Proceedings of the 6th International Conference on Statistics: Theory and Applications (ICSTA'24)
Barcelona, Spain – August 19 - 21, 2024
Paper No. 160
DOI: 10.11159/icsta24.160

The Statistical Assessment of Variables Affecting Conservation Condition for Historic Houses

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Abstract – Conservation condition is the structural state of a historic building at a particular time. This study aims to determine the variables affecting conservation condition of heritage buildings in historic urban sites. The methodology includes selection of the case study, site survey and listing of historic house characteristics with conventional tools of architectural conservation, and determination of variables affecting their conservation condition with statistical tools. The houses in a portion of Kuyulu neighborhood, and in a portion of Kurtuluş Street, presenting variety in terms of built heritage characteristics in Antakya historic urban site, which experienced a destroying earthquake sequence in 2023, were focused on. The dataset prepared in 2019 site survey is examined by T-tests, ANOVA, regression, and exploratory spatial data analysis statistical tools. As a result, construction technique, land use, and number of storeys were determined as significant variables affecting conservation condition. While addressing abandonment issues and considering both commercial and residential functions for adaptive reuse can positively affect conservation conditions, it is crucial to recognize buildings with combined construction systems show a negative effect on conservation condition which should not be preferred in future constructions and need priority for consolidation interventions. Meanwhile, the construction period and alterations are revealed as insignificant variables on conservation condition. The study concludes that systematic planning, guided by statistical insights, can prioritize interventions and enhance positive variables corresponding to the heritage qualities that have positive impact on conservation condition while mitigating negative ones, thus ensuring the preservation of historic urban sites.

Keywords**:** Historic urban site, historic buildings, conservation condition, T-test, ANOVA, regression analysis, exploratory spatial data analysis, Antakya.

1. Introduction

Historic urban sites are precious components of modern cities, exemplifying periodic development and unique settlement patterns, construction techniques, and lifestyles that existed in the past. The conservation of these sites requires careful analysis of their authentic characteristics and also conservation condition. Firstly, the dataset should be gained by site surveys revealing knowledge on different characteristics of the historic buildings such as construction technique, land use, number of stories, alterations, and conservation condition. The structural state of a historic building at a particular time is identified as conservation condition [1]. Among these characteristics, the conservation condition can be distinguished as the dependent variable affected by the other building characteristics, which are independent variables since they have been shaped by the old or contemporary users, building masters, local administrations, etc. The catastrophic earthquakes experienced in Antakya in 2023, and the disappearance of many cultural heritage buildings exemplify the importance of conservation condition variable for the sustainable existence of heritage. Understanding which building characteristics significantly impact the conservation condition will help shape the intervention decisions.

To uncover the comparison of different variables, statistical methods like T-test and ANOVA can provide scientific insight. The T-test helps compare the mean values of two distinct groups. When there are more than two groups to be compared, ANOVA analysis is required. These two analyses reveal the initial results of the assessment. The regression analysis shows the relationship between multiple variables and one dependent variable. This analysis is used in different disciplines like engineering [2], mathematics [3], economy [4], and architecture [5]. Therefore, the regression analysis type provides the core end result for the case to determine the effects of different building characteristics on the conservation condition. Additionally, the Exploratory Spatial Data Analysis-Univariate Local Moran I provides the opportunity to make

visual clustering assessments on the examined main variable. This analysis type is also used in different disciplines, such as social sciences [6], engineering, and urban studies [7]. For example, in urban studies, it explains whether there is a tendency to cluster for the same variable or whether it is randomly located within the area. In light of these, the study aims to evaluate the relationship between the conservation condition of historic houses and their building characteristics such as construction technique, land use, construction period, number of storeys and alterations.

2. Method

The methodology of the study covers selection of a site: a portion in Kuyulu Neighbourhood, containing 53 houses representing the Ottoman housing architecture in Antakya historic centre, and a portion on Kurtuluş Street, which has 17 houses representing the French Period. Within the limits of this study, the site survey data gathered in 2019 was used for statistical analysis. The dataset on the inventory sheets, which was in form of descriptive knowledge, was converted into numerical representations. Then, statistical analysis was carried out in different software such as Excel, SPSS, and GeoDa, and the results were compared and interpreted.

In the first stage, conservation condition, construction technique, land use, construction period, number of storey, and alterations qualities were listed for the 70 buildings. While conservation condition is the dependent variable, the other variable types are independent. There are two types of construction techniques: Combined (masonry walls and reinforced concrete slab supported with I beams) system and masonry system. For land use, residential, commercial, and abandoned types are possible. For the period, Ottoman and French types are possible. For the number of storeys, one, two, or three-storey types can be seen. Lastly, the alterations are categorized into four with no alteration, changes in architectural element scale, changes in mass scale like storey/mass/roof loss or addition, and changes in both mass and architectural element scale. For conservation condition; good, moderate, poor and ruin were defined as the types (Figure 1).

	Building Numbers	Conservation Condition	Construction Technique	Land Use	Construction Period	Number of Storeys	Alterations
KURTULUŞ STREET	Building 2	Poor	Type 1(combined):	Abandoned	French Period(1918-1938)	2 storey	Architectural element scale change
	Building 3	Moderate	Type 1(combined):	Abandoned	French Period(1918-1938)	2 storey	Mass and architectural element scale change
	Building 4	Good	Type 2(masonry):	Commercial	French Period(1918-1938)	Single storey	Mass scale change
	Building 16	Ruin	Type 1(combined):	Abandoned	French Period(1918-1938)	2 storey	Architectural element scale change
KUYULU NEIGHBOURHOOD	Building 24	Ruin	Type 2(masonry):	Residential	Ottoman Period (before 19th century)	Single storey	No alteration
	Building 27	Poor	Type 2(masonry):	Residential	Ottoman Period (before 19th century)	2 storey	Mass scale change
	Building 29	Moderate	Type 2(masonry):	Residential	Ottoman Period (before 19th century)	3 storey	Mass scale change
	Building 33	Good	Type 2(masonry):	Residential	Ottoman Period (before 19th century)	Single storey	Mass and architectural element scale change

Fig. 1: A descriptive dataset sample for the classification of heritage characteristics with examined building locations on sites [8].

In the second stage, the type descriptions of each variable are converted into numeric representations. For conservation condition variable, scaling of types from 1 to 4 is preferred: Good (4), moderate (3), poor (2), and ruin (1). For construction techniques variable, combined and masonry system types are converted to 1 and 2, respectively. The three types of land use that are residential, commercial, and abandoned, are listed on three separate columns in a table, and the existence (1) or non-existence (0) of the related function within each building is represented by 1 and 0 dummy numbers. For the number of storeys, one, two, and three storey building types were attributed 1, 2 and 3, respectively. In the period, the French and Ottoman types are represented by 1 and 2. For the alteration variable, a scaling strategy from 1 to 4 is chosen: No alteration (4), element change (3), mass change (2), and both mass and element change (1). When matching numbers with values, a hierarchy is considered from positive to negative, going from largest to smallest. Lastly, coordinate data gained from Google Earth (2019) is also added to the numeric dataset table to be used in Exploratory Spatial Data Analysis.

Since the conservation condition is the dependent variable, the effect of construction technique, land use, and period on it is examined by T-test in Excel software using the numeric dataset. As the type, one-tailed distribution and two-sample unequal variance (heteroscedastic) are selected. The gained p-value shows the significance of each variable on the conservation condition. If the p-value is under 0.1, the parameter is evaluated as significant. Furthermore, if it is under 0.01, the parameter is very significant. ANOVA analysis is preferred for the number of storeys and alterations variables because they have more than two types. Within this analysis, the control of the p-value once again shows whether the independent variable is significant on the dependent variable or not.

In the next stage, regression analysis is applied in the SPSS software, considering all types relevant for each variable: Construction technique, land use, number of storeys, construction period and alterations. Conservation condition is selected as the dependent variable. The p-value control shows the significance level of each parameter. If it is under 0.1, the variable is admitted as significant. The gained coefficient value symbol can give information about whether the independent variable affects the dependent variable in a positive or negative way. If it is minus (-), there is a negative impact on the dependent variable, and if it is plus (+), a positive impact on the dependent variable exists.

As the last analysis, ESDA (Exploratory Spatial Data Analysis-Univariate Local Moran I) is carried out using GeoDa software. After the shapefile (.shp) containing the dataset and coordinate knowledge of buildings are opened in GeoDa, the selection of the Univariate Local Moran I analysis type generates a significance map, cluster map, and Moran scatter plot. Within the analysis, the conservation condition is selected as the first variable, and the results show whether there is significant clustering for the similarly conditioned buildings or if they are spread randomly in the site.

After all statistical analyses are completed, the final interpretations for the statistically significant and insignificant variables are determined as the end results. These outcomes can help identify the main variables affecting the conservation condition of historic buildings and be a direct guide in the prioritization of interventions for the conservation of historic urban sites of Antakya and similar cases.

3. Results & Discussion

Results of T-test, ANOVA, regression analysis, and ESDA analysis are presented one by one.

3.1. T-test

The p-value for construction technique and conservation condition T-test is 0.02. Therefore, the construction techniques have a significant effect on conservation condition. Since the conservation condition value average is lower for combined technique compared to masonry, the combined technique has a negative impact on conservation condition.

For land use and conservation condition T-test, all types have a p-value lower than 0.01, leading up to very significant results. This shows that all function types are effective on the conservation condition. The commercial and residential functions have average values higher than 3, covering moderate-good condition levels, so these functions positively affect the conservation condition. However, the average of abandoned is between poor and moderate levels, validating that abandonment leads to structural deterioration and problems.

For the construction period and conservation condition T-test, the p-value is 0.15, so this parameter is not a significant factor for the conservation condition. However, the French Period buildings are in worse condition compared to the Ottoman period ones, with a small conservation condition average difference between them (Figure 2).

	Construction Technique
Average for Combined	2.67
Average for Masonry	3.22
T-test (p value)	0.02

	Period
Average for French Period	2.88
Average for Ottoman Period	3.17
T-test (prob.)	0.15

	Residential	Commercial	Abandoned
Average for non-existence	2.74	3.07	3.26
Average for existence	3.24	4.00	2.59
T-test (prob.)	1.1724E-33	8.84703E-39	8.1049E-40

Fig. 2: The T-test results for construction technique, land use, and construction period.

3.2. ANOVA

In the ANOVA analysis for the number of storeys, the p-values are higher than 0.1, so the number of storeys is not a significant variable for the conservation condition. Similarly, for the alterations, the p-values are higher than 0.1; therefore, despite there are a number of interventions, alteration is not a significant factor on the conservation condition (Figure 3).

ANOVA For Number of Storeys

	N	Mean	Std. Deviation	Std. Error	Interval for Mean Lower Bound	Interval for Mean Upper Bound	Minimum	Maximum
1,00	21	2.8095	1.20909	.26385	2.2592	3.3599	1.00	4.00
2,00	46	3.2174	.86700	.12783	2.9599	3.4749	1.00	4.00
3,00	3	3.3333	.57735	.33333	1.8991	4.7676	3.00	4.00
Total	70	3.1000	.98024	.11716	2.8663	3.3337	1.00	4.00

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.569	2	1.285	1.350	.266
Within Groups	63.731	67	.951		
Total	66.300	69			

ANOVA For Alterations

	N	Mean	Std. Deviation	Std. Error	Interval for Mean Lower Bound	Interval for Mean Upper Bound	Minimum	Maximum
1,00	9	3.7778	.44096	.14699	3.4388	4.1167	3.00	4.00
2,00	13	3.0000	.91287	.25318	2.4484	3.5516	1.00	4.00
3,00	13	2.7692	1.01274	.28088	2.1572	3.3812	1.00	4.00
4,00	35	3.0857	1.03955	.17572	2.7286	3.4428	1.00	4.00
Total	70	3.1000	.98024	.11716	2.8663	3.3337	1.00	4.00

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.694	3	1.898	2.067	.113
Within Groups	60.606	66	.918		
Total	66.300	69			

Fig. 3: ANOVA analysis results for the number of storeys and alterations.

3.3. Regression Analysis

Regression analysis was conducted to further demonstrate the effects of the variables on the conservation condition. Therefore, the dependent variable is the conservation condition in regression analysis. Abandonment has a significant negative effect on conservation condition. Meanwhile, land use as commercial function has a positive significant effect. Results showed that alterations and period do not significantly affect the dependent variable condition.

Although the number of storey variable in the ANOVA test has been found as insignificant for the conservation condition, the regression analysis shows that it is a significant variable for the conservation condition. The higher the building is, the better the conservation condition of it. Generally, the higher buildings are with storey addition and maintained by the user. Therefore, the better conservation condition of higher buildings can be related with land use as well.

The construction technique also has a significant impact on the conservation condition. As detected in the T-test, the masonry system has a positive impact, while the combined system creates low conservation condition performance (Figure 4).

Dependent Variable: CONDITION
Method: Least Squares
Date: 12/22/23 Time: 11:39
Sample(adjusted): 1 70
Included observations: 70 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ABANDONED	-0.460474	0.271929	-1.693357	0.0953
ALTERATIONS	-0.115494	0.098805	-1.168911	0.2468
COMMERCIAL	1.172530	0.701895	1.670520	0.0998
PERIOD	0.078140	0.321487	0.243059	0.8087
STOREY	0.493605	0.215466	2.290868	0.0253
TECHNIQUE	0.624466	0.314761	1.983937	0.0516
C	1.418705	0.882702	1.607230	0.1130

R-squared	0.228325	Mean dependent var	3.100000
Adjusted R-squared	0.154833	S.D. dependent var	0.980240
S.E. of regression	0.901164	Akaike info criterion	2.724379
Sum squared resid	51.16203	Schwarz criterion	2.949229
Log likelihood	-88.35328	F-statistic	3.106771
Durbin-Watson stat	1.323669	Prob(F-statistic)	0.009925

Fig. 4: Regression analysis results.

3.4. ESDA (Exploratory Spatial Data Analysis)

Within the GeoDa software, the Univariate Local Moran's analysis is carried out by selecting the first variable as the conservation condition. Significance map, cluster map, and Moran scatter plot outcomes are gained, and the results show no significant clusters, as shown in the Moran Scatter Plot (Figure 5).

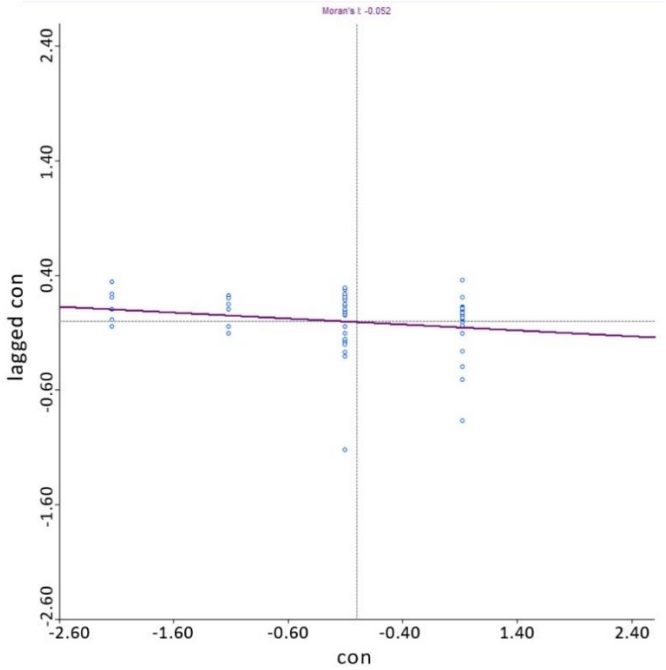

Fig. 5: Moran Scatter Plot graph of ESDA

The significance maps for Kuyulu Neighbourhood and Kurtuluş Street are shown in Figure 6. In the Kuyulu Neighbourhood, at three spots; and on Kurtuluş Street, at one spot, there are exceptionally significant areas with p=0.05 value pointing cluster existence (Figure 6).

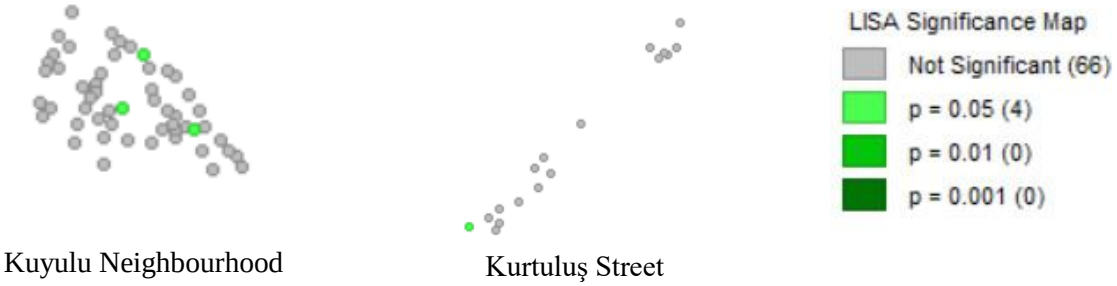

Fig. 6: Significance maps for Kuyulu Neighbourhood and Kurtuluş Street

The cluster maps for Kuyulu Neighbourhood and Kurtuluş Street are shown in Figure 7. In Kuyulu Neighbourhood, one red-dotted spot shows the good condition for structures, and two light-blue dotted spots exemplify areas that are close to poor condition. On Kurtuluş Street, one area close to good condition exists, represented by light red.

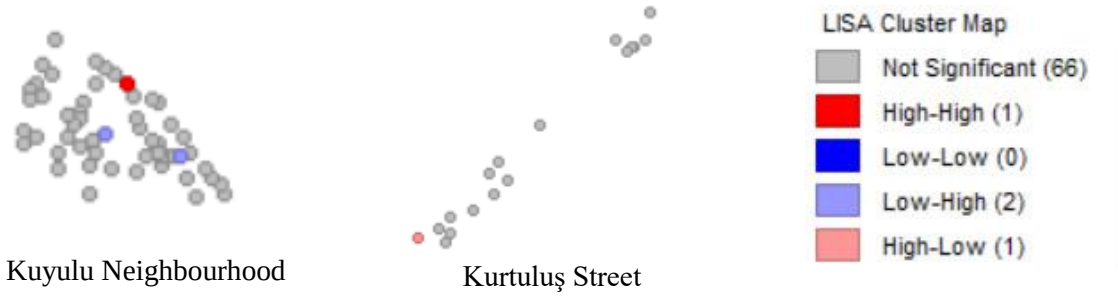

Fig. 7: Cluster maps for Kuyulu Neighbourhood and Kurtuluş Street

As a result of ESDA analysis, there is no significant clustering of similarly conditioned structures within the sites, and they are spread randomly without clustering in general.

4. Conclusion

Preservation of historic urban sites necessitates the consideration of various variables that contribute to their authentic characteristics. Among these, the conservation condition is the dependent variable, while construction technique, land use, period, number of storeys and alterations are the independent ones. Through a series of analyses, including T-tests, ANOVA, regression, and ESDA (Exploratory Spatial Data Analysis), several key conclusions have been drawn:

- Significant variables affecting conservation condition are construction technique, land use, and number of storeys. Specifically, structures built using the masonry system tend to exhibit better conservation conditions, while those employing a combined system demonstrate lower average values. Regarding land use, commercial and residential functions positively influence conservation condition, whereas abandonment has a detrimental effect. Additionally, an increase in the number of storeys correlates with the improved conservation condition.
- Conversely, the period and alterations variables were found to be statistically insignificant in relation to conservation condition.
- Notably, buildings categorized as being in good, moderate, poor, or ruin condition are distributed randomly throughout the sites without forming distinct clusters.

Based on the core results, the houses constructed with a combined system have priority for structural consolidation interventions since they negatively affect the conservation condition and this structural system type should not be preferred in post-earthquake reconstructions. Furthermore, the abandonment problem should be resolved, and both commercial or residential functions can be sustained in the sites since both positively affect conservation condition. While alterations do

not directly affect conservation condition, they can indirectly influence it through their relationship with land use and thus cannot be overlooked.

It is crucial to recognize that heritage buildings embody more than just physical stability; they hold significant contextual values. Therefore, during interventions, these values should not be only acknowledged but actively incorporated in the design and execution regarding alterations for the refunctioning processes [9]. Moreover, the condition of a historic building is influenced by a series of factors beyond the examined variables despite their prominence. These variables extend beyond tangible characteristics but include environmental and natural aspects as well [10]. In the case of Antakya, the devastating earthquakes of 2023 resulted in the widespread destruction of a significant portion of its built heritage due to their magnitude. In such extraordinary events, statistical research becomes imperative to provide updated insights to direct interventions and requires further fieldwork and analysis.

The development of this information regarding the statistical analysis of the relevant variables on conservation conditions needs to be further supported through the utilization of advanced data collection by digital means, periodic monitoring, and non-destructive testing that allows the assessment of masonry structures [11]. In conclusion, statistical evaluations enable systematic planning for the preservation of historic urban sites. This approach facilitates the establishment of priorities and emphasizes the enhancement of characteristics that positively contribute to the integrity of sites, while highlighting the impact of those that have a negative effect. By employing this methodical approach, preservation efforts can be tailored effectively to safeguard cultural heritage.

Acknowledgements

The authors would like to thank Prof. Dr. Hasan Engin Duran for his methodological suggestions in the development of the study.

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