Morphological study of Kabanjahe Subdistrict assessed from physical aspects of ecology (2010-2019)

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Abstract. Kabanjahe Subdistrict has a central contribution to the Karo Plateau, this plain is the widest plateau in Indonesia and administratively included in the Karo District. The eruption of Sinabung Volcano since 2010 has triggered an increase in the city's physical growth rate. So, needs planning for expansion of facilities. Realizing the complexity of the problems faced, the researchers decided to focus the study on the morphological review of Kabanjahe District in terms of the physical aspects of the city's ecology. The purpose of this study was to determine the effect of physical aspects of ecology on the morphology of the urban/rural in Kabanjahe Subdistrict. This study uses an associative method with a qualitative approach, by assessing the correlation between the city morphological variables and the physical variables of urban ecology in Kabanjahe Subdistrict. This study will find 4 (four) things, covers: topographic correlation with road network systems and mass building placement, correlation of landforms with land use, natural shape correlations with the dynamics of urban development, and correlations between city morphology and the physical ecology of the city. The authors expect this research as a preliminary study in producing a theory for the Kabanjahe Regency Government in making a City Spatial Detail Plan.

1. Introduction
The eruption of the Sinabung Volcano since August 29, 2010, has affected the physical development of the city in Kabanjahe Subdistrict as an evacuation area for refugees. Kabanjahe Subdistrict is the most important part of Karo Plateau (figure 1a), the plain is the widest plateau in the Unitary State of the Republic of Indonesia and administratively includes the Karo District. Kabanjahe subdistrict is in the highlands and alluvial plains of Mount Sibayak with the highest altitude of ± 1,300 masl. The outermost part is at relatively low altitudes, with an average circumference of about ± 1,170 masl (figure 1b). The location of the Kabanjahe Subdistrict resulted in the physical pattern of the city being formed with distinctive characteristics.

The character is in the form of developing Kabanjahe Subdistrict (44.65 km²) consisting of urban and rural areas that organically follow high density natural forms in the main accessibility and flat topography (almost flat) gradually decreasing density to the topography with suburban sloping slopes to hilly topography with moderate slopes with an altitude of ± 1,150 masl - ± 1,180 masl. Thus, it forms a relatively compact city surrounded by green open spaces in the form of green belts and agricultural land (figure 1c). In the central part of the city consists of building with diverse functions
and in the outer part surrounded by land use functions of agricultural land, protected forests, as well as a network of interconnected river flows.

![Figure 1](image1.png)

**Figure 1.** (a) Location, (b) position, dan (c) physical condition of the city in Kabanjahe Subdistrict

The physical development of the city and changes in land use in Kabanjahe Subdistrict are affected by the increasing population, recorded in 2014 there was a drastic population growth of 5,710 people from the total population in 2013, and the population of Kabanjahe Subdistrict was 74,702 in 2017 (figure 2a) [1]. The increase in population growth in Kabanjahe Subdistrict due to the evacuation (urbanization) of residents around the countryside mainly come from Naman Teran Subdistrict and Payung Subdistrict which were severely affected by Sinabung Volcano (eruption) activity in 2014 (figure 2b). The increasing number of inhabitants that are rapidly unpredictable and results in their spread not being directed (figure 2c) impacts the deterioration of the physical, social dan cultural environment.

![Figure 2](image2.png)

**Figure 2.** (a) Population diagram, (b) Total population growth rate diagram, and (c) map of population density in Kabanjahe Subdistrict

Increasing the number of residents demands the need for expansion of facilities and infrastructure, to meet community service needs, especially the need for shelter. Kabanjahe Subdistrict has a history of development and character of the city that has not been exploited and utilized its full potential in the process of structuring the city. Therefore, it is very crucial to find the process and patterns of physical development of the city in Kabanjahe Subdistrict. Because, every data about changes in the shape of the area is very valuable information for handling in order to anticipate and meet the demands of expanding service facilities in Kabanjahe Subdistrict.

According to Burgess (2008), the physical aspects of ecology (city ecology) are one of the internal factors that most influence the development of a city [2]. The Kabanjahe Subdistrict in the highlands shows that the physical development process of the city is closely related to the physical aspects of ecology. According to Earns Haekal in Hutagalung (2010), physical aspects of ecology correlates with organisms [3]. In urban and rural areas, the main organisms that affect the physical aspects of ecology are humans. Kabanjahe Subdistrict is formed from a relatively long historical process that gradually develops according to its ecological state. Thus, the core formulation of the problem to be studied is "what is the morphology of the Kabanjahe Subdistrict in terms of the physical aspects of the city's ecology?".
Pontoh and Iwan (2000) proposed that the phenomenon of urban development (morphology) can be explained well through ecological concepts. By looking at the city as a system consisting of ecological and social systems, it has opened a new preparation for human adaptive mechanisms to the environment based on energy flows, matter, and information [4]. Subdistrict Morphology Study Needed From the Physical and Ecological Aspects of the City as reference material to formulate the concept of handling the physical development of the city with the concept of ecology with the main consideration of the environment and socio-culture. The purpose of this study was to determine the effect of ecological aspects on the morphology of Kabanjahe Subdistrict. The process and patterns of physical development per city and villages that are imprinting are very crucial to be found to optimize handling (control and planning) of land management, expansion of facilities, and improvement of service infrastructure in Kabanjahe Subdistrict.

2. Method

To successfully answer the problems and fulfill the research objectives of the Kabanjahe Subdistrict Morphology Study in terms of ecological aspects, it is crucial to find the forming elements of the city morphology and the components of the physical aspects of urban ecology to examine the correlation between the two. Sima (2009) proposed that in the city morphology analysis system, the road network system, land use, and building patterns as integrated from the physical city. Forms and changes (urban evolution) that are examined in urban morphology are the focus of the explanation of urban elements that are part of urban structures [5]. Based on this theory, the study of city morphology is based on 3 (three) variables, covers: road network systems, building mass placement, and land use. According to Hutagalung (2010), suggesting the constituent components in the process of studying ecosystem changes consist of abiotic and biotic factors. Abiotic factors (city physical ecology) especially those that are variables to discuss urban and rural physical changes are topographic and natural forms [4].

![Figure 3. Schema Method of correlation analysis between city morphological variables and the physical ecology of the city](image)

The research method used is an associative method with a qualitative approach [6]. The method is effective and efficient for explaining, predicting, and controlling the symptoms of correlation between urban morphology and the ecological aspects of the city in Kabanjahe Subdistrict. Explanation of the method of analysis (figure 3) is as follows: correlation analysis between topography and road network systems and building mass placement, correlation analysis between landforms with land use, correlation analysis between landforms with the dynamics of urban physical development, as well as correlation analysis between natural forms with the shape of the city.

3. Result and discussions

3.1. Correlation studies between topography and road network systems and building masses

The topography of Kabanjahe Subdistrict that is formed and is in the highlands is predicted to be a limitation on the development of road networks and building mass placement [7]. The correlation between topography and the road network system and mass building placement can be seen in the following figure. The topography of the Kabanjahe Subdistrict that is formed and is in the highlands is
predicted to be a barrier to the development of road networks and mass building placement [7]. The correlation between topography with the road network system and building mass placement is shown in figure 4.

![Figure 4. Correlation between topography with road network system and mass building placement in Kabanjahe Subdistrict](image)

Road network topographic linkage study: Constraints; road network system in the form of congestion at a certain time on the road grid pattern on the topography is almost flat (downtown). Potential river boundaries around the city center. The solution is to make connecting the grid pattern road network in the city center (almost flat topography) with a ring radial (ring road) system by utilizing and considering river border lines to unravel congestion in the city center.

Building mass topographic linkage study: Constraints; placement of building masses develops on steep topographic sides so it is prone to landslides. Potential: the availability of land with almost flat topography and a rather sloping topography that is quite extensive but spread out. The solution: develop new roads or those that have already reached almost flat and slightly sloping topography areas around Kabnajahe Subdistrict, so that they can stimulate placement on an almost flat topography and slightly tilted topography.

3.2. Study of the correlation between landform with landuse

Landform is predicted to influence changes in landuse in Kabanjahe Subdistrict [8]. Correlation between landform with landuse in Kabanjahe Subdistrict is shown in figure 5 below.
Figure 5. Correlation between landform with land use in Kabanjahe Subdistrict

The study of the relation of landform - landuse, among others: Constraints; the change in the use of green belts on the riverside into prone agricultural and housing land has reduced the quality of the environment, especially landslides and decreasing water quality. Potential: available vacant land in urban areas (flat) and agricultural land in rural areas (sloping slopes). The solution: maximizing the function of flat land in urban areas as a mix-used function and developing supporting (satellite) areas in rural areas (flat land and sloping slopes) for settlements. And, to optimize agricultural land in the north as agribusiness and to the west of the city center as a function of the use of agribusiness land [9].

3.3. Study of correlation between landform with the dynamics of urban growth

Landform is predicted to affect the development of the city in Kabanjahe Subdistrict, where in urban areas it grows solid and on sloping land follows the form of the existing transportation route with consideration of the natural slope to slightly sloping shape [10]. The correlation between landform with the dynamics of the development of the city of Kabanjahe Subdistrict between 2010-2019 is shown in figure 6 bellow.
Figure 6. Correlation between landform with the dynamics of urban and rural developments

The study of the relation of landform - the dynamics of urban development in Kabanjahe Subdistrict, among others: Constraints; the physical growth of the city in the form of building growth that is not directed and does not pay attention to the decreasing quality of the landscape from the uncontrolled urban environment. Potential: the landform of Kabanjahe Subdistrict is dominantly sloping surrounded by rivers. The solution: it is crucial to make green open spaces, both public and public, to prevent densities that can cause slums. In rural areas use the river borderline as a transportation route, walk (walk river), green belt, and others, to prevent the development of buildings that have the potential to damage the structure of natural forms to respond to the growth of cities in the district of Kabanjahe Subdistrict.

3.4. Study of the correlation between natural form and the development of the shape of the city
The importance of looking for the history of urban development patterns (morphology) of Kabanjahe Subdistrict which is influenced by natural forms, as a source of motivation to restore the spirit and image of a city that is sourced from ancestral wisdom as the main consideration in future city design [11]. Analysis of the correlation between the physical
ecology of the city towards the morphology of the city in Kabanjahe Subdistrict is shown in figure 7.

Study of the relation of natural forms - developments in the form of cities, among others: Constraints: the natural form of the eruption of Volcano Sibayak forms a relatively extreme nature but becomes a distinctive identity / character, becoming the foundation for the growth and physical development of the city of Kabanjahe Subdistrict. Potential: Kabanjahe Subdistrict located in the Karo Plateau has the good natural physical potential to be developed (tourist destinations), supported by the potency of culture (Karo Tribe Culture) that continues to run can be a provision to restore the spirit and image of the city that used to be good. The solution: the physical development of the city in harmony with the increasing service needs of its population must pay attention, maintain, and beautify its natural form so that the landform remains friendly and willing to become the supporting pillar of the physical development of the city.

The summary of the Morphology study in Kabanjahe District in terms of the physical aspects of ecology is in accordance with Burges's theory (2008). The Morfologi (physical development of the city) Kabanjahe Subdistrict is strongly influenced by the internal factors of the city, namely the physical aspects of the city's ecology, so that the physical form of the city develops with a fan shape. Fan Shape was formed from a long process since 1948 (after the scorched earth events of Kabanjahe Subdistrict in 1947 due to the Netherlands' second military aggression). Physical cities began to grow in the delta (alluvial plains) of the volcanic activity of Mount Sibayak which was last recorded in 1880. The development of a compact city and limited to fluid-volcanic plan (Volcano Sibayak) caused the city's physical development to move to the flat foot area (volcanic foot plain Mount Sibayak) with a limitation of natural forms consisting of gentle slopes and slopes.

4. Conclusions
The development of the network system process a major challenge in the form of diverse topography in Kabanjahe Subdistrict. The development of road network system can eventually become a stimulus for building mass placement, so that building density can be minimized to prevent slums. The design of the network of urban ring roads and widening of national and provincial roads can be a short-term solution for the future physical development of Kabanjahe Regency.
Optimizing land function of land in Urban Kabanjahe Subdistrict that have flat landform and soft slopes by applying mixed building functions can be a solution to prevent residential land use in the landform of sloping slopes and steep slopes to avoid natural deformation (landslides). And, Optimizing the function of Land in the Kabanjahe Subdistrict which has the potential for soil fertility (high nutrient content due to volcanic activity) can be optimized by applying land use for agribusiness and agro-tourism development. So that land can generate maximum income while preserving nature (natural form).

The physical development of urban and rural areas in the form of road networks and building masses in Kabanjahe Subdistrict between 2010 and 2019 has grown and developed organically without serious city control and planning. This development led to the growth of the plural mass, which force changes in nature. If it does not apply the concept of sustainable development correctly, it will potentially cause natural disaster changes in natural forms. The solution to this problem is first to conduct a study of soil resistance for the development of road networks and the growth of building masses in the Urban and Rural Areas of Kabanjahe Subdistrict.

City morphology in Kabanjahe Subdistrict forms a fan-shape. This a general adjustment by the physical city (road network system and building mass placement) to the physical ecology of the city which is on the alluvial fan of Sibayak Volcano (last eruption in 1881 [12]) and the Toba Giant Volcano (the last 74,000 years eruption then [13]). Urban physical in the form of a road network in the pattern of a grid pattern that is connected to the main road (diagonal) and the physical city of building mass in urban Kabanjahe grows densely on the alluvial plain and spreads to Fluvio-volcanic Plain of Sibayak Volcano. The rural physical form of building mass grows and develops laterally on the main road in the Kabanjahe Subdistrict Rural. This Development occurred in the volcanic-foot plain of the Sibayak Volcano and the Fluvio-volcanic Plain Toba Volcano. The design of the development of the shape of the city in the future is the expected a form of nature. For the rural and urban physical Kabanjahe Subdistrict to grow well and sustainably, by exploring the introductory ingredients of other city designs, namely local wisdom in the form of the physical pattern of Traditional Karo Villages.

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