supply, protect, and support natural resources in a sustainable manner.
- It uses procedures that pay attention to the sustainability of ecosystems’ functions and abilities to support life in the present and the future.

2. Research methods
The research used a mixed-method approach that combines descriptive methods and qualitative exploratory methods based on field data to discover the characteristics of settlements located along the Kali Pepe in Surakarta. Data collection commenced with a general survey of the study locations to determine the physical boundaries of the study area. The study focuses specifically on the Kestalan Urban Village (RW1), Keprabon Urban Village (RW 5), Ketelan Urban Village (RW 4-5), and Setabelan Urban Village (RW 7-9). The survey results are presented using descriptive methods and analyzed qualitatively to identify settlement characteristics on the banks of the Kali Pepe. The settlement variables refer to the five elements of settlements, i.e., nature, humans, society, shell, and networks [7].

3. Results
The results and discussion refers to the five elements that influence the formation of a settlement, i.e., (1) Nature, the land that is used and utilized to build a residence and for other functions; (2) Humans, individuals or groups who occupy the land; (3) Society, referring to the interactions and social relations; (4) Shells, a shelter for human life; (5) Networks, the infrastructure used to support human livelihood activities. Based on this theory, the characteristics of slums along the Kali Pepe can be identified as follows.

3.1. Nature characteristics
The Kali Pepe River is in a flood-prone area with inadequate drainage facilities, which causes flooding when it rains. In 2016, the government started making concrete canal lining and dredging along the riverbanks, stopping flooding until now. Access to water for the community can be classified as good and is supplied by using shallow well water, rainwater, or by purchasing canned water. Judging from the survival of animals and plants, the climate conditions are also favorable. Currently, the
government has initiated a program to develop river tourism along the Kali Pepe, which is expected to restore the historical function as a water transportation route.

![Concrete canal lining along the Riverbank of Kali Pepe](image)

**Figure 5.** Concrete canal lining along the Riverbank of Kali Pepe

### 3.2. Human characteristics

The characteristics of the residents can be identified from the social and economic conditions of the community. This can be viewed from the source of livelihoods that affect the environmental conditions and the type of shelter in the area. The majority of people who live in slums work in the informal sector. Along the riverbank, garbage is dumped in allocated space along the pedestrian even though the garbage collection system is inadequate as the garbage is collected only twice a week. In the neighborhood along the Kali Pepe riverbank, there is a 1-2 meter wide road that serves multiple functions, i.e., as a public space, a place for cooking, washing & drying laundry, and parking (Figure 6).

![Public spaces on the Kali Pepe’s Riverbanks](image)

**Figure 6.** Public spaces on the Kali Pepe’s Riverbanks

### 3.3. Characteristics of society

The population density, social stratification, and cultural patterns are unchanged in the area along the Kali Pepe riverbank. The average area of the houses is 12 m² and occupied by one household comprising 4-5 people. The houses consist of 1-2 floors of multifunctional space, yet toilets and kitchen are still outside the house. This causes the 1-2 meters wide neighborhood road to have multiple functions and be characterized by sharing of space. There are various social activities in the Ketelan RW 05 area, these include efforts to mobilize the youth to be active in the community, there are routine meetings of fathers, as well as welfare empowerment gatherings. Most residents of this urban village have inhabited this area since 1998. Around 50 families live in the Keprabon area. The shared communal space is frequently used for meetings of men and women and sometimes services are provided.

![Public spaces along the Kali Pepe](image)

**Figure 7.** Public spaces along the Kali Pepe
3.4. Shell characteristics

Building irregularities can be seen from the orientation, size, and shape. In general, buildings are semi-permanent and unregulated. The roofs, floors, and wall material does not meet the minimum health standards. For instance, many houses still have dirt floors, or the wall is made of makeshift material, which causes unhealthy air circulation. On Jl. R.M. Said and Keprabon there is an apartment building. This development involved various stages including (1) initial socialization, (2) mapping of physical, environmental and social aspects, (3) socialization of mapping results (Figure 8).

Along the Kali Pepe, row houses have been constructed in Pringgading Village, Stabelan Village (see Figure 9). These row houses were built in collaboration with non-governmental organizations and are occupied by low-income households, who can get building permits and construction funding from the government. These houses provide sanitation facilities. The average house along the riverbank of the Kali Pepe has an area of 3x4 meters and is inhabited by one household (4-5 people). These houses do not have a private toilet and the kitchen of some houses is situated outside the house. Figure 10 shows the location of the flats and row houses after the restructuring program from the Surakarta City Government (Figure 10).

3.5. Network characteristics

The range of services can be seen from the road network in the area along the Kali Pepe, which is identified as adequate. Accessibility to residential roads along the banks gives a sense of security and comfort and facilitates the movement of pedestrians, cyclist, and motorbikes. The road infrastructure that connects houses within settlements also supports the creation of more suitable and comfortable settlements on the banks of the Kali Pepe. Similar infrastructure development is carried out in all residential areas along the banks of the Kali Pepe. Some of the infrastructures that have been constructed include communal toilets, well pumps, wastewater installations, and repair of road paving for pedestrians (Figure 11).
Based on the five elements by Doxiadis, the residential characteristics of the settlements on Kali Pepe's riverbanks are as follows:

- **Nature characteristics:** The Kali Pepe offers great natural potential. For instance, it offers the possibility of river tourism while restoring the function of rivers as a historical water transportation route. This is expected to have a long-term impact on the socio-economic conditions of the community.
- **Human characteristics:** The optimization of various river potentials can lead to an increase in the standard of living for the people who live along the banks of the Kali Pepe.
- **The characteristics of society:** The composition remains unchanged in terms of population density, social stratification, and cultural patterns. However, lately, significant changes felt were in terms of increasing sources of livelihood along the riverbanks.
- Shell characteristics: Apartments were constructed in the form of in-situ handling whereas another protection program is the construction of row houses in Pringgading Village, Stabelan Village. These were built independently, where occupying residents are from low-income groups and can have access to building permits, construction financing from the government, and sanitation.
- (e) Network characteristics: The road infrastructure that connects houses within the settlement unit also supports the creation of settlements along the riverbanks that are livable, healthy, safe, and comfortable. The infrastructure that has been constructed in all settlements along the Kali Pepe are communal toilets, wells pumps, waste treatment, and repair of road paving.

4. Discussion
This section addresses the relationship between the settlement characteristics and the sustainability of Kali Pepe by discussing the elements of settlement by Doxiadis tied in with the concept of sustainable development. The first characteristic of sustainable development is the preservation of the functions and capabilities of the ecosystem, either directly or indirectly. Based on their natural characteristics, the Kali Pepe has natural potential for river tourism while at the same time restoring the river function as a water transportation route that has historical value. This is expected to have a long-term impact on the socio-economic conditions of society. These findings suggest that the rearrangement of the Kali Pepe has a good impact on improving the natural conditions of its surroundings.

The second feature is utilizing natural resources and technologies that will minimize harm to the environment. This can be viewed from the shell and network characteristics of the settlements along the river. This is indicated by the construction of in-situ buildings and self-help programs targeted at low-income people. Road infrastructure that connects houses within settlement units facilitates the creation of a decent settlement that is healthy, safe and comfortable. The infrastructure improvements that have been implemented along the riverbanks include the construction of communal sanitation, well pumps, wastewater treatment facilities, and paved roads and pedestrian paths. Furthermore, the government has carried out the normalization of the river by dredging and constructing concrete canal lining.

The third element is the natural characteristics that affect the long-term socio-economic condition of the community due to the potential of water transportation tourism and human characteristics of residents working in the informal sector such as traders and tailors. These community members make use of pedestrian paths in a comfortable public space because of the clean river conditions. The fourth characteristic can be seen from the 5 km long concrete canal lining and the planting of vegetations on both sides of the river embankments to maintain a comfortable climate and protect the ecosystems along the riverbanks.

The fifth characteristic of sustainable development is the use of procedures that observe the sustainability of the functions and capabilities of the ecosystem to support life, both the present and the future. This includes all of the rearrangement of Kali Pepe, which is done according to the correct procedures and regulated by the government. This program started with a government plan to improve slums in the center of the city. On 12 December 2014, the plan was ratified by the Decree of the Mayor of Surakarta No: 032/97-C/1/2014 on the Determination of Residential and Slum Locations in Surakarta. This regulation has been the basis for the planning and implementation of urban slum handling in Surakarta. These efforts aim to achieve the goals of the National Medium-Term Development Plan 2015-2019.

The government of Surakarta has a major aim in the optimization of Kali Pepe to turn the river into a great potential of Surakarta City. The river's strategic location shows its strategic potential as a tourist location that is expected to bring positive change for the city of Surakarta and for its inhabitants [8]. Surakarta’s development program for Kali Pepe commenced with a participatory review of the environment of the river by the Surakarta Department of Housing, Settlements and Land Affairs in 2017. Then, the area was divided into three zones that were redeveloped in 11 development phases from Gilingan Urban Village up to Sangkrah Urban Village. The waterfront rearrangement began in
2016 and was completed in 2018 as part of a government effort to rebrand Surakarta as a waterfront city.

The discussion indicates a connection between the characteristics of Kali Pepe and the features of sustainable development. In fact, all characteristics of the settlements along the Kali Pepe in terms of nature, human, society, shells, and networks fit the characteristics of sustainable development. These results can be used as a recommendation for the improvement of environmental problems of rivers in other cities to add to previous research on the Cikapundung River in Bandung. In addition, the paper can provide input on the structured method of identifying river characteristics or other residential neighborhoods using the 5 elements of settlements of Doxiadis.

5. Conclusion
Based on the discussion above, it can be concluded that the restructuring of the Kali Pepe has a good impact on its sustainability. The findings are also evidence of Doxiadis’ principles of a balance between the elements of settlements. These are all interconnected and changes in one or several elements will influence the others. This paper aimed to provide a comprehensive presentation of the characteristics of the Kali Pepe’s riverbank, although characteristics are different in each region. Based on the characteristics along the Kali Pepe, two major potentials are evident: (1) nature characteristic that can be developed through an integrated program of water transportation and tourism; and (2) The emergence of the home-industry that is backed by the potential of employment in the informal sector and accommodates riverbank tourism.

Acknowledgments
This research was supported by the Universitas Muhammadiyah Surakarta. We are grateful to our advisors for providing insights and expertise that have greatly helped the research. However, all interpretations and conclusions from this paper were ours alone.

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