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ANALYSIS OF THE EFFECT OF URBAN CHANGE ON URBAN SILHOUETTES BY ENTROPY METHOD

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ABSTRACT

The urban population, and consequently urban development, have increased in recent years and the urban silhouettes have been greatly affected. The aim of this study is to reveal how urban development affects urban skylines and urban identity aesthetically. The photographs of the eastern, northern and western fronts of Boztepe, an important landmark of the city of Trabzon, from the 1900s, 1950s and 2000s, were examined using the concept of entropy where the aesthetic measure could be digitized and the data were obtained. As a result of the comparisons, the positive and negative effects of urban development on urban silhouettes were digitized. It was determined that the uncontrolled development of cities negatively affected the city skylines. The impacts of the new projects are determined in advance and suggestions are given to take the necessary measures.

KEYWORDS:
Silhouette, Skyline, City Silhouette, Silhouette Analysis, Entropy, Digitization of Esthetics

INTRODUCTION

Human beings have started to migrate to cities because they think that they can easily reach basic needs such as water, electricity and heating with the developing technology and they think they can lead their lives more comfortably. As a result of this migration, the inadequacy of the establishment of the center has improved the settlement of the city. Rapid urbanization has led to irregular urbanization. Recreation areas and natural areas were destroyed and the city grew towards these regions [1]. This situation has caused green areas to transform into structural areas over time.

The impact of the increasing population in urban centers is not only the diminishing green areas. Factors such as factories established to provide employment with the increase in human population, increasing urban vehicle traffic, shelter and heating need, and increased flue smoke increased CO_2 emissions, and greatly affected the city's air and living population in the city [2-3].

Population change and consequently increased construction caused visual and aesthetic changes in the city from inside and outside. This change has taken people away from the nature they belong to, has negatively affected them psychologically and caused the existing identities of cities to be disrupted. The most important elements that make up the city identity are the topography, vegetation, historical structures and city plans specific to that city. These are the highlights of the city. The emphasis points found by the effect of urban growth have lost their value, changed or disappeared [4].

Urban identity can be strengthened by preserving its unique historical texture and natural beauties from the past. Correct city plans contribute greatly to this situation. If the planning is done correctly, both the visual quality of the people living in the city and the quality of the city identity and silhouette will increase.

According to Max Wertheimer, the human brain is programmed to perceive the simple. It detects complex images by simplifying them. Silhouette is two-dimensional and simply perceptible, unlike other methods of view. This feature makes the silhouette different and useful on large scales.

The important factors that make up the skyline of a city are the high-rise buildings that are needed in the developing cities as well as the historical, cultural and geographical development of that city. City skylines; they consist of numerous panoramas according to their viewpoints and temporal changes. Nowadays, most cities are under the influence of high-rise buildings. These buildings both negatively affect the city in terms of aesthetics and reduce the effect of natural, historical and geographical structures that are aesthetically pleasing [5].

While urban planning, historical and cultural structures and newly rising buildings directly affect the silhouette, they also affect spatial organization and habitable space designs and as a result, the silhouette is also affected.

In urban development, some countries develop their cities by considering economic reasons rather than planning aesthetics, natural and urban identity. This has often been a major problem for underdeveloped or developing countries. Even if this planning seems economical for today, it may have bad economic consequences in the future [6].

Professions such as Landscape Architecture, Architecture and City Regional Planning consider topography, building, plant organization and plant community individually or together. Urban skylines are a major factor in the formation and perception of urban identity [7].

Important factors of urban skyline are urban function, regional image formation, topography shape and the city's capacity to form a skyline [6].

City skylines are a panoramic view of topography, urbanization, urban planning and plant compositions. While each of these units has individual effects, their effects together and on each other are very important. Like tall buildings topography-structure, topography-plant, structure-plant relations affect the aesthetics of that silhouette while examining the city skylines [8-9].

Wagemans revealed what human beings are actually more aesthetically approaching and what they consider more aesthetic. In this study, the basic principles determined by the human aesthetics were used for examining the aesthetics of images and observation values were obtained with these principles [10].

Guney et al. used 2D silhouette lines and made 3D analyzes while analyzing city silhouettes with Geographical Information Systems (GIS). They stated that with this application, geospatial objects can be detected better. Guney et al. stated in the 10-year cleaning analysis of Istanbul that especially high-rise buildings affected the city to a great extent. It has been suggested that the settlement planning of the city of Istanbul can be followed in a more efficient way through 3D maps, not 2D maps [5].

Karimimoshaver and Winkemann investigated the negative aesthetic effect of high-rise buildings on urban landscape using the Analytical Network Process (ANP) method on high-rise buildings such as the Main Tower, Opernturm and the European Central Bank in Frankfurt. In order to determine the aesthetic effect, the ratio of the visible surfaces of these structures to the field of view of the observers in an area of 2500m radius was used. A pictorial questionnaire filled out by 420 participants was used to determine the effect of the aesthetics of these three buildings on the city skyline. As a result of this study, Karimimoshaver and Winkemann determined that high-rise buildings are elements that express the greatest meaning in the silhouette line and change the aesthetic value greatly. It has been observed that the individual aesthetic values of high-rise buildings and the aesthetic values of the city skyline do not match [11].

Wang and Ogawa used the fractal method for visual analysis of natural and urban areas. They stated that the reason why they preferred the fractal method is that it is a method that can be applied regardless of scale and comes from nature and naturalness. In this study, a collection of natural and urban images, the counting method for black and white photographs, and the Brownian model for color photographs are discussed [12].

Wu et al. stated that the theory proposed by Claude Shannon was widely used in information science for many years. Shannon defined entropy with a random variable as a measure of complexity based on parameters. Wu et al., using these concepts, utilize a random image generator and obtained results by processing fewer image pixels with local Shannon entropy measurement according to the global Shannon entropy measurement. In addition, this study allows image comparisons [13].

Bostancı stated that the analysis of city silhouettes can be done by combining the parameters that make up the silhouette with the entropy of Shannon, the values obtained by a kind of counting method. Silhouettes taken from certain points of the city of Istanbul were transformed into 2D and 3D linear images using Geographical Information Systems, and the images to be used to determine the entropy method parameters were obtained. As a result of this study, Bostancı reveals that silhouettes can be evaluated as numerical data using the entropy method and this assessment method works successfully [14].

Aesthetics is expresses the relationship between order and disorder. The results of qualitative studies are obtained with large sample groups and statistical studies due to the differences of opinion of the participants. The results of quantitative studies are obtained with numerical data. In this study, parameters that can be used in digitization method were created by determining the building blocks of order and irregularity. Shannon Entropy was used to process the data in the most accurate way and to determine the complexity. If the aesthetics can be digitized, the plant designs, spatial designs, accuracy and aesthetics of the city plans will be measured and the in progress projects prepared can be evaluated numerically before implementation. The effects of in progress projects that are evaluated numerically on aesthetics will be determined.

Structural development, which affects aesthetics, changes with the perspective towards the silhouette, distance and vision barriers. With this study, a natural topography that affects the central silhouette of the city to a great extent has been evaluated with images obtained from three fronts without any obstacles.

In order to observe how urban development affects the city skylines, to prevent the ongoing urban development from further disrupting the city skylines, to change the identity of the city lost through small interventions if possible and to improve the city skyline, the change of Trabzon Boztepe example over the years is examined by visual digitization method.

MATERIALS AND METHODS

Materials. The name of Trabzon city is thought to come from the colonies of Miletus who founded the city. Trapezus, which means a table because its topographic structure resembles a flat and sharp-edged table, was used. Later, each new community replaced the word in its own meaning with names that resemble the first name. For example, it was named as Trab-ıEfsun by Fatih Sultan Mehmet because of its beautiful nature and clean air during the Ottoman Empire [15].

Although the geographical conditions of the city of Trabzon are very challenging in terms of road and settlement, the settlement and trade history dates back to 2000 BC. The city was founded in 756 BC [15].

Boztepe was used as a natural observation tower to protect the city from external dangers during and before the Ottoman Empire. After the establishment of the Turkish Republic, it was used by the armed forces and NATO as a base for the military and communication center. For this reason, settlements were far from Boztepe.

After the establishment of the Republic of Turkey, the city's plans for the first time were made in 1937 by the French Urban Planner Jacques Henri Lambert. At the core of this plan are wide corridors extending from the sea to the hills in order to reduce the humid air of the city as much as possible, to ensure wind circulation and most importantly to increase the city's integrity with the sea and transportation [16].

Lambert gave great importance to the historical texture of Trabzon in his planning. In addition to planning to preserve historical buildings, he respected the architecture of the city and made the planning thinking that this architecture should be preserved [16]. With the increase in migration to cities in the 1900s, adequate control could not be achieved and the plan prepared could not be followed. Planning has changed considerably with the later revised plans.

Located in the city center of Trabzon, reflecting the gloomy character of the city and considered as one of the important places of Trabzon with its magnificent view and natural beauty, Boztepe has started to be affected by these revisions in recent years.

Boztepe, which is the liver of the city with its natural beauty and plant population, was previously used in the recreation area. Later, due to the excessive rise of urban development and the limited construction area of Trabzon, many settlements became new construction sites.

The deterioration of the naturalness of Boztepe, which directly affects the silhouette of the city of Trabzon, which is considered to be the prominent feature of the city of Trabzon, and the continuation of unplanned construction adversely affected the identity and silhouette of the city. To detect the effects of this change, similar silhouette images were found for similar year intervals. Visual effects on these silhouettes have been studied.

Methods. Aesthetic value is influenced by many factors such as the environment in which the individual live, the mood they are in, the psychological state at hand, the environmental conditions such as educational status, cleanliness, naturalness, light effects from individual characteristics such as previous good or bad experience. While the aesthetic value of the environment is directly affected by the decisions and practices made by individuals or societies about the environment, it indirectly affects emotions and experiences [17].

Aesthetic is a variable value, but there are also accepted mathematical evaluation methods. These evaluations aim to get results by digitizing the aesthetic values by taking the averages of all parameters.

Aesthetic assessment methods actually go back to many years. The most important example of this is the Golden Ratio, which appears in many places. It is known that it was used in Ancient Egypt and Ancient Greek civilizations in the 3rd millennium BC. The best-known example of this is the Mona Lisa painting. The Golden Ratio is the most perfect distribution of an object. It has been observed that human body structures and faces, many occurrences of nature, many animals and plants make up this ratio. Golden Ratio is accepted as 1,618 [18]. The Golden Ratio exists directly in nature and in many current areas. This method pioneered other aesthetic digitization methods.

Thinking that aesthetic can be solved with a mathematical formula, Birkhoff has worked on this subject and become a pioneer. As a result of the researches, he found a formula of M = O / C (Aesthetic Value = Order / Complexity) to convert the aesthetic values of the forms into mathematical data. This has led to many scientists seeking to quantify aesthetics with their formulas and studies [18-19].

The evaluation of the aesthetic qualities of cities has long been among the issues of urban design research and development. Although these evaluations are generally abstract and personal, they have been used and have proved to be successful in numerical methods. Entropy is one of them [18].

The digitization method used in the study has emerged from the concept of Entropy. Almost all known physical processes in the universe can be explained by thermodynamics, the structured discipline for the operation of complex systems [20-21]. After studies on closed and isolated systems, thermodynamic studies were developed to investigate open systems such as ecosystems [22]. Many concepts developed in thermodynamics have been used in areas such as ecology, landscape ecology, architecture and urban planning [23-24-25-26-27].

The first law of thermodynamics, also known as conservation law, states that energy is always conserved in different states. The second law of thermodynamics or the entropy law states that the beneficial energy, which is also defined as exergy or working capacity, is destroyed and entropy is produced irregularly [27]. Entropy is a thermodynamic term in physics with the symbol "S". It ıdentifies irregularity and randomness.

Entropy is the law that tells us that everything in physics will either destroy or deteriorate. As these deteriorations increase, the entropy value increases. In other words, entropy is the value of irregularity or uncertainty. For example, if the probability of an event occurring or not occurring is the same, this leads to an increase in uncertainty. This means that the entropy level is maximum. However, if an event is more likely to occur, the uncertainty decreases and the entropy value decreases.

Entropy always has energy and always tends to move towards balance [28]. According to Capra, according to the second law of thermodynamics, there is a tendency in physical phenomena from order to disorder, to ever increasing entropy [18-29]. So, the universe always prefers irregularity and turns towards it. In our opinion, this disorder may be an order for the universe.

Studies on thermodynamics and Shannon entropy have been conducted in many scientific fields [30]. Additionally, entropy is suitable for studies presenting open spatial methods [31–32].

Cities are a complex and artificial ecosystem that shapes social and ecological processes, is organized under human domination, and has managed mechanisms [33]. These mechanisms are explained in part by current concepts, theories and approaches developed by ecological disciplines [33]. Urban growth, planning and aesthetic levels can be explained by entropy, the second law of thermodynamics [34].

Shannon studied the concept of entropy, revised the theory of information and discovered a method of finding measurable numerical value. With this method, entropy became quantifiable [35]. Shannon's work on entropy has become the accepted and preferred method by many. But many scientists, except Shannon, have tried to develop the method of entropy on many concepts. Renyi was applied to calculate the biodiversity ratio, and Tsallis was applied for studies in statistical fields and was successful [35].

Shannon, who was involved in the theory of information in entropy, revisited this equation and improved the mathematical structure. He used a two-sided logarithmic formula he developed to reduce the loss of information. In this way, he managed to turn entropy into a numerical value. The unit of the resulting value is called 'bit' [19].

$$\log_2 2^N = N$$

Shannon used the ratio of the number of events in the subclasses to the number of elements in the universal set to measure the probability values of the events in the subsets and calculated the uncertainty of the future of the subset in this set. This equation shown below is defined as 'Shannon's Informational Entropy'.

$$H = -\sum p(i) \log_2 p(i)$$

According to Shannon, it takes the minimum value of "0" if the situation contains certainty, and the maximum value of "1" if the situation contains complete uncertainty.

Aesthetic evaluation methods and digitization methods were examined in determining the method of the study. Aesthetics is a unique concept and can vary from person to person. But there are certain principles that the brain perceives as aesthetic. Since the aim is to create precise numerical data, aesthetic principles and concepts that may be appropriate Shannon's information Entropy formula are discussed.

Psychological and aesthetic value of Gestalt theory was taken into consideration and it was determined that there are principles that can be digitized. In order to bring these principles into conformity with the informational entropy theory, analyzes were made through photographs and the values were obtained by combining the formula with the determined raw data.

Boztepe creates three different silhouettes from different points of the city. These silhouettes have changed greatly over time. In order to achieve the aesthetic measure of all the silhouettes of Boztepe, three different facades are considered. In order to observe the change, studies were carried out on visuals at the same angles from three different time periods at approximately fifty-year intervals. The order of application of the method is schematized in Figure 1.

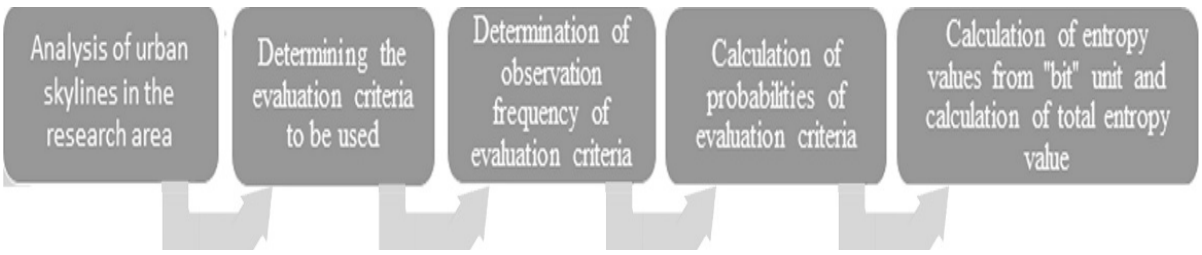


FIGURE 1
Method Diagram

RESULTS AND DISCUSSION

The purpose of evaluating by years is to observe the change of Boztepe from past to present. While doing this, the East, North and West fronts of Boztepe were used. The reason for this is that Boztepe, which has a dominant character in Trabzon, can be seen from inside the city and from the sea, and the facades that form its characteristic appearance are these three facades. While evaluating by years, fronts are evaluated with three different year intervals (-1900, -1950+, 2000+).

When the entropy value is calculated, the decimal part of the numbers obtained is taken as five digits. For example, the continuity effect for the northern front of 1900 is determined to be 0.143609027. The analysis value is accepted as 0.14461.

Over the years, the frequency of observations has increased in Boztepe, which has various structures such as roads, buildings, parks and bridges. The increase in the frequency of observation affects all parameters and decreases the bit values.

As seen Figure 2, when the values and observation frequencies are taken together, on the eastern front, although the vegetative effect has increased, the structural density has increased. This situation caused the degradation of the topography and the increase of dominant and repeat elements. Since probability is taken into account in the esthetic value calculation method, each of the values is affected by this change. As a result in Table 1, it has been observed that the bit value on this front gradually decreases every year.

East Side

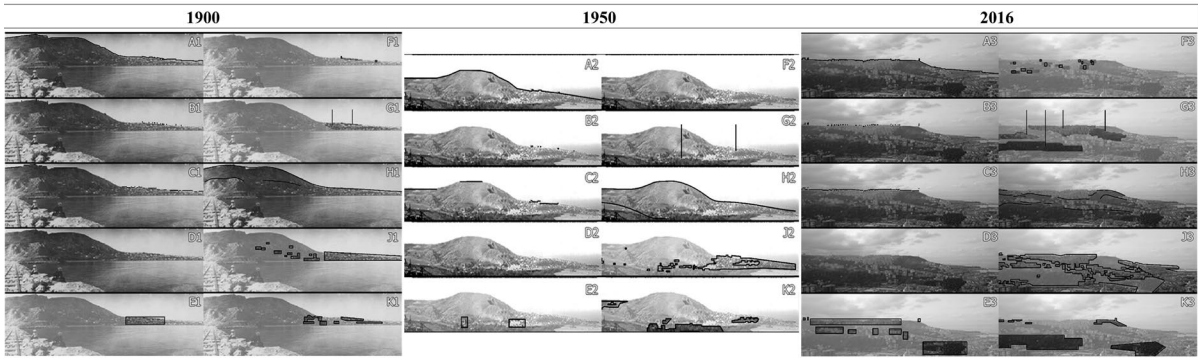


FIGURE 2
Trabzon Boztepe, East, 1900, 1950, 2016

TABLE 1
Trabzon Boztepe, East, 1900, 1950, 2016 Entropy Value

Evaluation Scales	Obs. 1900	Entropy Value 1900	Obs. 1950	Entropy Value 1950	Obs. 2016	Entropy Value 2016
Contour Effect (A)	18	0.50000 bit	22	0.50314 bit	162	0.52437 bit
Vertical Effect (B)	9	0.37500 bit	7	0.29456 bit	42	0.35120 bit
Horizontal Effect (C)	6	0.29875 bit	8	0.31872 bit	49	0.38106 bit
Color Effect (D)	5	0.26722 bit	5	0.23862 bit	8	0.11726 bit
Dominant Effect (E)	1	0.08569 bit	2	0.12619 bit	10	0.13810 bit
Repeat Effect (F)	2	0.14361 bit	0	0 bit	12	0.15742 bit
Continuity Effect (G)	2	0.14361 bit	2	0.12619 bit	4	0.06916 bit
Topography Effect (H)	3	0.19104 bit	2	0.12619 bit	12	0.15742 bit
Occupancy-Void Effect (J)	20	0.51333 bit	21	0.49666 bit	56	0.40711 bit
Herbal Effect (K)	6	0.29875 bit	17	0.46232 bit	25	0.25829 bit
Total	**72**	**2.81700 bit**	**86**	**2.69259 bit**	**380**	**2.56139 bit**

North Side

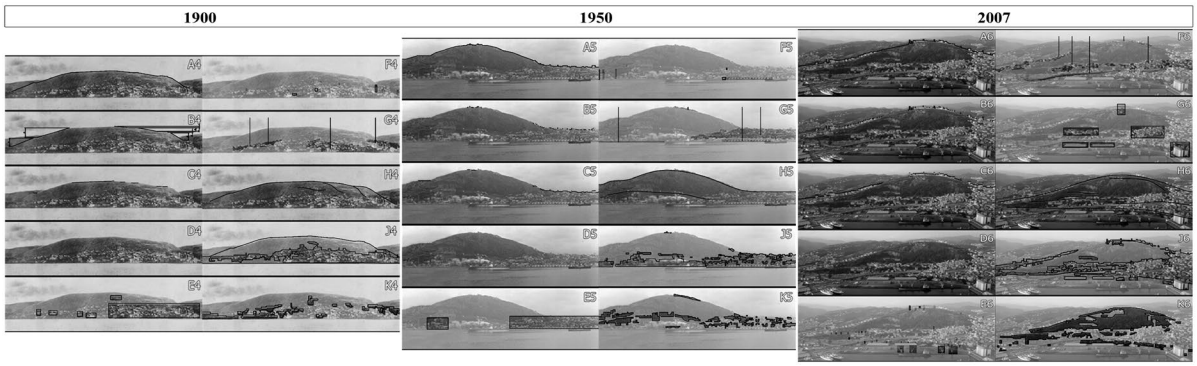


FIGURE 3
Trabzon Boztepe, North, 1900, 1950, 2007

West Side

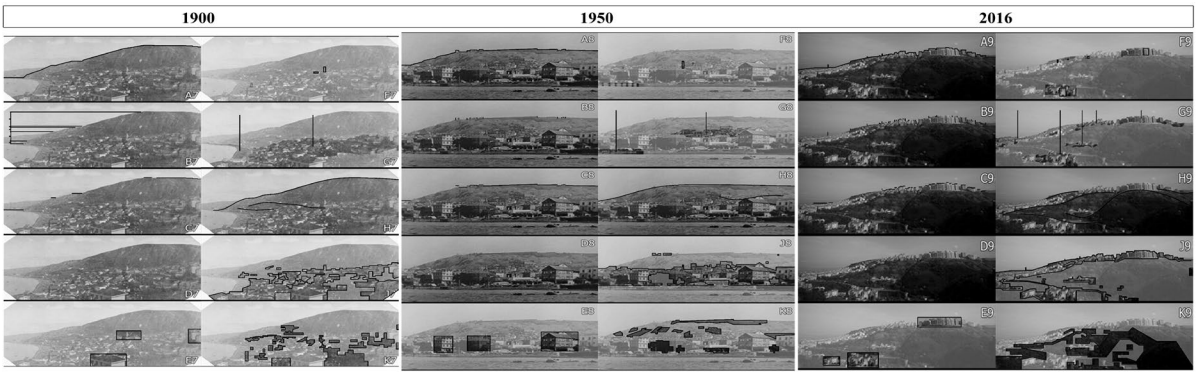


FIGURE 4
Trabzon Boztepe, West, 1900, 1950, 2016

TABLE 2
Trabzon Boztepe, North, 1900, 1950, 2007 Entropy Value

Evaluation Scales	Obs. 1900	Entropy Value 1900	Obs. 1950	Entropy Value 1950	Obs. 2007	Entropy Value 2007
Contour Effect (A)	13	0.37129 bit	78	0.52871 bit	147	0.53057 bit
Vertical Effect (B)	6	0.23451 bit	44	0.45490 bit	69	0.43267 bit
Horizontal Effect (C)	6	0.23451 bit	40	0.43725 bit	74	0.44581 bit
Color Effect (D)	5	0.20783 bit	5	0.11931 bit	8	0.11082 bit
Dominant Effect (E)	6	0.23451 bit	2	0.05912 bit	6	0.08919 bit
Repeat Effect (F)	3	0.14556 bit	3	0.08112 bit	6	0.08919 bit
Continuity Effect (G)	4	0.17841 bit	4	0.10100 bit	5	0.07753 bit
Topography Effect (H)	4	0.17841 bit	2	0.05912 bit	7	0.10026 bit
Occupancy-Void Effect (J)	42	0.52920 bit	36	0.41711 bit	49	0.36628 bit
Herbal Effect (K)	17	0.42347 bit	18	0.28614 bit	39	0.32285 bit
Total	**106**	**2.73770 bit**	**232**	**2.54378 bit**	**410**	**2.56517 bit**

As seen Figure 3, the center of Trabzon city is located on a part of the northern border of Boztepe. Therefore, between 1900 and 1950, construction increased significantly. Restoration continued in the remaining areas, and some of the old buildings were demolished and rebuilt. Therefore, the frequency of observations varied greatly between 1900 and 1950.

Considering the values and the frequency of observations together in Table 2, the graphs on the north side for the years 1950 and 2007 show almost the same level of bit values. In 1900, it was observed that the bit value was higher.

There were no large buildings on the western side of Trabzon Boztepe until 2000s. However, Trabzon, a growing city, has taken over the western edge of Boztepe because of the limited residential areas and the construction has increased exponentially. Although the frequency of observation of vegetative effect has improved over the years, it has not been enough due to the other factors brought about by this urbanization.

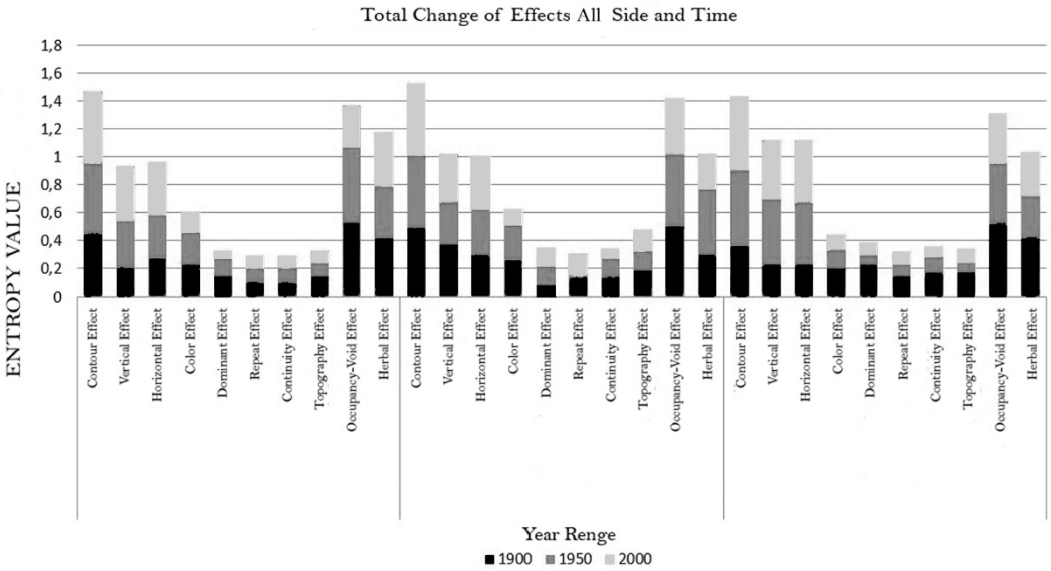


FIGURE 5
Trabzon Boztepe, Total Change of Effects All Side and Time

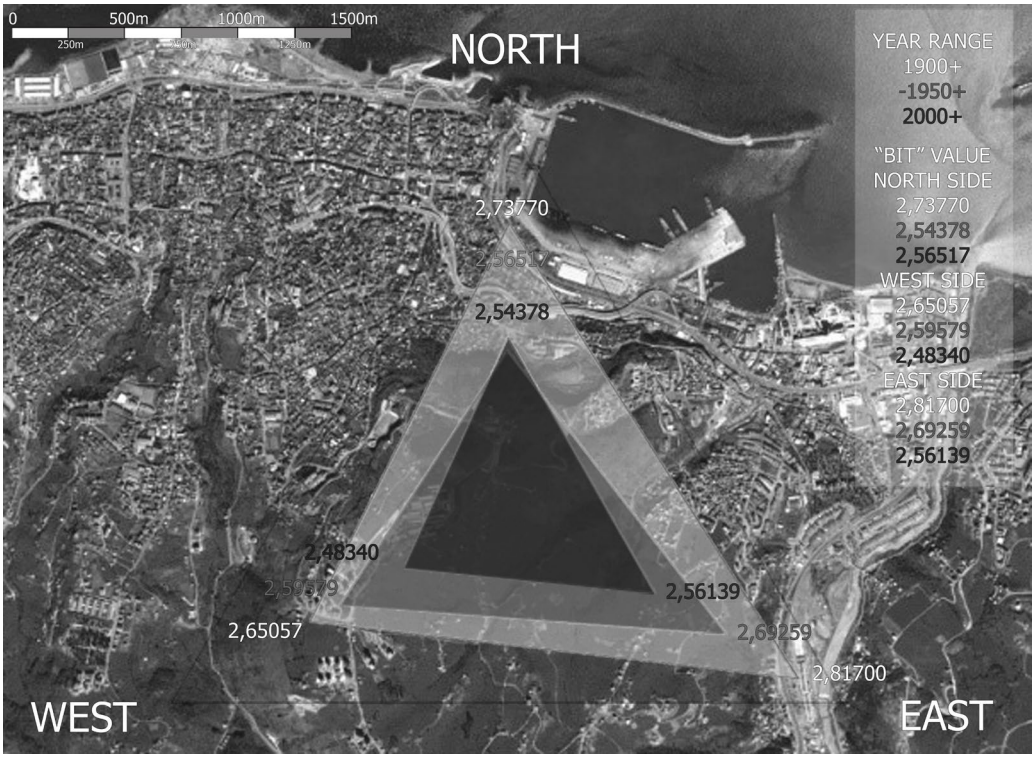


FIGURE 6
Trabzon Boztepe, Total Change of Effects All Time

As seen in Figure 4, Between 1900 and 1950, when the frequency and values of the observations are taken together, the west side bit values did not differ significantly. A great change was observed with the increase in construction in 2016. It is clear that the bit value decreases with the settlement.

When the average aesthetics of all the facades of Trabzon Boztepe are examined, aesthetics have continuously lost value since the 1900s. If urban development continues at this rate, it is predicted that the aesthetic value will gradually decrease. However, the aesthetic value can be increased numerically by making the right planning decisions in the future, increasing the visual quality of the existing construction and vegetative designs that will highlight the urban touch and are suitable for the region. In Figure 5, the change values of parameters according to years for the east, north and west directions, respectively, and in Figure 6, the total aesthetic values of Boztepe and its changes over the years can be seen.

CONCLUSIONS

The simplest method of benchmarking is to move through numerical data. This study is based on Shannon's method of digitizing aesthetics, which he developed as a result of his studies on entropy. For the method, principles appropriate to the study area were determined and the changes related to these principles were observed through photographs. The frequency of observations was adjusted to Shannon's equation and aesthetic values in terms of "bit" were obtained.

Using the digitization method, the change of Boztepe, one of the landmark points of Trabzon, from the past to the present is discussed. It has been determined how the increasing population of the city over the years affected the basic elements that make up the silhouette and what kind of a change these basic elements caused in the whole city silhouette. With the findings, the changes that occurred over the years were transformed into mathematical data. The numerical values obtained were compared with the estimates. According to the data obtained from the study;

One of the most important factors affecting aesthetics is the increase in the structural density and consequently the decrease in the bit value of the total aesthetics.

With the development of technology, the discovery of new techniques, the ease of plant care, and the understanding of the importance of the plant for society and the city, the city of Trabzon has generally progressed in terms of vegetation. However, in addition to increasing plant density, light green areas were filled with structures. According to the analysis data, the frequency of observing the vegetative effect increased as we approached to the present day, but the herbal effect density decreased.

None of the silhouettes studied from 1900 to the present day have seen a visually impressive, aesthetic and eco-friendly building or landscape. This may be the biggest deficiency of the city of Trabzon.

It is noteworthy that the Trabzon city plan is sloppy and inefficient. The poorly designed city plan caused large area losses, aesthetically affected the silhouette negatively and was functionally inadequate. It is clear that the city is not seen as a whole.

The green areas in the city center are small and scattered. There is a need for areas where people can move away from urban life and spend time with nature, but these areas should not be small and piece by piece. Within the city as much as possible, a whole natural area can contribute to the city both visually and in terms of the quality of life of the inhabitants. At the same time, these areas will greatly improve the silhouette.

The use of areas that are not suitable for construction or which are landmark for Trabzon has caused a significant change in the natural topographic lines of Trabzon.

The construction of tall buildings has gradually increased the dominant elements observed in silhouettes. The increase in observed dominant elements has an adverse effect on the whole, even if it is thought that Boztepe has increased the cue point property. In addition, high buildings cause to hide the historical texture and natural beauties.

Over time, the structural expansion of the city towards Boztepe caused the silhouette to lose its aesthetic value to a great extent.

The highest aesthetic value of the eastern facade was measured in the 1900s. However, it was the facade that lost its value at the highest rate during the year. The reason for this is that the facade, which was completely natural in the beginning, turned into a settlement in the 2000s.

Since the northern front is the front that hosts the center of the city of Trabzon, urban development has existed since the 1900s. Therefore, it was less affected by urban development, or it can be said that it was already affected by urban development in the 1900s.

With this study, the change over the years has been tried to be monitored. The evaluation of the projects to be made with 3D models can be done with this method. Before the projects are carried out, it can be predicted to what extent it will affect the silhouette.

REFERENCES

[1] Celik, K.T. (2015) Generating a Gis-Based Campus Urban Furniture Information System (CUFIS): Example of Kanuni Campus - Karadeniz Technical University. Master Thesis Karadeniz Technical University.

[2] Martinez-Zarzoso, I. (2008) The Impact of Urbanization on CO2 Emissions: Evidence from Developing Countries. Fondazione Eni Enrico Mattei. 2008.050, 1-32.

[3] Dascher, K. (2014) City Silhouette, World Climate. Annual Conference 2014: Evidence-based (Hamburg). Economic Policy. A16-V3.

[4] Gul, A. (2008) Landscape and Humanbeing Relation and Landscape Architecture. Turkish Journal of Forestry. 1, 97-114.

[5] Guney, C., Girginkaya, S.A. Cagdas, G. and Yavuz, S. (2012) Tailoring a geomodel for analyzing an urban skyline. Landscape and Urban Planning. 105, 160-173.

[6] Yusoff, N.A., Noor, A.M. and Ghazali, R. (2013) City skyline conservation: sustaining the premier image of Kuala Lumpur. ScienceDirect. 20, 583-597.

[7] Karakaya, B. (2013) Urban landscape-sustainability-city silhouette: The historic core from Edirne. Master Thesis. Trakya University.

[8] Yaran, A. (2016) Investıgatıng the aesthetıc ımpact of tall buıldıngs on urban landscape. Journal of Building Performance. 7(1), 1-8.
[9] Puspitasari, A.W. and Kwon, J. (2019) Analysis of the Visual Quality of Riverfront Skyline Through the Feature of Height and Spatial Arrangement of Tall Building. Architectural Research. 21(4), 91-98.
[10] Wagemans, J. (2013) Historical and conceptual background: Gestalt theory, Oxford Handbook of Perceptual Organization, Oxford University Press. 3-20.
[11] Karimimoshaver, M. and Winkemann, P. (2018) A framework for assessing tall buildings' impact on the city skyline: Aesthetic, visibility, and meaning dimensions. Environmental Impact Assessment Review. 73, 164-176.
[12] Wang, J.H. and Ogawa, S. (2015) Fractal analysıs of colors and shapes for natural and urbanscapes, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 36th International Symposium on Remote Sensing of Environment, Berlin, Germany. 1431-1438.
[13] Wu, Y., Zhou, Y., Saveriades, G., Agaian, S., Noonan, J.P. and Natarajan, P. (2013) Local Shannon entropy measure with statistical tests for image randomness. Information Sciences. 323-342.
[14] Bostanci, S.H. (2015) Shannon entropy and urban skylınes, Journal of the Technical University – Sofia Plovdiv Branch, "Fundamental Sciences and Applications", International Conference on Engineering, Technologies and System TECHSYS. 21.
[15] Oksuz, M. (2005) A Sort History of Trabzon From the Very Beginning to the XIX. Century. Black Sea Studies. 5, 11-25.
[16] Bilsel, A. and Bilsel, S.G. (2010) Urban Planning Competitions, Stages of Development from the 1960s to the late 70s. Journal of the Chamber of City Planners. 50, 89-124.
[17] Hagerhall, C.M., Purcell, T. and Taylor, R. (2004) Fractal dimension of landscape silhouette outlines as a predictor of landscape preference. Journal of Environmental Psychology. 24, 247-255.
[18] Bostanci, S.H. (2008) Evaluation of the urban skylines by the entropy approach. Ph.D. İstanbul Technical University.
[19] Birkhoff, G.D. (1933) Aesthetic Measure. Publisher: Harvard University Press, Massachussets.
[20] Ying, L. (2015) Twin universes: Universal laws of thermodynamics. American Journal of Modern Physics. 4, 1-4.
[21] Bejan, A. and Errera, M.R. (2016) Complexity, organization, evolution, and constructal law. Journal of Applied Physics. 119, 1-20.
[22] Kondepudi, D. and Prigogine, I. (2015) Modern thermodynamics: From heat engines to dissipative structures. John Wiley & Sons, Ltd. 523 pp.
[23] Naveh, Z. (1987) Biocybernetic and thermodynamic perspectives of landscape functions and land use patterns. Landscape Ecology. 1, 75–8.
[24] Gobattoni, F., Pelorosso, R., Lauro, G., Leone, A. and Monaco, R. (2011) A procedure for mathematical analysis of landscape evolution and equilibrium scenarios assessment. Landscape and Urban Planning. 103(3), 289–302
[25] Ho, M.W. (2013) Circular thermodynamics of organisms and sustainable systems. Systems. 1(3), 30–49.
[26] Cushman, S.A. (2015) Thermodynamics in landscape ecology: The importance of integrating measurement and modeling of landscape entropy. Landscape Ecology. 30, 7–10.
[27] Pelorosso, R., Gobattoni, F. and Leone, A. (2017) The low-entropy city: A thermodynamic approach to reconnect urban systems with nature. Landscape and Urban Planning. 23-24.
[28] Ekinoglu, H. and Plunz, R. (2017) Modeling Spatial Wholeness in Cities Using Information Entropy Theory, A|Z ITU Journal of Faculty of Architecture. 67-81.
[29] Capra, F. (1996) The Web of Life, Publisher: HarperCollins, London.
[30] Taher Tolou Del, M.S. and Tabrizi, S.K. (2020) A methodological assessment of the importance of physical values in architectural conservation using Shannon entropy method. Journal of Cultural Heritage. 44, 135-151.
[31] Balocco, C. and Grazzini, G. (2000) Thermodynamic parameters for energy sustainability of urban areas. Solar Energy. 69(4), 351–356.
[32] Fistola, R. and La Rocca, R.A. (2014) The Sustainable City and the Smart City: measuring urban entropy first. The Sustainable City. IX, 537-548.
[33] Bai, X. (2016) Eight energy and material flow characteristics of urban ecosystems. Ambio. 45, 819–830.
[34] Girginkaya Akdag, S. and Bostanci, S.H. (2013) The ımpacts of prestıge projects on the skylıne of Istanbul. International Journal of Architectural Research. 7(2), 269-281.
[35] Zhang, F., Yao, L., Zhou, W., You, Q. and Zhang, H. (2020) Using Shannon Entropy and Contagion Index to Interpret Pattern Self-Organization in a Dynamic Vegetation-Sand Model. IEEE Access. 8, 17221-17230.

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