International Journal of Humanities and Social Science Invention (IJHSSI)
ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714
www.ijhssi.org ||Volume 12 Issue 9 || September 2023 || PP. 05-08

Development and validation of a tool for tree risk assessment in the urban environment: Statistical tests of reliability and validity

Vassios Dimitrios
Electrical Engineer Forester M.Sc. Ph.D., Municipality of Thessaloniki, Greece
Corresponding Author: Vassios Dimitrios

ABSTRACT: *Urban greenery leads to the sustainable development of cities through the interaction of a number of factors. However, in many cases trees show various structural defects and deviations from their typical shape, a fact that made them dangerous. The objective of the study is to develop and validate a tool for tree risk assessment in the urban environment. The tool includes 7 variables related to structural defects, deviations from standard shape, age, robustness, crown and also, height to breast diameter ratio. The specific tool can be a useful "weapon" in the hands of geotechnical municipal officers regarding the risk assessment of trees that growing in the cities, as well as for making the appropriate management decisions. The results are highly encouraging, but the procedures must be repeated on suitable samples of urban trees, in order to revalidate the tool and make possible improvements.*

KEY WORD*: Urban greenery, tree risk assessment, Thessaloniki*

Date of Submission: 20-08-2023 Date of Acceptance: 04-09-2023

I. INTRODUCTION

Urban greenery leads to the sustainable development of cities through the interaction of a number of factors, namely the social context, the management objectives, the means, the management's results and the various information (Dwyer et al, 2003). However, in many cases trees show various structural defects and deviations from their typical shape, a fact that made them dangerous e.g. in adverse weather conditions (Tsoumis, 1991; Kane, 2008; Kontogianni et al., 2011). In order to assess the risk of trees, many studies have been carried out (Kolarik, 2003; James et al., 2006; Coder, 2007; Kontogianni et al., 2011) which however, require specialized knowledge and instruments, while generally being time-consuming.

II. RESEARCH OBJECTIVES

The objective of the study is to develop and validate, through reliability and validity testing, a tool for tree risk assessment in the urban environment, mostly on sidewalks. With this tool, the assessment can be done quickly and easily without the use of specialized and complex instruments, but macroscopically and visually. The conditions for trees in the cities are particularly difficult, while the possibilities for intervention mainly concern pruning, or in some cases even cutting.

III. RESEARCH METHODOLOGY AND DATA ANALYSIS

The tool includes 7 relatively easily assessable and measurable variables related to structural defects, deviations from standard shape, age, robustness, crown and also, height to breast diameter ratio (slenderness index). Variables are measured on an ordinal scale of 1 to 5. 1 corresponds to findings of zero/negligible risk, 2 to findings of mild risk, 3 to findings of moderate risk, 4 to findings of high risk, while 5 to findings of very high risk. Further information and instructions are given for the convenience of the evaluator for slope, age and height to diameter ratio. The sum of the score of each variable constitutes the total risk score of each tree (VAR8). From a score of 15 and above, interventions on the tree are considered, from mild pruning to cutting, always depending on the individual score and in combination with the overall macroscopic image of the tree, the species, the total growth space and the general conditions as well.

A total of 101 trees (elms/*Ulmus* sp.) growing on Stratou Avenue were evaluated. Stratou Avenue is a central road of the Municipality of Thessaloniki and most of the trees show strong defects and deviations mainly due to the chronic infestation by the *Galerucella luteola* insect. The evaluations of the trees were carried out in August 2023.

Data handling and analyses were conducted using the IBM SPSS Statistics 21. More specifically, statistical analysis included:

Descriptive statistics. Descriptive statistics deal with methods of organizing and presenting data (Anderson & Finn, 1996).
Reliability. The reliability of a questionnaire relates to the consistency with which it measures the concept that it claims to measure. One of the most common reliability coefficients is Cronbach's alpha (Bland & Altman, 2002).
Validity. The term validity refers to whether a questionnaire measures what it is intended to measure and how well it measures (Babbie, 2011).
Categorical regression. Categorical regression quantifies categorical variable data by assigning numerical values to the categories for the purpose of the best linear regression of the transformed variables (Van der Kooij and Meulman, 1997). With categorical regression it is possible to predict values of a dependent variable for any combination of independent variables (Androulidakis and Siardos, 1999).

IV. FINDINGS

Descriptive statistics:

The ratings of 101 trees are presented in total in Table 1.

Variable	1	2	3	4	5
	Percentage (%)				
Cavities (VAR1)	68.3	6.9	22.8	2.0	0.0
Crown asymmetry/crown size (VAR2)	27.8	45.5	25.7	1.0	0.0
Other defects (bend/warp, forks, twists, base swelling, etc.) (VAR3)	9.9	67.3	22.8	0.0	0.0
Vitality/robustness (VAR4)	4.0	56.4	34.6	5.0	0.0
Deviation from the vertical axis (VAR5)	69.3	27.7	3.0	0.0	0.0
Age (VAR6)	1.0	36.6	62.4	0.0	0.0
Height to breast diameter ratio (H/D) (VAR7)	13.9	44.5	41.6	0.0	0.0

Table 1: Trees' ratings

The total score's (VAR8) histogram and box plot are depicted in Figure 1.

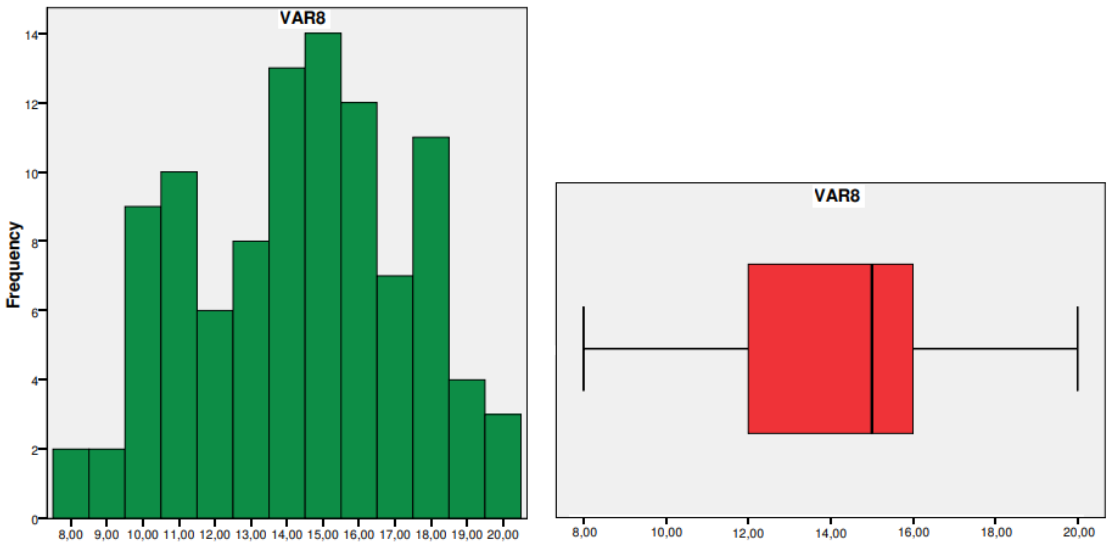

Figure 1: Histogram and box plot

Reliability analysis:

The entire questionnaire has a Cronbach's alpha coefficient of 0.759.

Construct validity:

The construct validity check was performed by using the Factor Analysis. The extraction of factors was done by Principal Component Analysis and the rotation of the axes by Varimax Method. The analysis met the appropriate factorization criteria (KMO, Bartlett's Test of Sphericity, Communalities). A 3-dimensional solution (3 factors), gave characteristic values of 2.125, 2.010 and 1.359 respectively, which state that 30.36% of the

explained variance is explained by the first factor, 28.72% by the second and 19.41% by the third, accounting for 78.49% of the total explained variance. The loads of the factors are presented in Table 2. The first factor can be called "Dimensions & asymmetries", the second "Robustness/health" and the third "Deviations & structural defects". For the sake of brevity and ease of processing, the three factors were given the abbreviations F1, F2 and F3 respectively and will henceforth be used in the text.

Variable	Factor		
	1	2	3
VAR1		0.899	
VAR2	0.839		
VAR3			0.673
VAR4		0.905	
VAR5			0.915
VAR6	0.722		
VAR7	0.912		

Table 2: Factors' loads

Categorical regression:

In this analysis, the 3 factors are the independent variables while the total score is the dependent variable. Categorical regression yielded a multiple correlation coefficient R value of 0.981 and a multiple determination coefficient R^2 of 0.961 indicating that 96.1% of the variance in the transformed values of the dependent variable is explained by the transformed values of the independent variables. The analysis of variance for a significance level α equal to 0.05 gave an F value equal to 805.747 which corresponds to a zero significance level, showing the very good fit of the model to the data.

At a significance level 0.05, the absence from the equation of each variable separately, with the presence of the others, reduces the exploratory capacity of the equation as all variables are statistically significant (sig<0.001). The standardized regression coefficients are all positive and relatively high. The third factor has a slightly smaller coefficient. Table 3 presents the standardized coefficients along with the F values.

	Standardized Coefficients	df	F	Sig.
	Beta			
F1	,588	1	213,712	0,000
F2	,594	1	200,409	0,000
F3	,399	1	181,907	0,000

Table 3: Standardized coefficients and F values

Of the correlation coefficients, all are positive while somewhat smaller than the others is the one corresponding to the third factor (zero-order and part). Regarding importance, the third factor has a lower value. Regarding tolerance, high values are observed in all three factors. Table 4 presents the zero-order correlation coefficients, partial correlation coefficients, part correlation coefficients, importance and tolerance values of the independent variables.

	Correlations			Importance	Tolerance
	Zero-Order	Partial	Part		
F1	,660	,948	,585	,404	,990
F2	,655	,949	,592	,405	,993
F3	,462	,897	,398	,192	,994

Table 4: Correlations, importance and tolerance

The transformation plots of VAR8, F1, F2 and F3, are depicted in Figure 2.

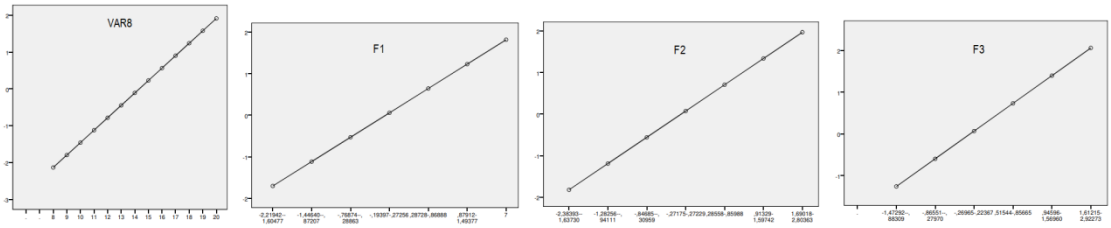

Figure 2: Transformation plots

As the factors increase, so does the total score (VAR8).

V. DISCUSSION

According to the results of the study, it appears that:

- Most trees (13.8%) have a score of 15, which is also the median. The data show some asymmetry towards the highest scores, while there are no outliers or extremes. The range is from 8 to 20. Only 3% have the highest score. On average, these trees show moderate risk findings in general. Half of them (50.5%) have a score of 15 and above, which means that some operations will have to be done on them, from mild to severe pruning mainly, while those with a high score should be scrutinized.

- The results are highly encouraging regarding the reliability and validity of the tool. More specifically, the tool shows satisfactory reliability, as well as 3 very distinct factors which strengthen its construct validity. The loadings of the original variables on each of the factors are high and positive, while each variable loads highly on only one factor. Furthermore, the 3 factors explain a very large percentage of the total variance. However, it would be useful to carry out other such records and evaluations on suitable samples of urban trees, to revalidate the tool and make possible improvements.

- Concerning the categorical regression, all 3 factors contribute greatly to the predictive ability of the model. As the factors increase, so does risk (VAR8). The third factor shows slightly less zero-order and part correlation and importance. Due to the very high R^2, combined with the total explained variance, the Beta coefficients, the correlations and the importance, the third factor could possibly be omitted from the model, without reducing its predictive ability.

- The specific tool can be a useful "weapon" in the hands of foresters and agronomists who deal with urban greenery regarding the risk assessment of trees that growing in the cities, as well as for making the suitable management decisions. Of course, the appropriate information and training of the staff should be preceded. It can also be used to educate students of geotechnical and environmental schools on structural defects and deviations from the standard shape of trees.

BIBLIOGRAPHY

[1]. Anderson, T, & Finn, J. (1996). The new statistical analysis of data. New York: Springer.
[2]. Androulidakis, S., & Siardos, G. (1999). Leadership ability dimensions as related to rural women's characteristics: A methodological approach for further consideration. In J. Kania and M. Dygar (Eds.), Proceedings of the 14th European Seminar on Extension and Education. Volume 1, August 30-September 4 (pp. 163-175). Poland: The Agricultural University of Cragow.
[3]. Babbie, E. (2011). Introduction to social research. Wadsworth: Cengage Learning.
[4]. Bland, J., & Altman, D. (2002). Validating scales and indexes. BMJ 2002, 324(7337), 606-607.
[5]. Coder, K. (2007). Storm wind loads on trees. University of Georgia and Warnell: Outreach Publication SFNR07-3.
[6]. Dwyer, J., Nowak, D., & Noble, M. (2003). Urban forests. Journal of Arboriculture, 29, 1, 49-55.
[7]. James, R., Haritos, N., & Ades, P. (2006). Mechanical stability of trees under dynamic loads. Am. J. Bot., 93(10), 1522–1530.
[8]. Kane, B. (2008). Tree failure following a windstorm in Brewster. Massachusetts, USA. Urban Forestry and Urban Greening, 7, 15-23.
[9]. Kolarik, J. (2003). The application of the static integrated approach for arboricultural practice. In: Proc. Workshop, Westonbirt, UK, July.
[10]. Kontogianni, A., Tsitsoni, T., & Goudelis, G. (2011). An index based on silvicultural knowledge for tree stability assessment and improved ecological function in urban ecosystems. Ecological Engineering, 37, 914-919.
[11]. Tsoumis, G. (1991). Science and technology of wood: Structure, properties, utilization. New York: Chapman and Hall.
[12]. Van der Kooij, A., & Meulman, J. (1997). MURALS: Multiple regression and optimal scaling using alternating least squares. In E. Faulbaum & W. Bandilla (Eds.), Softstat '97. Stuttgart: Lucius & Lucius.

Vassios Dimitrios. "Development and validation of a tool for tree risk assessment in the urban environment: Statistical tests of reliability and validity." *International Journal of Humanities and Social Science Invention (IJHSSI)*, vol. 12, no. 9, 2023, pp. 05-08. Journal DOI- 10.35629/7722