

Landform Control On Settlement Distribution Pattern in Progo Delta, Indonesia

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Abstract Landform is part of the Earth's surface whose characteristics affect resources and geomorphological hazard, and therefore, affect humans in determining their choices in building settlements. This research aims to : (1) analyze landforms control on settlement distribution pattern in abandoned Progo Delta, and (2) analyze the factors that influence humans in choosing their residential locations. Landform control on the settlement distribution was analyzed from produced geomorphological and settlement maps and overlay them. The influence factors were analyzed from the results of in-depth interviews conducted in each village in the study area. The results show that the settlement in the study area is distributed in a dispersed pattern, following the presence of abandoned delta's natural levees. The influencing factors include flat topography that implies a good accessibility, soil fertility that defines land capability in sustaining their life, water resource availability, and security from disasters especially floods.

Keywords: Settlement distribution pattern, Landform control, Abandoned delta, Progo River

Abstrak Bentuklahan merupakan bagian permukaan Bumi yang memiliki karakteristik tertentu dan mempengaruhi sumberdaya dan bahaya geomorfologi. Kondisi tersebut akan mempengaruhi manusia dalam menentukan lokasi permukiman. Penelitian ini bertujuan untuk: (1) menganalisis kontrol bentuklahan terhadap pola persebaran permukiman di Delta Progo tak-aktif, dan (2) menganalisis faktor-faktor yang mempengaruhi penduduk dalam pemilihan lokasi permukiman. Analisis kontrol bentuklahan terhadap persebaran permukiman dilakukan dengan pembuatan peta-peta geomorfologi dan permukiman dan kemudian keduanya ditumpang-susunkan. Analisis faktor-faktor yang mempengaruhi pemilihan lokasi permukiman dilakukan dengan wawancara mendalam pada setiap dusun di lokasi kajian. Hasil penelitian menunjukkan bahwa permukiman di Delta Progo tak-aktif memiliki pola menyebar mengikuti keberadaan bekas tanggul alam delta tersebut. Diketahui pula bahwa faktor-faktor yang mempengaruhi pemilihan lokasi permukiman penduduk adalah topografi datar yang menjadikan akses yang mudah, kesuburan tanah tinggi yang menentukan kemampuan lahan dalam menopang kehidupan masyarakat, ketersediaan sumberdaya air banyak dan keamanan lokasi permukiman dari bencana khususnya banjir.

Kata kunci: Pola sebaran permukiman, Kontrol bentuklahan, Delta tak-aktif, Sungai Progo

1. Introduction

Settlement is a place used by a group of people in conducting their social and economic activities as substantial parts of their life sustainability (Yunus, 2005, 2007). The existence of a settlement in an area represents a harmonious interaction between human and environment. Such interaction is reflected in the form of different settlement shapes and patterns between regions.

High population growth leads to an increasing demand on residential land (Giyarsih, 2010; Amar, 2012). However, not every land is suitable for settlement as well as the wide variety of social and economic activities conducted by its residents (Gwalema, 2011). Generally, humans, either as individuals or as groups, tend to choose a settlement whose location is deemed

suitable for their life sustainability (Muta'ali, 2011). Therefore, only a certain land has a high suitability for settlements located in landforms of various origins. Regarding the aspects entailed by a settlement, i.e. engineering aspects in house construction as well as social and economic aspects in achieving a decent life (Giyarsih and Alfana, 2013), considerations in selecting a location include a good accessibility (Oluwole and Daful, 2014), adequate water supply, security from natural disasters and wild animals, as well as a supportive surrounding area that is able to sustain the life of the residents (Dibyosaputro, 1987).

The spatial distribution of a landform, which has specific land characteristics required in developing a settlement, is different between forms of origin (Verstappen, 2014), as implicitly represented in the third principal concept of geomorphology which states that:

"Geomorphic processes leave their distinctive imprint upon landforms and each geomorphic process develops its

own characteristic assemblage of landforms" (Thornbury, 1958).

Therefore, each of these landforms owns different potentials depending on their morphology/topography, climate, rock, and formation process (Cooke and Dornkamp, 1974; Panizza, 1996).

Landform is the main study object in geomorphology, as presented in its definition, which is a science that describes landforms (genetically) and processes that lead to their formations as well as the relationships between landforms and processes in a spatial arrangement (van Zuidam and Cancelado, 1979; Huggett, 2011). Due to the extremely complex landscapes on the Earth's surface, the spatial distribution of various composing landforms is firstly defined by classifying landscapes into simpler units, i.e. landform units based on their similarities in nature and character (Gorum et al., 2008; Verstappen, 2014). These similarities include:

- a. the configurations of the Earth's surface including topographic impressions, e.g., terrain and topography (undulating, rolling, hilly, mountainous);
- b. topographic expressions, emphasizing on the composing parameters of landforms, e.g., the degree, shape, and length of slopes, local elevation difference (local relief), and the shape of valleys;
- c. geological structures and types of rock/material; and
- d. geomorphological processes that lead into the formation of landforms.

Based on the previously described nature and character similarity and the principle to landforms genesis (forms of origin), Verstappen and Zuidam (1975) as well as van Zuidam and Cancelado (1979) distinguished landforms into two major classifications, namely a classification based on endogenous forces and geology/geological structures and a classification based on geomorphological processes originated from exogenous forces.

Settlement growth that occurs without development planning plausibly results in a suboptimal land utilization in supporting the activities of each resident (Kurniawan and Krol, 2014). This condition would likely occur because the development planning doesn't consider both potential and land suitability for settlement in related landforms. Consequently, several problems may eventually occur, for instance, many disaster-affected settlements, lack of resources (e.g. clean water) in some parts of the settlement, and other environmental damages.

In addition to potential and land suitability for settlement, a residential pattern arrangement within a settlement needs to pay attention to the spatial distribution of landforms of certain origins. Initially, a residential location is naturally selected from locations with good accessibility which follows the pattern of the landform where a residence is built. In the past, houses of a settlement were built individually according

to the taste of each resident or a group or residents. Furthermore, the houses were built, either individually or communally, in locations that were not only fitting the residents' tastes but also accessible, surrounded by areas with good carrying capacities in supporting their life sustainability, and also owning easiness in obtaining water and security from natural hazards and wild animals. Naturally, this taste-based residential site selection indirectly refers to certain aspects which encompass geographical aspects, viz. physical, social, economic, and cultural aspects.

A settlement distribution pattern is a reflection of the adaptation level of human beings to their environment (Bintarto, 1977), which implies that in actuality they own alternatives in selecting a specific location for settling and building houses. Generally, these alternatives should follow both patterns and elements of highly potential landforms in meeting the requirements for residential sites because each landform entails hazards and geomorphological resources that influence the life sustainability of human beings (Gares et al., 1994; Mey et al., 2009; Alcantara-Ayala and Goudie, 2010; Crozier, 2010). Moreover, the characteristics of each landform certainly affect the accessibility of a location due to the entailed morphological features (Panizza, 1986; Marwasta and Priyono, 2007). Based on the previous description, this research is composed with aims to:

- a. analyze the landform control on the settlement distribution pattern in the abandoned delta of Progo River; and
- b. analyze the factors that influence humans in choosing their residential locations.

2. The Methods

The study area is located in a landform, the abandoned delta of Progo River. Administratively, it lies on two regencies, which are Bantul and Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. The location of the study area is shown in Figure 1.

This location was selected because it is a landform that developed in the past, therefore, it is expected to display a good control on the settlement pattern, which has occurred since the past. In addition, this location has various landforms with distinctive characteristics, therefore, it especially represents different controls on the settlement distribution pattern in each landform.

The tools and materials used in this study include:

1. The Geological Map of Yogyakarta, scale 1:100,000, published by the Geology Agency, Ministry of Energy and Mineral Resources of Indonesia;
2. The Topographic Map (Rupa Bumi Indonesia – RBI), scale 1:25,000, published by Geospatial Information Agency of Indonesia;
3. High-resolution satellite images obtained from Google Earth;
4. Global positioning system; and
5. Geomorphological survey equipment.

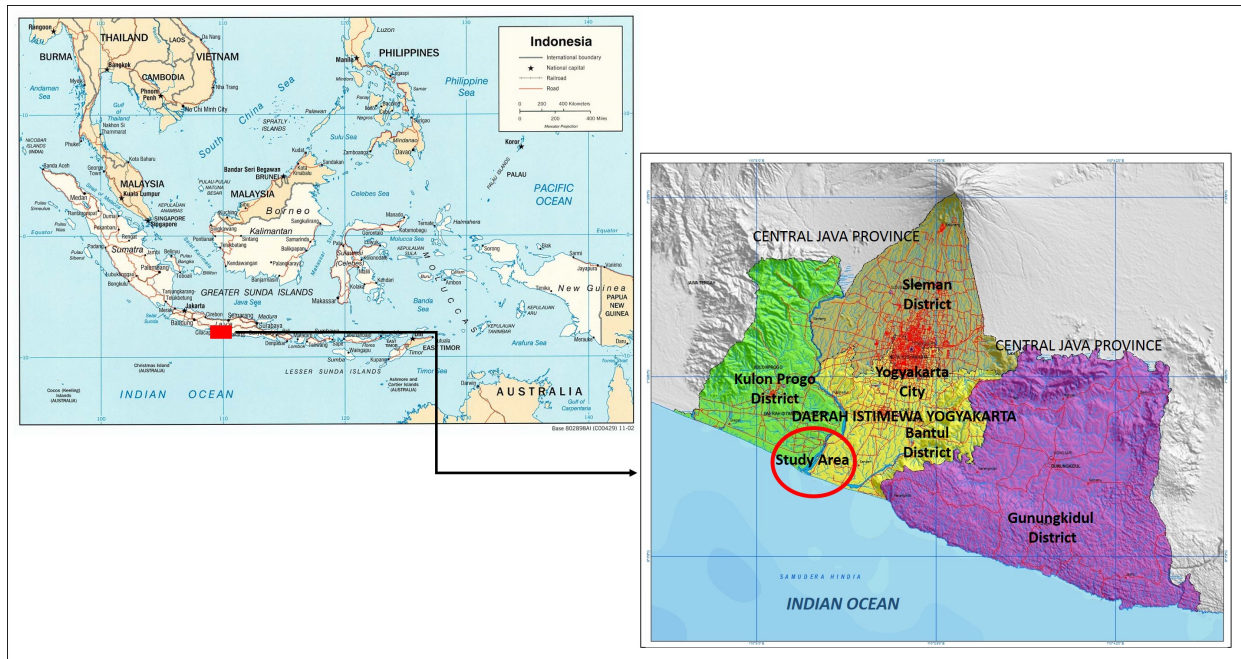


Figure 1. The location of the study area

Landform control on settlement distribution was analyzed using three steps, i.e. geomorphological mapping in the abandoned delta of Progo River, settlement distribution mapping, and analysis on the overlaid maps produced by the previous steps. Geomorphological mapping was conducted by digitizing landform units on high-resolution satellite images and by considering the analysis results on topographic map, geological map, and field survey. Meanwhile, the settlement distribution mapping was conducted by digitizing high-resolution satellite image and field survey. The result of overlaid geomorphological map and settlement distribution map shows the spatial pattern of the settlement distribution and its relation to landform.

The influencing factors in residential site selection were analyzed from the results of in-depth interviews to the public figures of each hamlet in the study area, which include the heads of hamlets and the local elders.

3. Result and Discussion

The fluvio-marine landform studied in this research is an abandoned delta. The condition of the study area is presented in a Google Earth satellite image in Figure 2 and the landform map of the delta is in Figure 3. This abandoned delta has not experienced any marine-induced geomorphological development, as presented by the farther located shorelines due to accretion at the mouth of Progo River.

Delta is one of many landforms resulted from sediment deposition at the mouth of the river, in which a pile of sediments cause irregular progradation on shorelines (Coleman, 1968). Delta formation is strongly

related to fluvial and marine processes (Goudie, 2004). However, it is generally related to three major forces, i.e. forces originated from streams, waves, and sea tides.

A river deposits its load onto a land whenever its transport ability weakens, viz. stream competency and stream capacity drop. This deposition occurs at the brakes of slope, inner meander bends, intersections between two rivers, and river gradient changes. Nevertheless, deposition also occurs when a river flows into a lake or sea and, then, forms a delta. The requirements of a delta formation are as follows:

- a. river flowing into a lake or sea;
- b. shallow sea;
- c. low sea waves and currents;
- d. no tectonic movements that cause seabed or lake (at the mouth of the river) down-lifting;
- e. strong tidal currents; and
- f. abundant rock materials deposited on the sea or lake from time to time.

Figure 3 maps the abandoned delta at the downstream end of Progo River. The existence of this abandoned delta proves that the shoreline of Java Island, particularly the southern part of Central Java, was formerly located way northward from the nowadays shoreline of Central Java and some parts of the Special Region of Yogyakarta. The shoreline was at the brake of slope between the hills of Kulon Progo and Sentolo and the alluvial plains of Progo and Serang River. The old mouth of Progo River is located approximately in Gulurejo Village at the valley of Progo River that flows from Sentolo Hills. In addition, this specific location is also the initial development of the abandoned delta. It

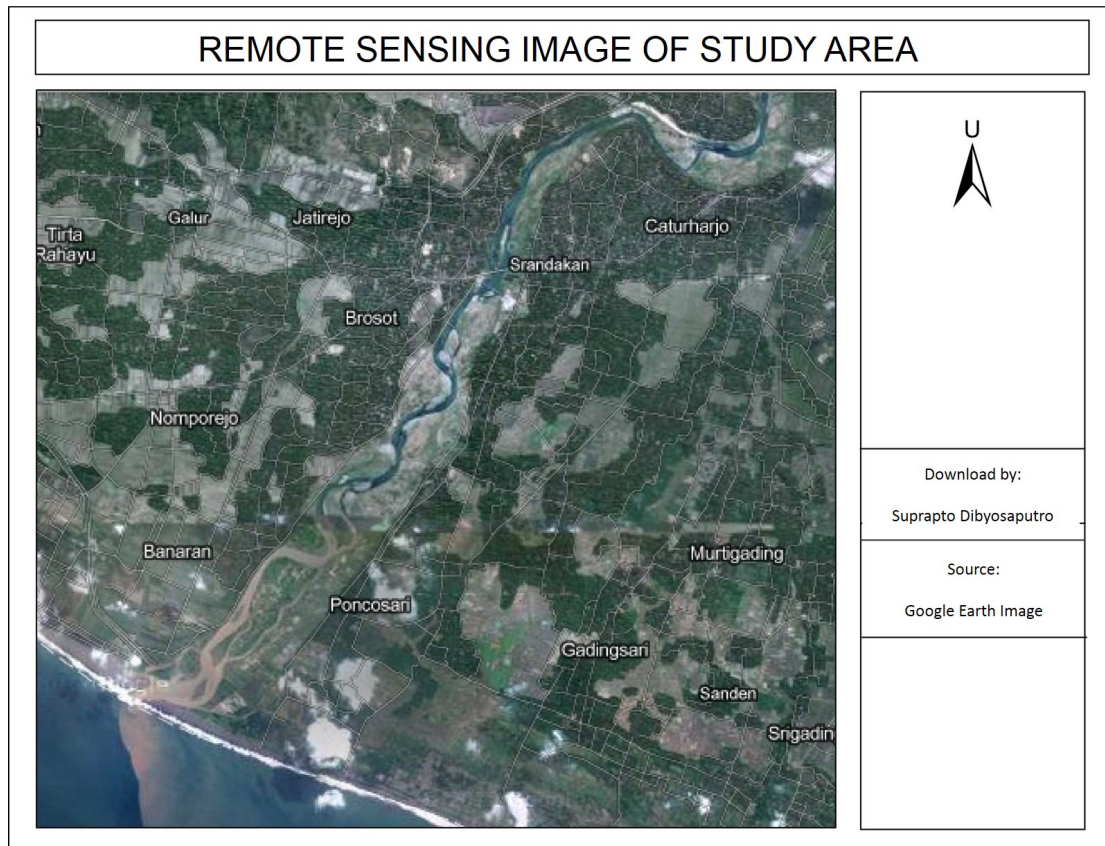


Figure 2. Remote sensing image of the study area

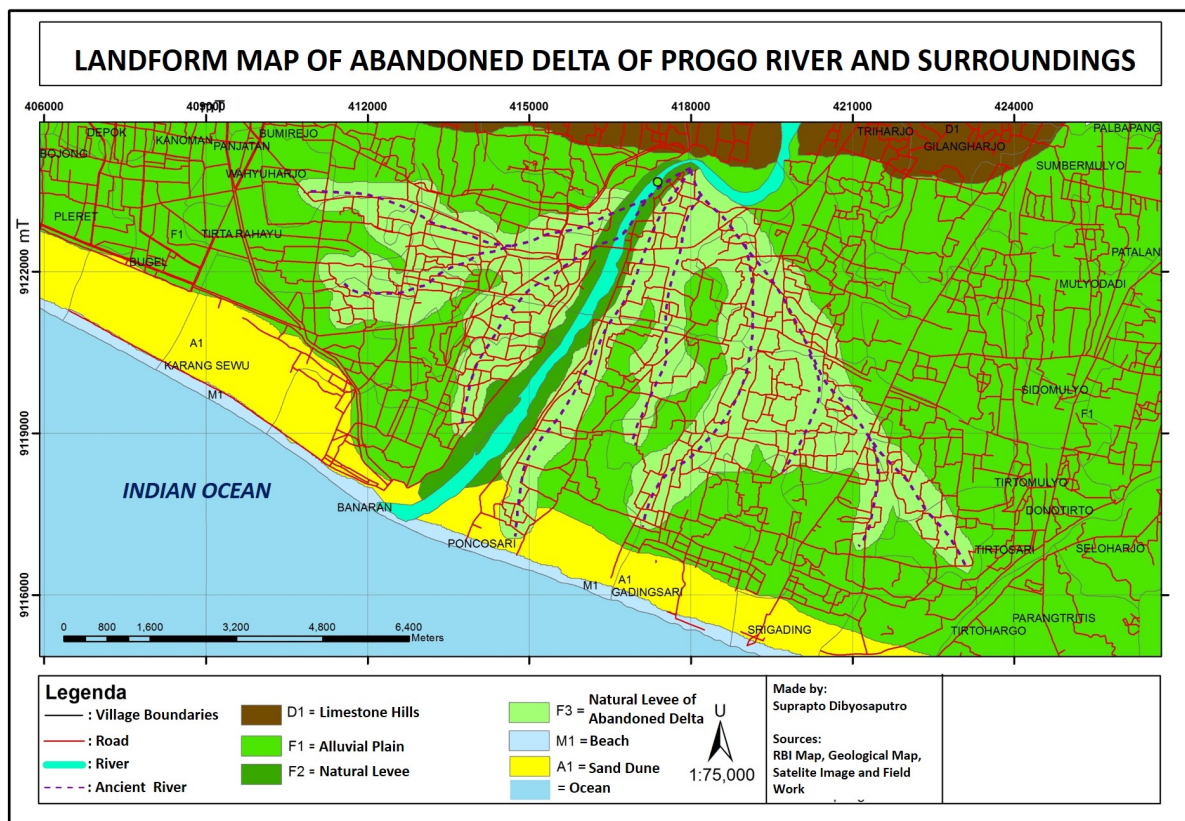


Figure 3. Delta of Progo River and its surroundings

is bordered by two limestone hills of Sentolo Formation that are administratively located between Sidorejo Village, western Kulon Progo Regency and Triharjo Village, eastern Kulon Progo Regency.

Considering the requirements of delta formation, it is known that the developing alluvial plains in the study area were previously a shallow sea. The delta formed at the Progo River in the past shows that during that time Progo River transported abundant sediments and that the sea tide closed to the river mouth was not strong enough; therefore, a bird foot delta was formed. The upper part of this bird foot delta were on a narrow valley, which was also right at the topographical change from Sentolo Hills to a shallow sea whose shoreline had been experiencing southward accretion and creating lowlands in the form of alluvial plains with a flat slope. The small river gradient created low stream capacity and stream competency and, therefore, transported smaller sediment volume and grain size. And finally, in the event of flooding, the transported sediments were overflowed and deposited on both sides of the river. This event, then, formed natural levees with a scatter pattern (dendritic divergent pattern) like a bird foot.

During the active delta formation, lowlands were formed by alluvium deposition between the old natural levees of delta in the forms of back swamps and alluvial plains. But, due to an inactive (dormant) delta formation,

sedimentation within a river body and onto interfluvial lands continued. This sedimentation occurred because the presence of sediment materials from soil erosion at river embankments or hills in the north. Therefore, old rivers along with their back swamps and alluvial plains became shallower than before and even had the same elevation as natural levees.

Lowlands located between the river channels are generally in the form of alluvial plains, composed of alluvial soils that have a higher moisture than the soils at the upstream river banks. Alluvial plains are always moist and characterized by shallow groundwater and dense vegetation (Verstappen, 2014). Most areas of lowlands are used for agricultural land, while the ones of the abandoned delta's natural levees are for settlement and dry cultivated area. The map shows a clear shape of the bird foot delta whose river levees are used for settlement and its yard, while its alluvial plains are used for wet cultivated area (rice).

Gulurejo Village, where Progo River emerges from Sentolo Hills, is the location of the delta's early development in the downstream end of Progo River. It was also the old mouth of Progo River in the past. Being situated between two villages, i.e. Sidorejo Village, Kulon Progo Regency on the west side and Triharjo Village, Bantul Regency on the east side, Progo River emptied into a shallow sea and, therefore, formed a

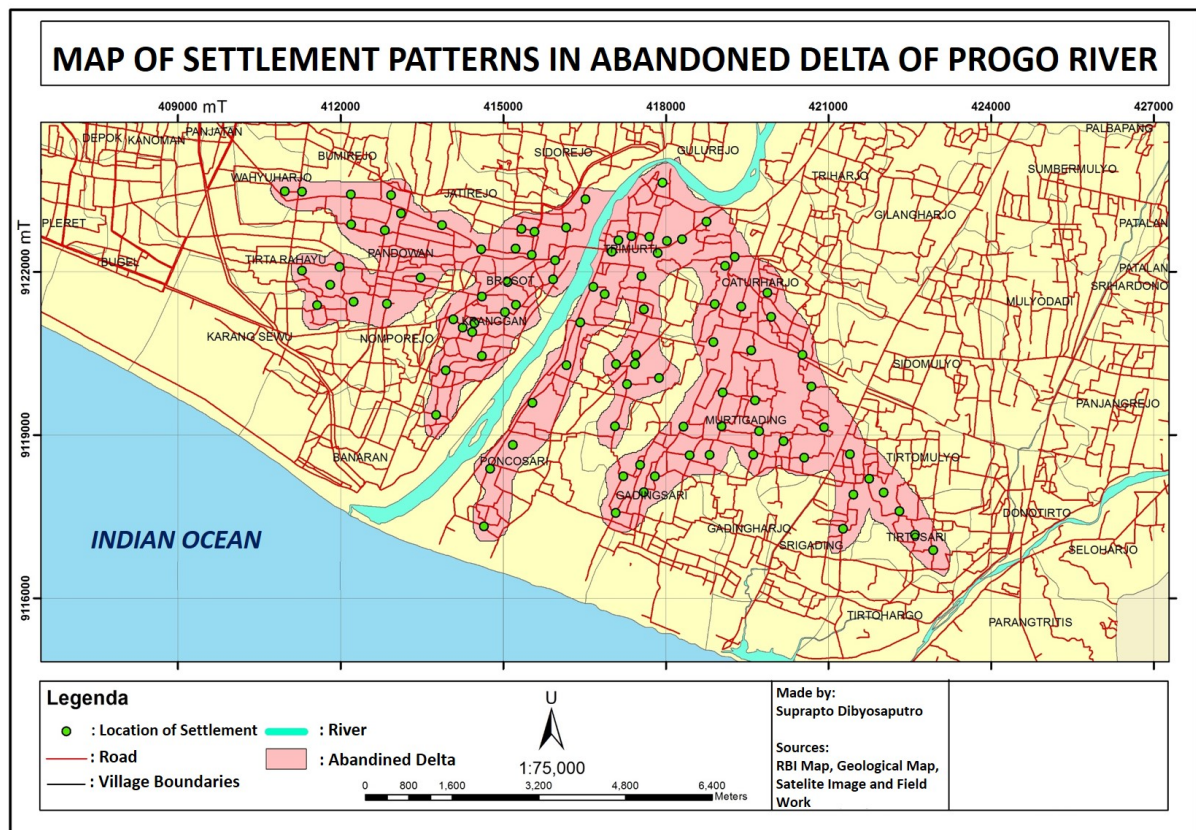


Figure 4. The settlement distribution pattern at the abandoned delta of Progo River

delta. Generally, the scars of today's dormant levees are chosen as residential locations. Figure 4 represents the plots of residential locations in this dormant bird foot delta. This figure also shows that the settlement pattern is clustered on the natural levees of the abandoned Progo Delta. The distribution of residences in the settlements located at the Progo Delta shows a scatter (divergent) pattern following the pattern of both the river and its levee.

Based on the results of in-depth interviews to the residents at the abandoned delta of Progo River, there are at least four main reasons of residential site location. The four factors are as follows.

a. A flat topography that supports a good accessibility, which is significantly related to the fulfilling of the residents' needs on goods and services that must be brought from the outside.

b. A surrounding area that sustains the residents' life. This surrounding area is fertile alluvial plains, composed of fertile alluvial soils, which are suitable for rice fields. This advantage is considered as an insurance to the residents for a better life.

c. A significant amount of water supply that fulfills both domestic and irrigation needs. The residents of the study area are generally farmers whose lands are utilized for wet agricultural practices (rice).

d. A secure area from threats, such as natural hazards esp. floods, due to its higher location than the active alluvial plains and floodplains of Progo River.

4. Conclusion

Based on the analysis conducted in this research, it can be concluded that the settlement pattern at the abandoned delta of Progo River is distributed following the pattern formed by its natural levees, and the influencing factors in residential site selection include a flat topography that creates a good accessibility, a fertile area that sustains the residents' life, an abundant water supply, as well as a secure area from natural hazards especially floods.

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