Comparative Mathematical Analyses Between Different Building Typology in the City of Kruja, Albania

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Abstract
The city of Kruja dates back to its existence from the 5th and 6th centuries. In the inner city are preserved great historical, cultural, architectural values that are inherited from generation to generation.
In the city interact and coexist three different typologies of dwellings: historic buildings that belong to the XIII, XIV, XV, XIII, XIX century (built using the foundations of previous buildings); socialist buildings dating back to the Second World War until 1990; and modern buildings which were built from 1990 onwards.
According to the questionnaires and the creation of mathematical models applied to each category will result contradictory attitudes but also fairy ones based on different percentages.
There are underlined 5 quality of life indicators(questions) from a total of 30 questions of the questionnaire, which are involved in mathematical regression and are statistically significant with a significance level $p<5\%$ (with a reliability of 95%), which interact for all three categories of buildings. The quality of life indicator: dwelling area, heating mode during winter, level of dwelling improvement, time spent in the dwelling, monthly electricity payments, are the main actors who will be compared in order to draw conclusions.

According to the statistical calculations trend, it is noted that socialist buildings category do not directly participate in the debate between historic and modern buildings by means of the quality of life indicators (questions).
Keywords: energy efficiency, mathematical models, occupancy behavior, physics characteristics of the buildings, quality of life indicators, social interaction.

I. INTRODUCTION

A. *Historical, topographical overview and existing situation*

The city of Kruja is a middle range city in Albania. The area of the city is 372km2 and the number of residents in the inner city is around 17000 [1].Known as the "white city" it is built in a sloppy terrain at an average altitude of 608 meters above sea level and when the weather is clear, from it you can

see the Adriatic coast from Durres to the discharge of the Buna River [2]. The castle of Kruja was built during the 5-th and 6-th century and extended to a town probably from the sixth to the ninth century AD. In 1190 Kruja became the first capital of middle age Albania [3].

The historical building are located in the inner citadel of the city. The socialist ones are located mostly in the center of the city

and the modern ones mostly in the outskirts and also in the center of the city. All of them date in different periods of time. This is a very good indication of the development of the city during time.

The historical buildings are positioned in the citadel which dates from XI century and some of the buildings where reconstructed after a big fire in the XVIII century, preserving the old ruins [4]. The socialist buildings date back after the Second World War (1945-1990) and the modern ones from 1990 onwards after the communist regime.

Figure 1 A (source: Google earth pro)

B (source: KlodjanXhexhi); C (source: KlodjanXhexhi)

B. Historical, topographical overview and existing situation

The built environment throughout history has been influenced and renewed by various factors, and innovations that have induced this development and have originated from either technological progress or social change. Today, however, climate change has added a new dimension, presenting our society with major challenges including a need to change how we define buildings [5].

Context is not only the surrounding environment. It is the manifold spatial, temporal, social, ecological and economic interdependencies within which the building exists [5].

Buildings consume up to 70% of the primary energy used in cities. Cities are paying greater attention to building energy efficiency in urban planning, and in meeting city goals for reduction of greenhouse gas (GHG) emissions [6].

The urban context, surrounding buildings and their direct individual effects on the building and their collective effects on the urban climate and microclimate (e.g., urban heat island effect) can strongly influence building energy use.

Modelling the energy use of a building, social interaction, occupancy behaviour, quality of life indicators, physics characteristics of the buildings of different categories and age requires a mathematical tool to mix them up. This paper is in search of a real and powerful collaboration of all three main groups of building in the city of Kruja.

C. *Historical, topographical overview and existing situation*

Buildings possessing similar characteristics are usually grouped together representing a large building stock and are named as archetypes [7].The archetypes are different buildings sharing similar characteristics in the stock [8].

Famuyibo proposed detailed statistical analysis methods for archetype developments which allows for a detailed representation of the overall building stock as compared to the traditional qualitative techniques. The author uses multi-linear regression analyses and descriptive statistics for the identification of the archetypes. The developed were representative of 65% of the population Irish house stock [7].

Lara used clustering and regression analyses approach to identify the most suitable parameters in the classification of a large sample of existing buildings [9].

The archetypes of this paper are the stock of building of all the three categories separately. The stocks of buildings for each category are sharing relatively similar characteristics.

II. METHODOLOGY FOR THE PROBABILITY MODELS

To evaluate the variables (questions) according to correlative and causal relationships in the econometric models, are applied binary models Log and Prob, and models for scaled variables Tobit.

These models were analysed to explain the correlation of the variables taken in the study, not only from the point of view of

correlative links such as bonding strength, but also to analyse the elasticity of scalable causative correlations of dependent variable from independent variables [10].

This methodology is applied to all the building categories (historical buildings, socialist buildings, and modern buildings). From the main table, (Fig.2) is picked the quality of life indicators (questions) which are statistically significant for the three categories of buildings. The other questions which are not part of the three categories will not be taken into consideration.

III. COMPARATIVE ANALYSES FOR HISTORICAL BUILDINGS, SOCIALIST BUILDINGS AND MODERN BUILDINGS

Mathematical models	Main questions	HISTORICAL BUILDINGS				
Model nr.1	P3	P1	P22	P18		
Model nr.2	P5	P23	P3			
Model nr.3	P18	P3	P11	P12	P13	P16
Model nr.4	P16	P18	P19	P3		
Model nr.5	P19	P11	P2			
		SOCIALIST BUILDINGS				
Model nr.1	P3	P11	P21			
Model nr.2	P5	P17	P22			
Model nr.3	P24	P6	P8	P17	P18	P23
Model	P7	P6	P1	P1		

nr.4			3	9		
		MODERN BUILDINGS				
Model nr.1	P3	P1	P18	P22		
Model nr.2	P8	P3	P22			
Model nr.3	P18	P3	P12	P13	P23	
Model nr.4	P19	P7	P10	P21	P23	
Model nr.5	P5	P8	P19	P23		

Figure 2. Statistically significant models of the main questionnaire for the three categories of Kruja's buildings

For historical buildings were asked 10 residents, for the socialist building were asked 14 residents and for the modern ones were asked 10 residents (year of interview 2015).

For the three categories there are in total 21 quality of life indicators (questions) out of 30 that correlate with each other for the three categories. The numbers of the questions (quality of life indicators) that are statistically significant for the three groups of buildings are only 5.
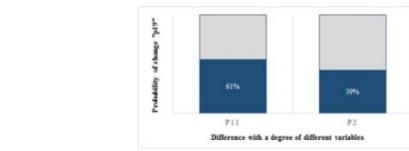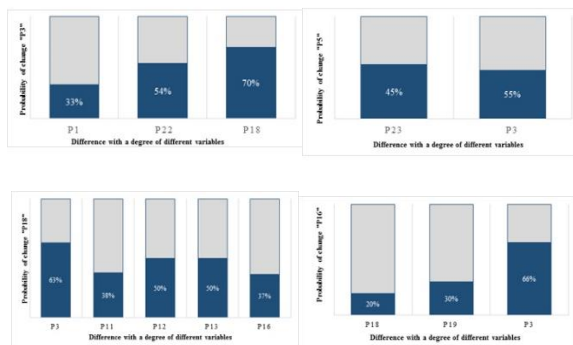

Figure 3. Historical buildings (evaluation models); source: by the author [11].
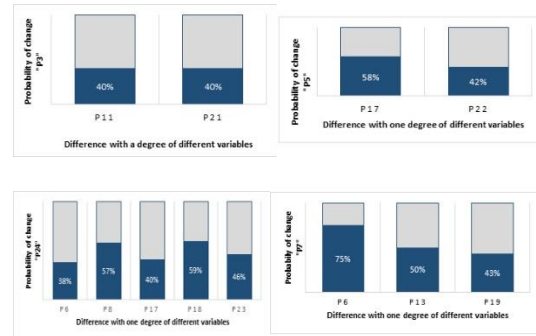

Figure 4. Socialist buildings (evaluation models); source: by the author.
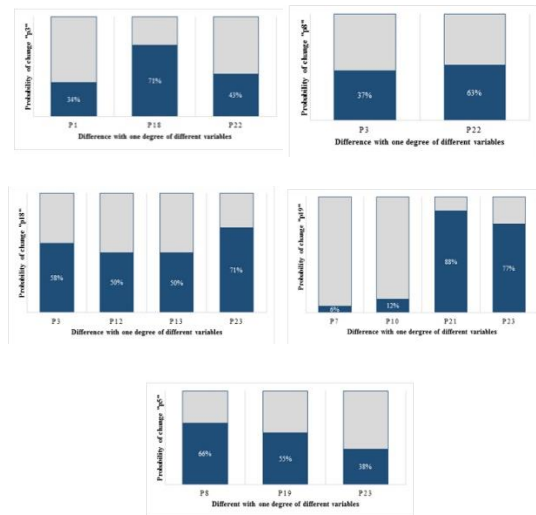

Figure 5. Modern buildings (evaluation models); source: by the author.

The quality of life indicators (questions) that participate in the three groups are: P3, P5, P18, P23, and P13. The questions(quality of life indicators) which are involved in Fig.2, P19 and P22 part of all three categories, are not statistically significant respectively P22 for the historical buildings and P19 for the

socialist building category, therefore thesequestions will not be part of further analysis. The main questions (quality of life indicators) interacts fairy or correlates negatively with the other questions with different percentages. If the secondary question (quality of life indicator) changes with one degree, the primary question will change with one degree with a probability showed in the figures below.

A. *Analyzing quality of life indicator P3*

The quality of life indicator P3 which is linked to the demand of space in the dwelling is correlated negatively with the number of residence. If the number of the residence increases, the indicator square meter / inhabitants will decrease [11]. This is valuable for historic buildings and modern ones with different percentages, meanwhile for the socialist buildings statistically doesn't make sense.

The current living condition will improve if there is improvement in the area of the dwelling [11]. Once again historical and modern building are sensitive to this issue meanwhile for the socialist ones this issue is not statistically significant.

Residence of the socialist buildings tell us that if the surface of the dwelling is reduced the demand for spending quality time in the apartment increases. As a consequence we will have a fair match with the other two categories of dwellings in accordance with the improvement of living conditions.

According to the mathematical regression model for modern building, the orientation of the dwelling is linked negatively with the area of the dwelling. If the surface is

reduced the need for a better orientation (from north-west to south-east) becomes bigger. The historical and socialist building statistically does not consider this issue.

QUALITY OF LIFE INDICATOR "P3"	HISTORICAL BUILDINGS (statistically significant questions of the questionnaire, 20 out of 30)	
WHAT KIND OF SPACES ARE INCLUDED IN THE APARTMENT ?	Fairy statistically linked	Negatively statistically linked
	Present living conditions 70% probability	Number of inhabitance 33% probability
	SOCIALIST BUILDINGS (statistically significant questions of the questionnaire, 16 out of 30)	
	Fairy statistically linked	Negatively statistically linked
		Time spent in the inner dwelling area, 40% probability
		Time spent with friends or family,

	40% probability
MODERN BUILDINGS (statistically significant questions of the questionnaire, 21 out of 30)	
Fairy statistically linked	Negatively statistically linked
Present living conditions 71% probability	Number of inhabitance 34% probability
	Orientation 43% probability

Figure 6. Quality of life indicator P3 responsible and statistically significant for the three categories of Kruja's buildings

B. Analyzing quality of life indicator P5

The quality of life indicator P5 which is liked with the heating mode during winter correlates negatively with the area of the apartment for historic buildings. In this case it is necessary to change or modify the heating instruments as the surface increases. It is also correlates negatively with the time spent in the dwelling. If the time spent in the dwelling increases this affect negatively to the heating instruments used in the dwelling. It is necessary to modify the heating instruments in order in order to get into the comfort zone [11]. Meanwhile for the socialist building the quality of life indicator P5 is fairy statistically significant with the

demand of painting the apartment within 5 years, and negatively statistically significant with the orientation from north-west to south-east.

For the modern buildings P5 is fairy statistically significant (according to the evaluation model) with the cooling facilities. If the demand for heating in the winter increases, also the demand for cooling in the summer time will be increased. P5 is also fairy linked to the improvement of the apartment in order to feel better. If the quality of heating mode increases the residents will feel better in their apartment. P5 is statistically negatively linked to the time spent in the living room. If the heating mode switches (negatively, reducing the quality of life) from electricity to gas the time spent in the living room will be decreased. This is a point in common with the historic buildings but with different percentages. The residents require an improvement in the living conditions.

QUALITY OF LIFE INDICATOR "P5"	**HISTORICAL BUILDINGS** (statistically significant questions of the questionnaire, 20 out of 30)	
HEATING MODE DURING WINTER	Fairy statistically linked	Negatively statistically linked
		Area of the apartment, 55% probability
		Time spent in the living room, 45%

	probability
SOCIALIST BUILDINGS (statistically significant questions of the questionnaire,16 out of 30)	
Fairy statistically linked	Negatively statistically linked
The demand of painting the apartment within years, 58% probability	Orientation, 42% probability
MODERN BUILDINGS (statistically significant questions of the questionnaire,21 out of 30)	
Fairy statistically linked	Negatively statistically linked
Cooling facilities, 55% probability	Time spent in the living room, 38% probability
Apartment improvements, 55%probablity	

Figure 7. Quality of life indicator P5 responsible and statistically significant for the three categories of Kruja's buildings

C. Analyzing quality of life indicator P18

For historical buildings the area of the apartment is fairy linked to the living conditions [11]. This issue is available also for the modern buildings, but with different percentage of performance. Also the time spent in the dwelling correlates negatively with the present living conditions for both categories.

Meanwhile monthly electricity payment is fairy linked to the present living conditions for the historical buildings and negatively linked for the modern ones. For socialist buildings the need of changing the apartment is statistically significant and fairy linked to the present living condition. This indicates that the residents are dissatisfied with the current conditions of the apartment.

QUALITY OF LIFE INDICATOR "P18"	**HISTORICAL BUILDINGS** (statistically significant questions of the questionnaire, 20 out of 30)	
ARE YOU SATISFIED WITH THE PRESENT LIVING CONDITIONS?	Fairy statistically linked	Negatively statistically linked
	Area of apartment,63% probability	Time spent in the inner dwelling area, 38% probability
	Monthly electricity payments, 50% probability	Home restoration, 37% probability
	SOCIALIST BUILDINGS (statistically significant questions of the questionnaire,16 out of 30)	
	Fairy statistically linked	Negatively statistically linked

Change of residence with a better one, 59% probability	
MODERN BUILDINGS (statistically significant questions of the questionnaire,21 out of 30)	
Fairy statistically linked	Negatively statistically linked
Area of apartment, 56% probability	Monthly electricity payments, 50% probability
Monthly water payments, 50% probability	Time spent in the living room, 71% probability

Figure 8. Quality of life indicator P18 responsible and statistically significant for the three categories of Kruja's buildings

D. Analyzing quality of life indicator P23

Once again for the two categories (historical and moderns buildings) the quality of life indicator P23 is negatively statistically significant with the heating mode during winter. If the time spent in the dwelling increases this will effect negatively the heating instruments in the inner dwelling. This will cause a decrease in the quality of heating instruments, reducing the quality of life, for historical buildings from wooden stove to gas [11] and for the modern ones (reducing the quality of life) from electricity

to gas.The residents requires to be included in the comfort zone, even if the quality of life decreases.

For the socialist buildings this indicator is not statistically significant. Time spent in the living room for the socialist group is negatively liked with the need to change the apartment. Meanwhile for the modern buildings if the residents spend more time in the living room the need for apartment improvements and the level of satisfaction will be improved.

QUALITY OF LIFE INDICATOR "P23"	**HISTORICAL BUILDINGS** (statistically significant questions of the questionnaire, 20 out of 30)	
	Fairy statistically linked	Negatively statistically linked
HOW MUCH TIME DO YOU SPENT IN THE LIVING ROOM?		Heating mode during winter, 45% probability
	SOCIALIST BUILDINGS (statistically significant questions of the questionaire,16 out of 30)	
	Fairy statistically linked	Negatively statistically linked
		Change of residence with a better one,

	46% probability
MODERN BUILDINGS (statistically significant questions of the questionnaire,21 out of 30)	
Fairy statistically linked	Negatively statistically linked
Present living conditions, 50% probability	Heating mode during winter, 38% probability
Apartment improvements, 77% probability	

Figure 9. Quality of life indicator P23 responsible and statistically significant for the three categories of Kruja's buildings

E. Analyzing quality of life indicator P13

The present living condition correlates fairy for the historical buildings and negatively for the modern ones with the quality of life indicator P13 (monthly electricity payment). If the monthly bill of electricity is higher the level of satisfaction is bigger for the historical building category [11]. Meanwhile modern building residents translate this effect differently. This is much related also to the current physic condition of the dwelling and also related to the economic issues. If the electricity bill increases the quality of life will be decreased. These are two different considerations for residents of both categories. Socialist buildingsdo not participate at this debate. They prefer to be present with the presence of moisture which is fairy linked to the monthly electricity bills.

QUALITY OF LIFE INDICATOR "P13"	**HISTORICAL BUILDINGS** (statistically significant questions of the questionnaire,20 out of 30)	
	Fairy statistically linked	Negatively statistically linked
	Present living conditions, 50% probability	
	SOCIALIST BUILDINGS (statistically significant questions of the questionnaire,16 out of 30)	
WHAT IS YOUR MONTHLY PAYMENT FOR ELECTRICITY?	Fairy statistically linked	Negatively statistically linked
	The presence of moisture, 50% probability	
	MODERN BUILDINGS (statistically significant questions of the questionnaire,21 out of 30)	
	Fairy statistically	Negatively statistically

	linked	linked
		Present living conditions, 50% probability

Figure 10. Quality of life indicator P13 responsible and statistically significant for the three categories of Kruja's buildings

CONCLUSIONS

According to the present statistical calculations trend on questionnaire, it is noted that socialist buildings category do not directly participate in the debate (dance) between historic and modern buildings by means of the quality of life indicators (questions). In this context these buildings are rather statistically separated from the other two groups despite being part of the history of the city of Kruja and also being an inseparable part of them. According to previous studies the socialists building group has also shown to be the most unsocial (unfriendly) that the other two categories. The other two groups, the historical and modern ones correlate statistically (fairly or negatively) with each other many times expressing different views of interpretation, and represent themselves as the main actors in the city.

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