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Layering Analysis of Typomorphology Dynamics in Rural Settlements Using the AHP Method

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Abstract

The objective of this study is to identify the typomorphological dynamics of rural settlements and to prioritize them hierarchically using the Analytical Hierarchy Process (AHP) method. Furthermore, the study aims to investigate changes in the top three dynamics over time in a sample village through the application of fractal and space syntax analysis. The dynamic and sub-dynamic elements of typomorphology were gathered from previous studies carried out at the urban and rural scales, and their equivalents in the rural settlement context were determined. The study participants, including 26 academics and independent architects and urban planners, were asked to participate in an online survey to rank the 12 typomorphological dynamics identified. The results were analyzed to determine the weighted outcomes of the dynamics and to form a hierarchical order of importance. The consistency ratio was also calculated. A fractal and space syntax analysis were conducted for the first three dynamics in a sample village to analyze the adaptation and mutation processes of the settlement region. The AHP results showed that cultivated and natural areas, socio-spatial references, and road/path networks are the key dynamics in the typomorphological analysis of rural settlements. The results emphasize the importance of enacting rural protection laws to regulate settlement and agricultural activities, given the significant impact of economic and demographic changes on rural settlement morphology. The study also highlights the need for sustainable land use practices that balance human settlement and agricultural activities with the preservation of natural ecosystems. Furthermore, the study underscores the role of road/path networks in shaping occupancy and emptiness. The results offer valuable insights into monitoring rural dynamics and managing rural settlements. The identified dynamics and their weighted values can guide decision-makers in rural planning and development.

Keywords:
Morphological dynamics, Typomorphology, Analytical hierarchy process (AHP), Rural settlements, Layer analysis

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INTRODUCTION

Housing has been a fundamental human need from ancient times to the present day. It follows the need for sustenance, which is considered a basic requirement for daily life, and is followed by the need for protection and shelter. Once individuals have satisfied their personal basic needs, they make efforts to understand their relationship with the environment, which is both an individual and a sociological aspect of living. Economic, social, cultural, and political factors play a continuous role in shaping the concept of housing.

Giddens (1971) analyzed the perspectives of prominent social theorists Marx, Durkheim, and Max Weber concerning the relationship between individuals and the environment within the framework of capitalism and the theory of modern society. Within this context, Giddens scrutinized the views of these three great sociologists on class struggles and the economy, the perspective of social integration and order, and ideal types. Giddens delves into how these theoretical frameworks can be applied to contemporary social structures and how they serve as the underpinnings of modern social theory. He further examined how people's responses to their natural environment impact their social structures, illustrating the interconnectedness of these reactions with culture, technology, and economic factors. Berger & Luckmann (1966) stated that individuals' reactions to their environment are an integral part of the social construction process and shape perceptions of their environment. Their work emphasises how people's interactions with the environment contribute to the ongoing construction of social reality. They argue that the ways in which individuals interpret and respond to their environment are deeply intertwined with the broader social frameworks within which these interactions take place. This perspective underlines the spatial implications of the dynamic and reciprocal relationship between individuals and their environments in the context of social construction.

The concept of space is defined not only by the dwelling itself but also by the combination of families, culture, and the evolution over time (Tanoğlu, 2010). Lefebvre (2014) and Stavrides (2016) view space not only as a physical entity but also as a reflection of social relationships and the social world. Beyond being a product of social, cultural, and communicative memory, space also functions as a guide(Ata & Başar, 2023). Space, while exhibiting subjective variations among individuals in its definition, possesses common qualitative and quantitative characteristics depending on shared reference points (Lefebvre, 2014). Social spaces such as settlements are formed through the harmonious and subjective syntax of qualitative and quantitative actions. Spatial studies focus on the concept of "genius loci," emphasizing the objectivity of collective unity and encompassing not only the subjectivity of individuals but also the collective actions of the community (Norberg-Schulz, 2019). This perspective establishes the integrity of space through a balance between meaning and structure. Place identities are expressed

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through various qualifications such as personal experience, ethnographic narrative, literary traditions, and popular culture, forming cultural hierarchies (Ching & Creed, 2013). The identity of a city and the formation of space progress parallelly over time, with urban transformation shaping the identity of the city (Lukez, 2007).

The long-term evolution of rural settlements has been shaped by the influence of collective living examples inherited from ancient times. These settlements, with economies based on agriculture and livestock, have maintained similar settlement characteristics from the past to the present (Taş, 2016). According to Taş (2016), settlement includes the housing units that people create depending on the space in order to sustain their lives. According to Cromartie & Bucholtz (2008), the concepts of rural and urban areas cannot be separated by a single definition and are multifaceted. The definition of rural areas differs in demographic, economic and scale dimensions and according to Tacoli (1998), these areas reflect the social, cultural and political aspects of the society in which they are located.

The definitional distinction between urban and rural areas is established by parameters such as economy, settlement size, demography, administrative boundaries, and more. In broad terms, cities can be characterized as settlements with sizable populations, a specific labor-power structure, social order, and a distinct settled culture (Sencer, 1979). Architects and urban scientists classify cities based on environmental, historical, social, economic, and planning theories (Keleş, 1990). While rural settlements also encompass all these abstract and concrete parameters that define a city, their definitions diverge from those of urban areas. Globally, rural areas are commonly defined based on land use, demographics, and economic factors; however, these definitions vary depending on local policies and characteristics (Sazak, 1990). With the transition to a production-based economy, the initial permanent settlements of humans are referred to as rural areas (Erkan, 2002). Classifications based on population density and numbers blur the relationship between rural and urban areas (URL 1). Rural areas can be characterized as intervention areas created either by natural processes or human activities; simultaneously, they encompass regions outside urban areas where geography plays a determinative role (Kurt, 2003). The definition of rural areas in the literature has been shaped through the utilization of administrative organizations, economic data, and demographic boundaries. Unlike urban areas defined by their sizes, rural areas can generally be characterized as diverse landscapes hosting various human economies. Although there are settlement forms with similar dynamics, rural and urban settlements are considered to be socially distinct from each other beyond dimensional differences. However, it cannot be ignored that each rural settlement can enter the urbanisation process over time and evolve its settlement identity into an urban one. Therefore, rural settlements are not merely a collection of residences; rather, they represent structural associations based on

settlement patterns, social organizations, and the aggregate of economic activities of regional users (Hill, 2003).

The dynamics used in the analysis of settlements are largely shaped at the urban scale, which has a regular settlement pattern. On the other hand, rural settlements are not only textures formed by organic dynamics. The formation of settlements with the subjective combination of abstract and concrete, built and natural environment data originates from a temporal stratification process and finally takes its present form. Rural typomorphological settlements can be analyzed through various methods. In their study, Ozorhon & Ozorhon (2021) emphasized the instructive potential of traditional rural living spaces for sustainable living. Utilizing a multi-layered model, they systematically explained the relationship between physical features and environmental sustainability parameters. Tian et al. (2014) examined rural areas based on expansion factors. In this context, they utilized criteria such as agricultural land, water, roads, and distance to the center for evaluation. The study revealed the changes in rural areas and demographics in the Beijing metropolitan region from 1978 to 2008. Yao & Wu (2023) analysed the spatial and temporal characteristics of rural settlements in the middle Yangtze River region using remote sensing monitoring data covering the period from 1990 to 2020 and revealed the factors affecting spatial change. They analysed a total of 13 parameters under two main headings of natural factors and socio-economic factors. Wang et al. (2022) employed eight datasets for rural settlement detection in China. Using a digital-based rural settlement analysis, they utilized spatial stratification techniques to group rural settlements, taking into account spatial autocorrelation and heterogeneity of rural settlements in China. Zhou et al. (2013) analysed rural settlement stratification in four stages: initial, transition, development and maturity stages. In the analysis, they analysed the effects of natural environment, infrastructure, urbanisation and rural industrial transformation, land use reform and innovation, regional cultural heritage and integration, rural household behavioural transformation and macro control policy dynamics on rural settlement evolution. In addition, they applied a new integrated method to rural settlement analysis by dividing rural settlements into three basic groups as basic, new type and mutation according to their formation and development stages. Xiao et al. (2023) studied seven multi-ethnic villages in the Dadu River Basin of Ganzi County and analysed the spatial patterns and influencing factors of different ethnic villages. The findings reveal commonalities in the location of the villages, how environmental influences shape spatial configurations, and how ethnic culture affects their internal structure. The study also shows how the rural area has evolved into a complex unit with a diverse and multi-layered character. Jia et al., n.d. (2023) examined the dynamics of the Rural-Urban Interface (RUI) through a comparative socio-spatial analysis approach and revealed the mechanisms of differentiation. Designed with the integration of geospatial analysis and qualitative methodologies, this

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study analyses the evolutionary stages of the RUI in detail in relation to historical and contextual factors. Yang et al. (2019) establishes a quantitative perspective with a scientific basis for the preservation and development of traditional rural spatial forms in rural settlement studies using the space syntax method. The spatial form of Baishe Village, characterized by historical and cultural features, and the relationship between spatial form and social activities of the users, are employed as fundamental analysis parameters in the study. Li & Mao (2022) address the transformation of the original rural culture and rural appearance of villages as the main problem. In their study, they applied the space syntax method in the form of axial analysis to the formal analysis of village streets. This study on rural settlement morphology and road trace change provides quantitative and interpretation of the stratification and chronological change of rural settlement morphology features. Hu et al. (2019) presented an integrated analysis of rural settlement with rural restructuring by selecting traditional villages in Huizhou as a sample. In this study, the researchers use the shape index of rural settlements to express the shape and compactness of rural settlements. They use the parameters of material space, social space and cultural space for a multidimensional analysis. In addition, the dynamics of the interaction of social, political and capital forces are also included in the conceptual analysis to understand the structuring mechanism. In their rural area study focusing on Pinggu District, Yanbo et al. (2018) constructed a multidimensional character assessment index system and a combination matrix to elucidate the depth and main components of rural settlement layout characteristics. Parameters such as rural settlement morphology, spatial scale, form and location were used in the research to typologically distinguish settlements. They also revealed the effects of infrastructure elements such as urban expansion and transport on the spatial status of rural settlements.

It is seen that many studies have been carried out in the morphological analysis of rural settlements. In these analyses, natural and built environment morphological parameters determined by the researcher are frequently used. In addition, there are studies in which many analysis parameters such as sustainability, rural policy, user mobility, rural character, expansion, etc. are applied in an integrated manner. However, concepts such as how the dynamics used in the morphological stratification analysis of rural settlements will be hierarchically ordered are unclear. The objective of this study is to assess the factors influencing rural settlements, categorizing them into abstract and concrete criteria, and establishing a hierarchical order for the concrete parameters through the Analytical Hierarchy Process (AHP) method. Furthermore, the study aims to examine the temporal evolution of the top three dynamics identified through hierarchical ranking in a sample village, Beyceğiz, employing fractal and space syntax analyses. This provides a realistic and analytical approach to reveal the change and transformation in the stratification process of the rural settlement. This study establishes

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a methodological intersection for the morphology of rural settlements among urban disciplines, digitization methods, and architecture. Furthermore, it will contribute the scholarly analysis of the evolution of rural settlements over time, a concept inherently multidisciplinary in nature.

DYNAMICS OF RURAL TYPOMORPHOLOGY

Residential areas are dependent on both abstract and concrete parameters that define their identity. Although these parameters may be the same for all settlement structures, the effects they create as a whole may vary. The same variable can have different effects in different settlements. The dynamics used in settlement morphology analysis can be referred to as dependent and independent variables.

Independent dynamics are relatively more abstract concepts in the morphological formation of settlements. They are variables that individuals cannot directly intervene in and are either management-related or matured within a process and made visible. Dynamics such as culture, socio-economics, and politics exist in every society, forming social cohesion;

CULTURE

According to Eker (2014), culture describes an organization in life and forms concepts such as identity, personality, understanding, and autonomy through the shaping of refined elements of this organization. Rapoport (1969) focuses on culture as the basis for the formation of architectural components in rural settlement structures. Cloke (2006) mentions that rural settlements encompass all types of cultures and can serve as a permanent living network for some, while for others, they may provide an alternative visitation destination to the city. In addition to its inherent cultural identity, today's mixed interaction culture also emerges in rural settlements.

SOCIO-ECONOMICS FACTORS

Residential areas are influenced directly by various demographic, social and economic factors that shape the lifestyle, personal and social use of time and space, and self-fulfillment tendencies of the individuals that make up the community (Gür, 2000). Hoggart (1988) characterizes urban socio-economic conditions as essentially similar to those of rural and surrounding rural areas. In contrast to urban areas, rural settlement patterns are more closely tied to the region's commonalities, such as language, religion, and ethnicity. The rural economy is primarily based on agriculture and animal husbandry. According to Geray (2011), the rural economy is typically evaluated in terms of the marketing, production, and problems of agriculture and animal husbandry, but it is also a comprehensive sociological phenomenon that includes human relationships, land organization, unemployment, rural infrastructure, administrative, educational and legal governance.

POLICIES

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Rural settlements are subject to government policies specific to their province, district, and country. According to Hillery (1955) the concept of a rural community is diverse, but its structural and relational issues can be addressed regionally and nationally through popular and political solutions recognized among social groups, families, and regions. However, all these policies have primarily examined regional development within the economic and political framework, providing support for urban development and subjecting the rural identity, which has a different spatiotemporal concept from the city, to major effects while providing minor benefits. Thus, the mutation/adaptation process of the subjective identity of each rural settlement pattern has been sidelined.

The morphological formation of settlements is dependent on dynamic variables that can be read through concrete data. The differentiation of one or more of these variables can change or transform the regional identity. To analyze the layering processes in settlements, dependent variables are often used by urban scientists. However, urban structures are usually selected as the sample for these studies, while rural settlement areas are grouped by geographical and economic data in morphological studies, making subjective analysis less detailed compared to urban areas. Nonetheless, the historical or touristic value of a rural region has made subjective analysis important for that region's analysis. In contrast, each rural settlement undergoes layering processes and experiences mutation/adaptation processes subjectively, similar to urban settlements, from their establishment to the present day.

In rural settlement patterns, dependent variables have a descriptive equivalent as in independent variables. However, they may be subject to a different hierarchy of importance than in urban settlements. This ranking is important for the numerical interpretation of the mutation/adaptation process of rural settlement patterns. Briefly, these dynamics can be defined as follows;

Cultivated And Natural Areas

Keleş (1998) and Çubuk (1985) define the design of spaces that benefit countries with rural areas where the economy is based on agriculture, animal husbandry, and forestry, and where there is a high level of individual relationships and a lack of division of labor. These researchers examine the form of cultivated and natural areas in rural settlements. While these areas ensure the region's economic sustainability, they undergo functional changes that directly affect the rural identity. Cultivated areas support agricultural activities, while natural areas conserve the region's natural resources and contribute to their sustainable use. Therefore, this dynamic contributes to the vitality of sectors such as farming and animal husbandry and the conservation and sustainable use of natural resources. These studies are important in understanding the future development and sustainability of rural settlements.

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Socio-Spatial References

The socio-spatial references of rural settlements include factors such as the settlement's history, cultural roots, social structure, economic activities, physical structure, and ecological environment. These references are useful in determining the layers of settlement structures and developing strategies for their future development. The formation of the socio-spatial structure in rural settlements is a result of the interaction of internal and external factors. Internal factors include cultural fabric, traditions, social structure, and economic activities, while external factors include the dynamics of the natural and built environment. Changes in the functions of the natural and built environment lead to the emergence of socio-spatial references. The examination of the socio-spatial structure of rural settlements is important in identifying the factors that preserve and develop the identity of the settlement.

Establishment Years

In the analysis of rural settlement typomorphologies, the establishment years play a significant role. These years indicate how old the settlement is and the level of technology and resources available during that period. As the establishment years increase, the physical structure and planning of the settlement become more dependent on geographical features. Consequently, as we go back in time and move away from modern technology and resources, the typomorphology of rural settlements also changes. Additionally, as the establishment years increase, the layering of changes and transformations in the settlement's needs also increases. This allows for the reading of the settlement's adaptation and mutation process and directly affects other underlying dynamics.

Geomorphological Structure

The geomorphological features of a region play a crucial role in the formation of rural settlements. The landscape identity of settlement areas is determined by the characteristics of land form, land cover, and land use (Hernandez, 2007). Natural resources, land slope, geographical form, and agricultural and livestock potential are all important factors in the comprehensive selection of settlement areas. These dynamics are also significant in the identity classification of rural settlements. The comprehensive structure of this dynamic enables the identification of the landscape identity and the interpretation of its changes in rural settlements.

Demography

Rural areas undergo significant functional changes with shifts in their demographics (Selman, 2006). Demographics, which is a defining and classifying feature of rural settlements, varies in density across different rural settlement areas. Particularly, rural areas may face negative

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consequences due to emigration and the disappearance of rural residents (rural abandonment) or uncontrolled internal migration (sudden urbanization). However, ensuring a proportional distribution of the existing demographics rather than concentrating on a single age group is more beneficial for rural settlements.

Hydraulic Structure

Water resources are one of the main factors determining the location of rural settlements. Prior to modern technologies, proximity to water sources was a significant determinant in the location of settlements in traditional agriculture. For rural settlements with agriculture and arable land-based economies, proximity to water sources is a critical requirement (Christaller, 1933). The geographic location of settlements must be close to water for the region's economy and compact structure's self-sufficiency. (Hill, 2003) identifies the hydraulic structure, which is the most important determinant and classifier of the location of villages, as one of the five fundamental elements of rural settlement (Figure 1).

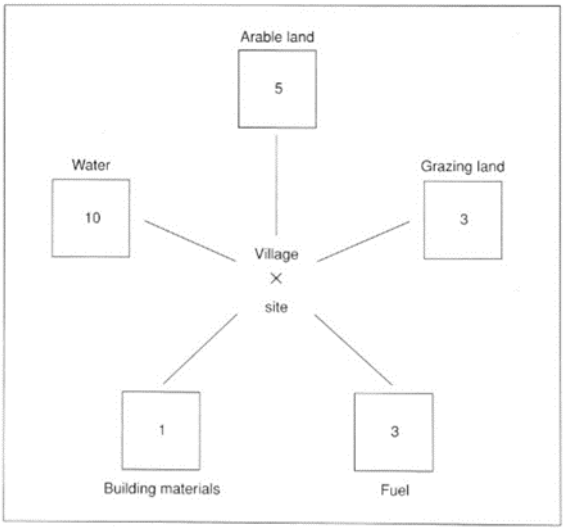

Figure 1. Chisholm's model of settlement location (Hill, 2003)

Attributes And Form Properties

Settlement areas are formed by many factors such as geographical characteristics, socio-cultural characteristics, climate conditions, and state and private policies. Rural area economy also directly affects settlement patterns. Rural settlements with different qualities and living styles may show different formations even in the same geography. Settlement patterns are shaped according to hinterlands, road traces, and political planning. Initial settlements in rural areas usually started as clustering for defense and mutual assistance purposes, and with time, formal differentiations occurred through other dynamic changes. Essentially, there are two types of settlement patterns, clustered and dispersed (Antrop, 1988; Sharp, 1946).

When examining this topic, Sharp (1946) classified settlement types as clustered, dispersed, and mixed; and classified settlement patterns as

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linear and clustered forms. These forms can also be classified as regular, irregular, and mixed settlement patterns.

Landmarks

The morphological structures of rural settlements are shaped by various factors such as subjective values, structural/natural topography, and the influence of the region. Unlike cities, each rural settlement is subjectively designed according to the region and its users, and has fewer buildings. Landmarks are important settlement features that stand out visually within the settlement silhouette in rural areas (Nita, 2015). In rural areas, landmarks are determined jointly by natural geography and human intervention, and the role of religious elements is also significant in characterizing users and settlements in rural areas. Mosques, squares, local government cafes, fountains, village halls, and other common areas in rural settlements are also considered landmarks. Topographic details such as sharp peaks, water sources, and landscape elements found in rural areas can also represent landmarks. Landmarks undergo changes and transformations over time, with new ones added to meet current needs. Existing landmarks may disappear, continue to coexist with new ones, or lose their importance.

Road/Path Networks

Settlements are dynamic spaces that interact both socially and physically with each other and their surrounding environment. The morphology of a settlement is influenced by neighborhood relationships and main transportation axes within and surrounding the settlement. The form of roads in a rural region, connecting it to other rural areas and urban centers, largely determines the spatial structure. Internal road networks shape daily activities, neighborhood relationships, and transportation within the region, while external road networks establish connections between the region and neighboring rural and urban centers. Rural roads have a significant impact on the development index (Barrios, 2008).

The transportation networks in rural areas were initially formed in a haphazard and organic manner. However, over time, various factors such as technology, trade, and communication have led to the differentiation of these networks, influencing their spatial forms. This differentiation has been instrumental in shaping the protection of rural settlements, farms, and agricultural areas, along with other non-abstract dynamics such as climate conditions, terrain data, and religious factors. In rural areas, networks that connect settlements, farms, and agricultural areas are important for regional accessibility (Kılınçaslan et al., 2012).

Solid-Void Composition of Buildings and Building Bocks

Particularly for settlements with a founding year dating back to a distant past, the geography plays the most determining role in the formation of building clusters. Depending on whether the region is flat or

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hilly, the building clusters can either follow each other or be spaced apart. The concept of fullness and emptiness is essentially related to the scale of the site; it concerns the proportional distribution of built and natural environmental factors. Within the built environment, user interventions in the region such as residences, vegetable gardens and orchards, gathering areas, squares, and agricultural fields are taken into consideration. In addition, for rural settlements with an economy based on agriculture, agricultural fields constitute an important parameter. The evolution of rural settlements is closely related to economic development and its supporting parameters (Oldfield, 2005). Over time, the built and natural environment-derived ratio of fullness and emptiness in rural areas changes.

Height of Buildings

In rural settlements, both changes in location and the vertical impacts of the built environment are crucial factors in the construction of buildings. Generally, the construction materials used in these settlements can be obtained from natural resources and are used in a manner that is in harmony with the region's natural landscape. Structures that are initially in harmony with the natural environment in the early settlements tend to differentiate over time due to the effects of building materials, heights, and changes in the landscape.

METHOD

The methodology and flow chart utilized in the study are presented in Figure 2. The AHP, fractal analysis, and space syntax methods utilized are elaborated upon in detail in this section.

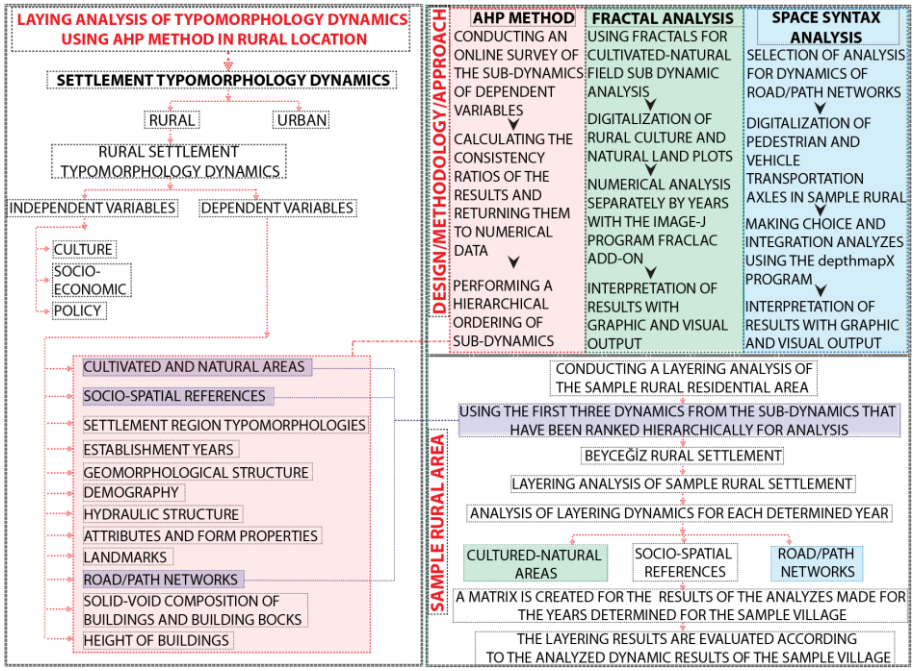

Figure 2. Research and flow chart

Fractal Analysis Method

The term "fractal" is derived from the Latin word "fraktus". It was coined by Mandelbrot to describe the combination of multiple pieces into a single large object (Mandelbrot & Mandelbrot, 1982). Fractal mathematics, which connotes fragmentation and brokenness, is employed in numerous disciplines to explain the relationship between parts and the whole.

Fractal geometry is a mathematical approach used to define and depict irregular and fragmented natural phenomena (Mandelbrot & Mandelbrot, 1982). Fractal calculations can be performed on objects with varying shapes, as defined by Euclidean geometry. The concept of dimension, which is crucial to the analysis, is used to describe objects in geometry. Both the object or group of objects to be analyzed and the abstract grid measures and scales used in the description are completely defined. Self-similarity, iterative measurement, and box counting methods are sub-analytic computations in fractal analysis (Kanatlar, 2012).

Housing and building blocks, which are important parameters of settlement morphology, are in a diachronic semantic relationship rather than instantaneous analysis. The settlement patterns of structures and building blocks with different forms can be analyzed using the fractal box-counting method. A semantic pixel grid is defined on the settlement patterns reduced to two dimensions. Boxes forming the pixel grid are reduced and enlarged in the aspect ratio, and the solid-void counts are performed at each different scale. While proportional growth occurs, the starting points for box counting can also be selected multiple times. The situation between two different box sizes is calculated as (Bovill, 1996):

$$D = \frac{\log(a) - \log(b)}{\log(c) - \log(d)} \qquad (1)$$

where D is fractal value (2 > D > 1), a and b are the number of filled boxes counted in the next and previous iterations; c and d are the number of boxes on the bottom line in the next and previous iterations.

An average fractal value (D) is expected to be between 1 and 2. As the result approaches 1, the presence of regular, simple, and linear geometric forms is indicated, while a result close to 2 shows a combination of irregular geometric shapes. This method, which emphasizes the mathematical balance between filled and empty space, helps to perceive the entropy status of the same or different types/tipologies. However, the situation where different density building regions are in the same order will cause fractal values to be similar. The lacunarity value in this situation will show the density difference. The method can be performed manually or through software programs. In this study, the FaracLac plugin of Imagej program was used to calculate the lacunarity and fractal values of the settlement area in different years. The maximum given by the program's grids was used for analysis. The method was used to

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understand the changes/transformations of cultivated-natural areas over time. The solutions made for determined years will show the relational status of the settlement's cultivated-natural areas with structural boundaries in layering analysis.

Space Syntax

The space sytntax method of the spatial configuration approach within the field of urban morphology is utilized in the analysis of multiple relational networks. This method is used to establish a hierarchical ranking of objects' movement areas, identify their relational situations, and analyze many spatial and urban settlement aspects, such as visibility, street-road-parcel configuration. Configuration is defined as a relationship network that calculates other relationships, and the quantitative expression technique of part-whole relationships is used in architectural and settlement locations with space syntax. The space syntax method demonstrates that the structural density and the constant symbiotic relationship between the road-street voids constitute the urban built environment within a dynamic lifestyle. The diachronic semantic relationships of changing/transforming settlement dynamics can be read quantitatively using the space syntax method (Hillier, 2007).

Based on the studies conducted by Hillier (2007), this method can provide strong predictions on pedestrian movement networks. The method successfully reads the movement corridors of urban settlements and allows for comparison over time (Penn et al., 1998). Multiple analytical tools are utilized for the analysis of transportation network dynamics, leveraging the segment map sub-analysis. This method aims to quantitatively read the transformation process of rural settlements by analyzing the movement corridors between the identified years.

The likelihood of a specific area being selected for development can be emphasized through the utilization of segment analysis, which employs the reading of choice and integration values. The results of this analysis can be used to determine which areas are more or less preferred over time. Additionally, the accessibility of a particular area within a settlement can be demonstrated through integration analysis. By comparing the results of this analysis over time, it is possible to identify which areas are more or less accessible for development.

The application of the method was realized through the Depthmap software. In the analysis to be calculated using the program, more heavily used axes are represented in shades of red, while relatively sparser axes are represented in shades closer to blue (İlhan, 2019).

AHP Method

The Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty, is a mathematical-based method that provides solutions to multi-criteria decision-making problems involving more than two alternatives. This method solves problems by allowing decision makers to rank the criteria and sub-criteria in order of importance and then rank the alternatives

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found accordingly using Saaty's 1-9 scale, based on the priority of the criteri (Saaty, 1980) . AHP is a commonly used measurement method in multiple decision-making choices, and it is applied using measurable criteria and mathematical operations. The success of this method depends on the careful selection of criteria and the creation of a hierarchy based on those criteria. The importance of data and experience in selecting criteria cannot be overstated. The simplicity and versatility of this method are among its key strengths, as it can be applied under various conditions (Tombus & Ozulu, 2007).

The AHP method involves the following steps:

1. Hierarchical Structuring: The problem is structured hierarchically with a goal at the top, followed by a set of criteria and sub-criteria, and finally a set of alternatives.
2. Pairwise Comparisons: Pairwise comparisons are made between each criterion and sub-criterion to determine their relative importance. A scale of values from 1 to 9 is used to represent the relative importance (Table 1)
3. Consistency Check: The consistency of the pairwise comparisons is checked to ensure that the judgments are coherent and logical. A consistency ratio (CR) is calculated to measure the consistency of the judgments. A CR value of less than 0.1 indicates an acceptable level of consistency.
4. Weight Calculation: The weights of each criterion and sub-criterion are calculated by synthesizing the pairwise comparison judgments. The weights are calculated by multiplying the normalized weights of each criterion by the corresponding normalized weights of its sub-criteria.
5. Aggregation: The weights of the alternatives are calculated by aggregating the weights of the criteria and sub-criteria that are relevant to each alternative (Figure 3)

Table 1. Saaty's 1-9 scale

Scale	Description
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	The importance between each of the above two scales

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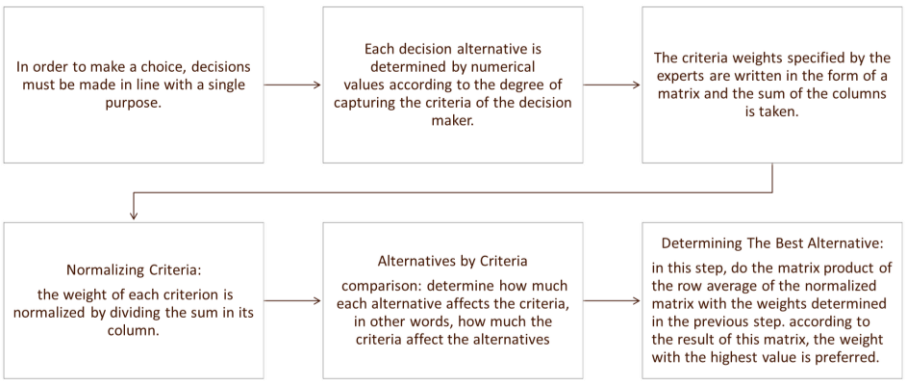

Figure 3. AHP method flow chart

SAMPLING AREA

This study focuses on analyzing the morphological layering of rural settlement patterns using multiple methods. A rural settlement, Beyceğiz neighborhood (village) in Polatlı district of Ankara, was selected as the study area (Figure 4). Polatlı is located in the southwest of Ankara and is 78 km away from the city center. It was established as an independent town under the jurisdiction of Haymana district in 1908 during the reign of Sultan Abdulhamid II. Polatlı, which has developed during the Republic era, consists of numerous villages (neighborhoods) outside the district center. Some of these villages were established even before the establishment of Polatlı center (Erdoğan, 2013).

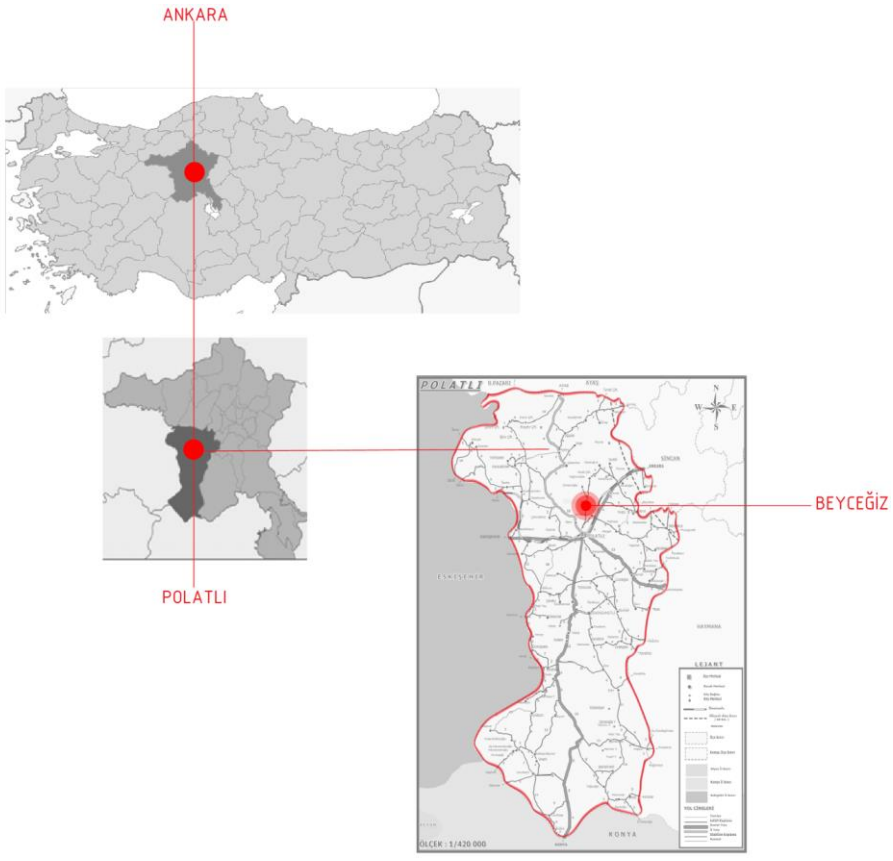

Figure 4. Ankara-Polatı and Polatlı-Sample Villages location

Beyceğiz Village is located 7 km north of Polatlı city center and 3.6 km away from the Ankara-Polatlı highway, on the natural valley slope formed by hilly terrain (Figure 5). The proximity of the village to the Ankara highway has provided an opportunity for settlement development along the road axis. The main source of livelihood in the village is agriculture and animal husbandry. The areas outside the settlement center are predominantly used as agricultural land, showing a natural morphological pattern. The village has been inhabited since ancient times and features the "Karatepe" mound and the "Belkavak" tumulus. The Ankara-Polatlı road, which intersects the village along a north-south axis, forms a threshold for the new settlement area while passing through the first settlement area. (Demiroğlu, 2020; Erdoğan, 2013).

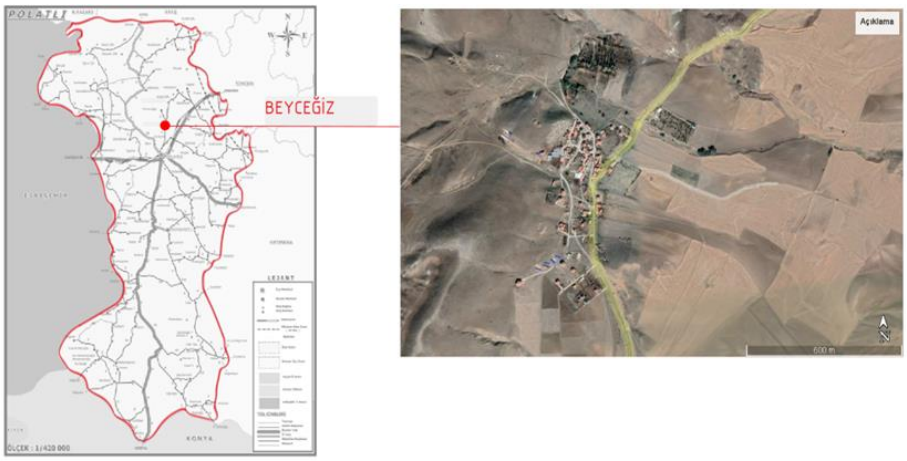

Figure 5. Polatlı-Beyceğiz village location/Google earth image

FINDINGS AND RESULTS

AHP Results

After conducting a literature review, 12 morphology dynamics were determined and applied online via Google Forms by architects. All responses provided in the survey were evaluated for consistency using the Analytic Hierarchy Process (AHP) method. For this purpose, the consistency of each dynamic was tested through a 12x12 matrix generated by pairwise comparisons, and responses with a consistency ratio <0.10 were selected to determine their weightings. In the survey conducted via Google Forms, 10 consistent responses were found among the 28 participants. Based on these data, the weighted values of each dynamic were calculated, and their averages were ranked.

Table 2 presents the hierarchical ranking of 12 dependent variables based on their average weight values. As seen in Figure 6, cultivated and natural areas have been identified as the most important dynamics in the typomorphological analysis of rural settlements. Socio-spatial references, which play a significant role in shaping the identity and formation of settlement areas, are ranked as the second degree of importance. Road/Path networks, which serve as corridors for vehicular and pedestrian movements, are ranked third in the analysis.

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Table 2. 10 questionnaires and weighted dynamics that were taken into consideration in the AHP method

Number Of People/ Dynamics	1	2	3	4	5	6	7	8	9	10	Average Weight
Cultivated And Natural Areas	0,136	0,115	0,119	0,106	0,048	0,114	0,064	0,186	0,136	0,186	**0,121**
Socıo-Spatial References	0,129	0,108	0,142	0,226	0,091	0,077	0,037	0,104	0,129	0,104	**0,115**
Settlement Region Typomorphologies	0,094	0,057	0,104	0,083	0,279	0,169	0,070	0,017	0,094	0,017	**0,098**
Establishment Years	0,037	0,033	0,087	0,066	0,027	0,029	0,035	0,085	0,037	0,085	**0,052**
Geomorphologıcal Structure	0,072	0,139	0,101	0,048	0,048	0,139	0,059	0,036	0,072	0,036	**0,075**
Demography	0,148	0,036	0,066	0,088	0,030	0,029	0,052	0,085	0,148	0,085	**0,077**
Hydraulic Structure	0,069	0,127	0,071	0,045	0,048	0,063	0,077	0,016	0,069	0,016	**0,060**
Attributes And Form Properties	0,099	0,089	0,061	0,093	0,132	0,098	0,075	0,038	0,099	0,038	**0,082**
Landmarks	0,095	0,069	0,079	0,040	0,087	0,039	0,114	0,194	0,095	0,194	**0,101**
Road/Path Networks	0,072	0,127	0,061	0,049	0,035	0,119	0,117	0,188	0,072	0,188	**0,103**
Solid-Void Composition of Buildings and Building Bocks	0,028	0,059	0,056	0,087	0,091	0,058	0,173	0,018	0,028	0,018	**0,062**
Height Of Buildings	0,023	0,040	0,053	0,068	0,085	0,066	0,128	0,033	0,023	0,033	**0,055**

In the hierarchical ranking, the "establishment year" dynamic is located at the bottom of the table. The establishment year plays a significant role in the layering history of the settlement area. However, it is observed that it has a less influential role compared to the other 11 dynamics in typomorphological analysis.

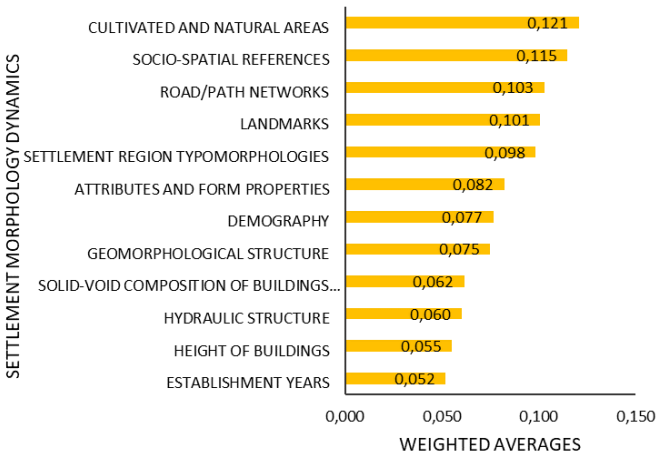

Figure 6. Weighted rankings of dynamics

Based on the AHP results, the top three dynamics selected for conducting a layering analysis on a sample area were "cultivated-natural areas, socio-spatial references, and road/path networks." Fractal analysis was used for the cultivated-natural areas dynamics, matrix analysis for socio-spatial references, and space syntax for the road/path networks dynamics.

Fractal Analysis Results of Cultivated-Natural Areas

The fractal analysis method was used to analyse the dynamics of the cultivated-natural area in the sample region, the village of Beyceğiz. The changes in agricultural and residential parcels of settlement areas over the years were overlaid on top of each other on a photo and vector map and subjected to fractal analysis. Changes that occurred in agricultural and residential parcels over the years were converted into a 2D jpeg format and individually analyzed at 8-bit, 2446x2726 pixel with a 300 dpi resolution. For each year, 12 starting points were selected and the average error rate was minimized using the fractal analysis method. The numerical results of the fractal analysis, including the lacunarity (λ) and fractal mean (DB), were presented in line graph form using Excel.

Beycegiz village is located in a rural area where agricultural activities play a significant role in shaping the landscape and settlement patterns. The fractal analysis conducted in this study aimed to assess the changes in settlement typomorphology and cultivated-natural areas over time, particularly between 1953 and 2019 (Aerial photographs were obtained from HGM) (Demiroğlu, 2020). The results of the fractal analysis are illustrated in Figure 7 and, the numerical results of fractal analysis, which include lacunarity (λ) and fractal mean (DB), are presented in Figure 8. The results of the fractal analysis showed that the fractal dimension value (DB) increased between 1953 and 1978, indicating a more irregular and fragmented settlement pattern due to the increasing number of built-up areas and cultivated lands. This increase can be attributed to the use of new agricultural machinery that enabled the use of previously uncultivated lands for agriculture. However, no significant differences were observed between 1978 and 1991, indicating a relatively stable settlement typomorphology during this period. Between 2013 and 2019, new settlement blocks were added to the south of the region, which led to an increase in fractal value due to the changes in the balance of cultivated-natural areas caused by the emergence of a secondary center.

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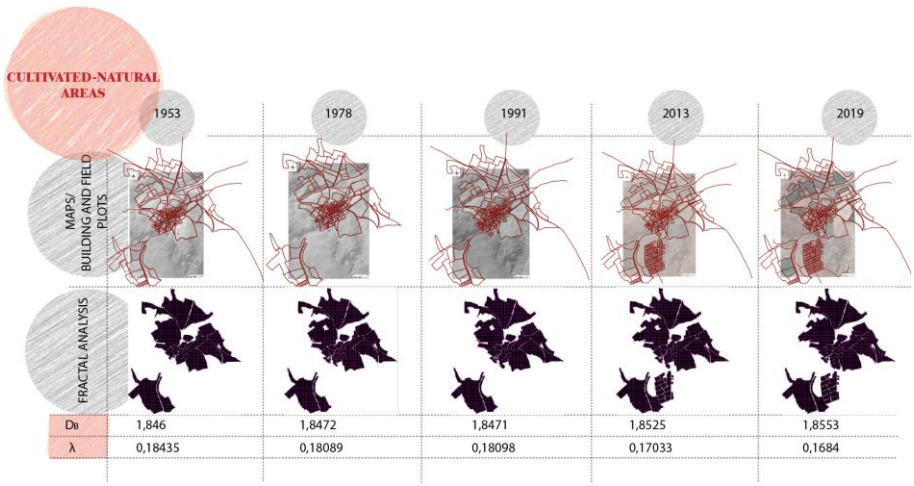

Figure 7. Beyceğiz village fractal analysis matrix

The lacunarity (λ) values also provided insights into the spatial distribution of built-up areas and their relationship with natural elements. The results showed that the lacunarity values decreased between 1953 and 1978, indicating a more homogenous and clustered settlement pattern. However, between 2013 and 2019, the lacunarity values increased, indicating a more fragmented and irregular settlement pattern due to the emergence of new settlement blocks.

Overall, the results of the fractal analysis suggest that the dynamics of settlement typomorphology and cultivated-natural areas in Beycegiz village have been shaped by human interventions such as the construction of new settlements and the conversion of agricultural lands for building constructions.

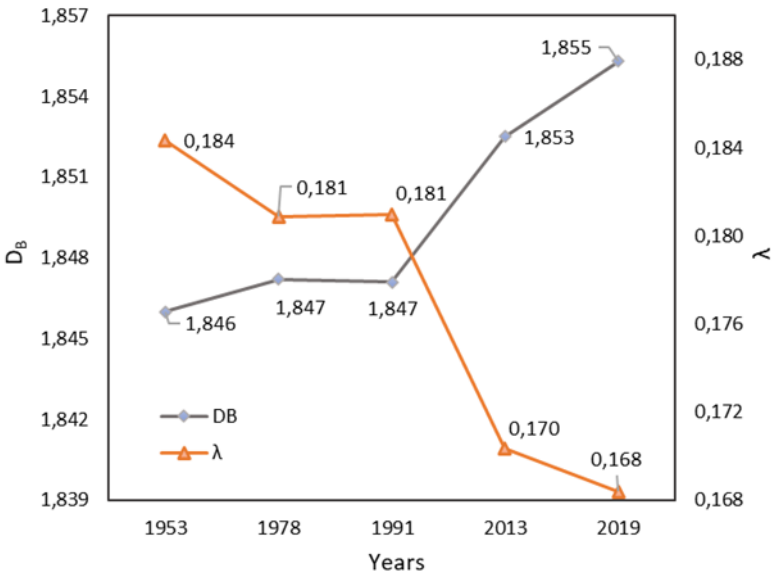

Figure 8. Beyceğiz village fractal analysis values

Space Syntax Results of Road/Path Networks Dynamics

Transportation routes were analyzed using the space syntax method. As a result of this analysis, the sparse and dense usage axes of residential structures and road/path networks were determined numerically. The

generated axis map was analyzed in the Depthmap program, and integration and selection maps were created for transportation axes using the spatial arrangement method for the village of Beyceğiz. The values obtained from these analyses were calculated separately at global and local scales and were examined using two different standards for walking distance, namely 500 and 1000 meters. The transportation network was examined through segment analysis based on selection and integration averages. Choice analysis indicates the likelihood of a specific region being selected, while integration analysis determines its accessibility within the settlement area.

Space syntax results are illustrated in Figure 9 and the evolution of choice and integration outcomes for R500 and R1000 over years are presented in Figure 10. The results reveal significant changes in the settlement pattern over time, shaped by the dynamics of road networks and parcel textures, as well as the emergence of weekend houses and new settlement areas. In 1978, the Polatlı-Beyceğiz road served as the primary arterial road, which contributed to the formation of a linear and square-shaped road network, following the traces of neighboring parcels. The integration and choice values for both radii were relatively high, indicating good accessibility and connectivity within the settlement. However, the subsequent increase in housing and new parcel textures led to the emergence of new road networks, which partially disrupted the old network's hierarchy and coherence.

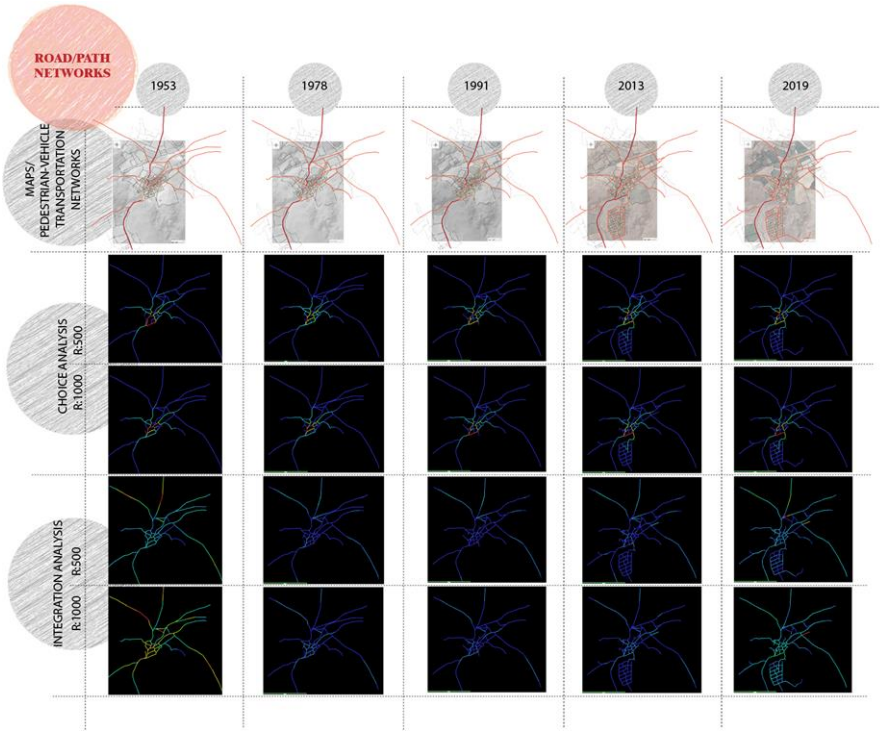

Figure 9. Beyceğiz village space syntax analysis matrix

In 1991, the integration and choice values for R500 radius decreased slightly, while those for R1000 remained stable. This suggests that the settlement's internal coherence and accessibility were partially

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compromised by the new road networks' emergence. However, the settlement maintained its connectivity with the surrounding region due to the continuous utilization of the Polatlı-Beyceğiz road as the primary transportation route

In 2013, the weekend houses' emergence and the formation of a new settlement area significantly affected the settlement pattern, leading to the formation of new road networks within and outside the settlement. The integration and choice values for R500 decreased further, indicating a less integrated and coherent settlement pattern. However, the values for R1000 increased significantly, reflecting a higher level of connectivity and accessibility to the surrounding area.

In 2019, the integration and choice values for both radii decreased again, indicating a continued decline in the settlement's coherence and accessibility. However, the values for R1000 remained relatively high, suggesting that the settlement still had a good level of connectivity to the surrounding area.

These findings have implications for architectural management, as they highlight the importance of considering the spatial configuration and accessibility patterns when designing and managing buildings in Beyceğiz Village. Specifically, the design and management of buildings should take into account the settlement's hierarchical road network and parcel textures, as well as the dynamics of the surrounding area's road networks. This can ensure that buildings are integrated into the settlement pattern and enhance the settlement's overall coherence and accessibility.

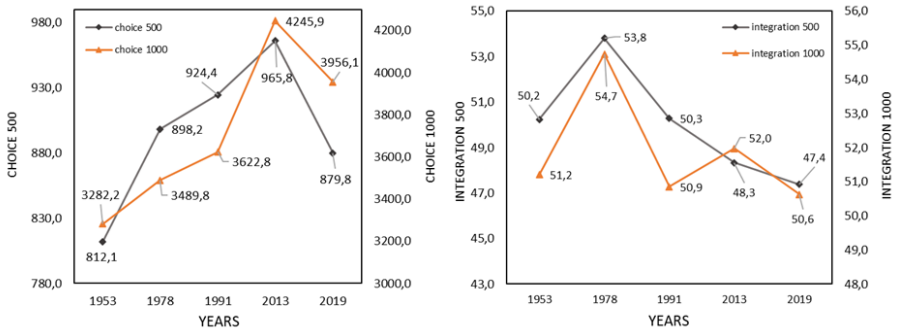

Figure 10. Beyceğiz space syntax Choice and Integration analysis values

Results of Socio-Spatial References

The Socio-spatial reference analyses covered the settlement pattern of the village, agricultural areas, clustered settlements, and proximity to the Polatlı district center as illustrated in Figure 11. The analyses conducted in Beyceğiz village have been examined over the years, and the results have been presented visually and in written form in a matrix format (Figure 12).

The expansion of the collective settlement over time has resulted in a new urban fabric around the reference points in the region. The areas outside the built-up zone are covered by agricultural fields, while the forested areas are less dense within the built-up zone. This settlement

pattern has emerged along the Polatlı road due to its proximity to the district center and its connection to other villages. Over time, a second settlement pattern has been added to the growing built-up zone, which is located closer to the city and district center. This new settlement, established in the 2000s, encompasses dynamic structures such as seasonal residences and grid-like road systems.

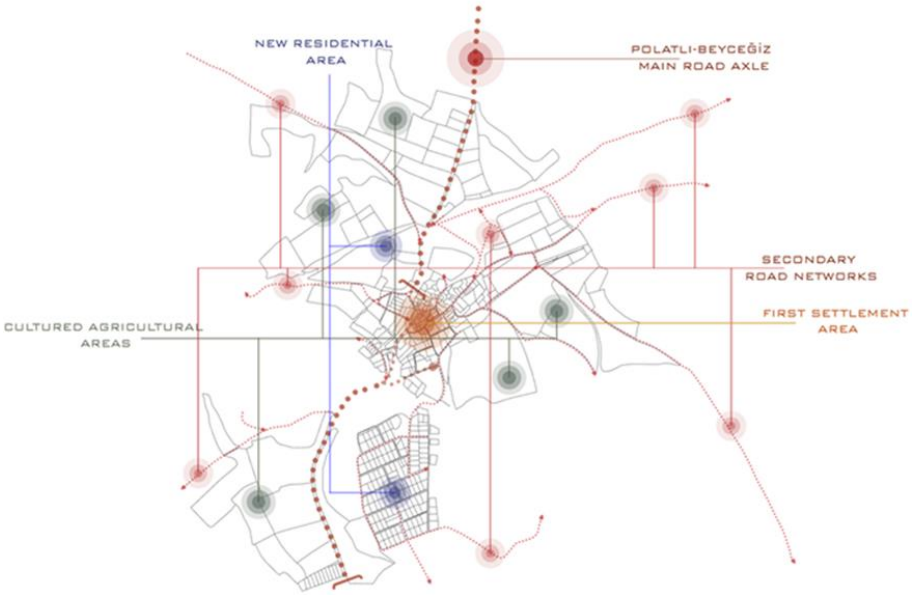

Figure 11. Beyceğiz Village Socio-Spatial settlement sketch

In the village, agricultural areas with rugged terrain are widely found outside the settlement area. The distant areas between these agricultural lands are filled with temporary, single-story houses for seasonal use. Footpaths and farm tracks made for these houses and agricultural vehicles have played a decisive role in the transportation network and structural partitioning of the region. In 1953, the settlement area in the village was used outside the agricultural fields, and the Beyceğiz-Polatlı road passes through the settlement pattern, and linear lateral roads were constructed to access the agricultural fields. Due to the morphological pattern of the village, agricultural fields are more densely developed than residential areas. The organic vegetation of the agricultural fields followed the natural topography of the village and was intervened for livestock farming. The structures built for the animals were constructed close to the residential area. In 1978, migration movements increased and agricultural areas increased slightly. New structures were built only as individual houses in the agricultural fields. The residential area increased in the southeast direction towards the Polatlı and Ankara Road. After 1991, the number of weekend houses with gardens increased, and the homeowners came from Polatlı, Ankara or nearby villages. Transportation roads and footpath axes increased, and morphological arrangements were formed. The residential area moved again towards the east side of the Polatlı road.

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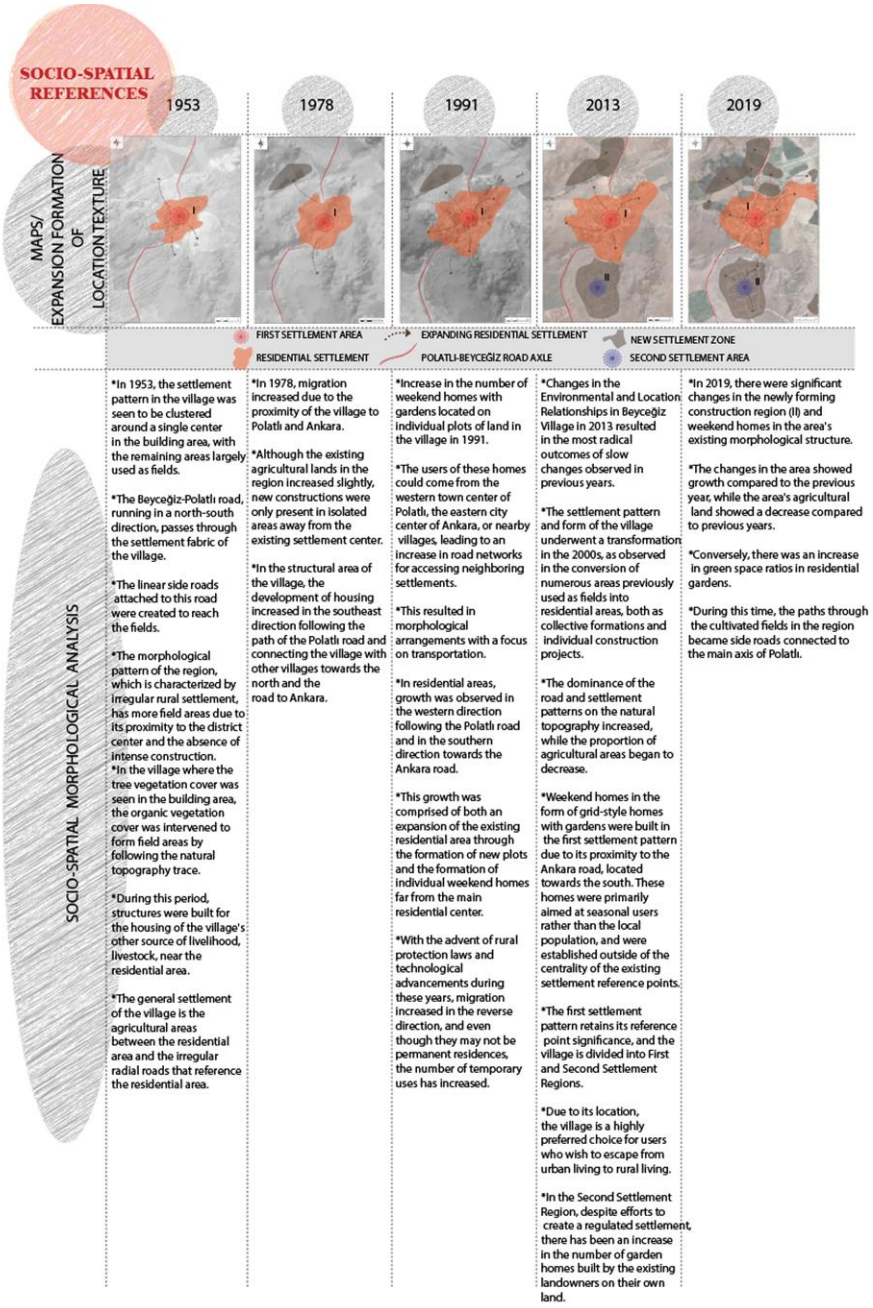

Figure 12. Beyceğiz Socio-Spatial analysis matrix

CONCLUSIONS AND RECOMMENDATIONS

The aim of this study is to determine the morphological dynamics of rural settlements in relation to typomorphology. Analytical Hierarchy Process (AHP) method is used to evaluate the factors affecting rural settlements and a hierarchical order was generated for concrete parameters. The study also analyses the change of the first three dynamics over time in Beyceğiz, a sample village, using fractal and space syntax analysis.

AHP results showed that cultivated and natural areas, socio-spatial references and road/path networks are the main dynamics in the typomorphological analysis of rural settlements. Cultivated-natural areas were analysed by fractal analysis method, which enabled the reading of

the temporal change of interventions such as new settlements, agricultural lands and building constructions on the settlement texture not only by observation but also numerically. With this method, it was also possible to observe lacunarity values, which indicate a more fragmented and irregular settlement pattern over time. The second parameter, road/path networks, was analysed using the Space syntax method. The method shows that there are significant changes in the settlement pattern influenced by various dynamics such as road networks, plot patterns, the emergence of weekend houses and new settlements. These results emphasise the importance of spatial configuration and accessibility patterns when designing and managing buildings in the village, allowing for a rational reading of mobility. The layering analysis of socio-spatial references at micro and macro scales has allowed the integrated results to read the change/transformation process of the settlement. It clearly shows the changes in the settlement centre, main road axis, side roads, new constructions and expansion networks of the settlement. This analysis reveals the pattern of development, change and transformation of the settlement.

The results of this study provide valuable information on monitoring rural dynamics and managing rural settlements. The identified dynamics and their weighted values can guide decision-makers in rural planning and development. The findings reveal the significant impact of economic and demographic changes on rural settlement morphology and emphasise the need for rural protection laws to regulate settlement and agricultural activities. The study underlines the importance of sustainable land use practices that balance human settlement and agricultural activities with the conservation of natural ecosystems. The study also emphasises the importance of road/path networks in shaping occupancy and emptiness. These findings can be extended to other rural areas to monitor changes in rural settlements and determine their identity and morphological characteristics in the future.

The presence of numerous parameters in the analysis of rural and urban settlement areas frequently poses challenges in making an impartial selection in scientific investigations. In this regard, the AHP method employed in this study's data can be employed for rural areas, or the parameters may be extended/modified and incorporated into comparable studies with a parallel AHP selection. The utilization of various techniques like fractal and space syntax, offering numerical outputs, will yield logical outcomes in rural/urban settlement studies, given their ability to analyze multiple parameters.

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Resume

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