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Mathematical Evaluation Methodology Among Residents, Social Interaction and Energy Efficiency, For Socialist Buildings Typology, Case of Kruja (Albania)

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Article Info
Volume 83
Page Number: 17005 - 17020
Publication Issue:
March - April 2020

Abstract
Socialist buildings in the city of Kruja (Albania) date back after the Second World War between the years 1945-1990. These buildings were built during the time of the socialist Albanian dictatorship and the totalitarian communist regime.
A questionnaire with 30 questions was conducted and 14 people were interviewed. The interviewed residents belong to a certain area of the city of Kruja. Based on the results obtained, diagrams have been conceived and mathematical regression models have been developed which will serve as a base for drawing conclusions.
The purpose of this study is to find a relationship that specifies the role of the inhabitants, the role of the dwellings, the physical-mechanical characteristics and their energy efficiency, in order to improve the living conditions of the inhabitants.
The independent variables interact with each other assuming positive or negative values depending on the probabilistic mathematical regression, giving different results based on the calculated data. The variables that co-exist among them are: living space, quality of life, time spent at home, social interaction of residents, dwelling humidity level, dwelling orientation, satisfaction level of the inhabitants, dwellings improvements demand , monthly electricity bills..

Article History
Article Received: *24 July 2019*
Revised: *12 September 2019*
Accepted: *15 February 2020*
Publication: *28 April 2020*

Keywords: *mathematical models, occupancy behavior, physics characteristics of the socialist buildings, social interaction.*

I. INTRODUCTION

A. Historical, topographical overview and existing situation

Socialist buildings in the city of Kruja (Albania) date back after the Second World War (1945-1990) the period of the totalitarian communist regime specifically between the years 1960-1970.

B. The site is located in the inner part of the city.

The groups of the buildings are not part of any historical value or any preservation

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policy. These buildings were built considering the socialist slogan standardization, and typification. The aim was to reduce the constructioncost of the dwellings.

Figure 1 The city of Kruja, A [source: Google earth]; B [Orthophoto, source: Gis Albania]; C [source: KlodjanXhexhi];D [https://www.google.al/search?q=kulla+e+veriut&source]

From the architectural point of view these dwellings have much in common with the typical north Albanian tower. The upper part resemble very much to the windows of the typical northern Albanian tower. The buildings are located in a sloping terrain and the urban situation is a well-defined one. The street penetrates in the inner block till to the entrances of the buildings. The orientation is an east-west one, leaving the north in one side of the cube, in order to benefit at the maximum from the southern part of the building. The actual situation of the dwelling is a very poor one, high level of humidity and no thermal insulation. The dwelling have a reinforced concrete structure combined with silicate brick and equipped with exterior and interior plastering.

However, also in Greece about half of the dwellings have no kind of thermal protection, since they were built prior to 1980, the year that the first Hellenic building thermal insulation regulation (HBTIR) was introduced [17].

C. Background

According to IEA, buildings are responsible for 40% of the final energy consumption [1].Strategies and tools aimed at promoting sustainable construction initiatives are encouraged and therefore buildings more energy-efficient, more comfortable, and less wasteful in terms of raw materials are incentivized. In many of the developed countries, in fact, the design tends toward Nearly Zero Energy Buildings based on the 2010 European energy performance of buildings directive [2].

The interaction between occupant and the technical and physical system is much related to the performance of the building system. Understanding the role of the user's effect in the energy performance of the building is important. The role of the human factor in the building register an increase of approximately 230% in 10years and of 30% in the past years [3].

The interaction between architecture, installations, engineering and inhabitants affect directly the energy performance and energy consumption of the building. If the inhabitants have no control over the comfort parameters of their internal environment

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they are more unsatisfied than the inhabitants that control it [4]. The demand for energy efficiency building and the challenge to ensure energy performance predicted during the design phase will be achieved after the building become in use. The knowledge of occupant behaviour is very important for building energy saving due to its influence on the performance of envelope and systems. It would be necessary to educate people to correct use of systems from an energy point of view. In fact, energy consumption in residential buildings is strongly influenced by occupants' behaviour and actions [5].

Furthermore, the energy-saving potential due to occupant behaviour ranges between 10% and 25% for residential buildings and 5–30% for office buildings [6].

Occupant behaviour can be integrated in energy calculation throughout an hourly presence schedules for each group of rooms with similar activity type and system usage schedules, so the user profile can be defined by how they interact with the building and the devices and how they use the system [7].

It is necessary to understand the factors influencing energy intensive occupant behaviours and to incorporate them in building design[8].

In this paper, the results of a certain methodology are presented and they are very much related to the current state of the socialist dwellings, energy consumption of the dwellings, the role of residents and the social interaction between users.

D. Literature review

Antoniadou and Papadopoulos take into account the multi-parametric nature of comfort. They analyse the acceptable level of all environmental conditions (thermal, visual, acoustical comfort and air quality) [9]. There are a lot different studies that are focused on this argument based on the questionnaire.

Influenced by several personal, social and building factors, the perceived comfort is much more than the average of perceived indoor air quality, noise, lighting, and thermal comfort responses [10].

There are found some correlations between buildings with more personal control on temperature and increased thermal comfort. The combination of control options, occupant's age, body, constitution and gender, influence their comfort perceptions. Meanwhile the discomfort can also affect not only the health of occupancy but also the level of the satisfaction [11].

The study of Karyono reveals that comfort perceptions vary with gender, body mass index and ethnicity [12].

There are many regression analysis used in order to determine the influence of building characteristics and occupant behaviour on energy use. Regression equations allow an analysis of factor influencing energy related aspect of dwelling use and choice that stimulation tools do not [13].The regression equations are a faster and easy way to predict energy use in a large sample of dwellings than are building simulation tools [14].

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ANOVA and regression analyses with SPSS are used to analyse three types of variables: building characteristics, household characteristics, and occupant behaviour and the variation in energy used for heating in different types of dwellings [15].

The number of residents, the surface of the dwelling, the heating instruments, monthly electricity bills, level of satisfaction, current dwelling conditions, the need for restoration, time spent in the dwelling correlate with each other with negative or positive values depending on the equation of the probabilistic model [16].

However calculations and even simulation tools may provide different results even for the same building [18]. This may be due to a multitude of reasons including: the accuracy of the calculation tool(s) that may overestimate or underestimate actual performance and savings [19].

In Greece was developed a software (TEE-KENAK) to support the implementation of KENAK in the country. The goal was to develop a common calculation tool for the building energy performance assessments. The calculation engine was based on the EPA-NR tool which was developed within the framework of a European project. Three more technical guidelines are in the pipeline to further support the implementation of KENAK and the design of energy efficient buildings: Bioclimatic architecture; combined heat and power; renewable energy sources [20].

II. Methodology for the probability model

To evaluate the variables (quality variables for the quality of the explanatory descriptors) 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 [21].

III. Questionnaire and interpretation Socialist buildings

It is undermine a questionnaire of 30 questions. 14 residents with different ages and gender were asked (year of the interview 2015).

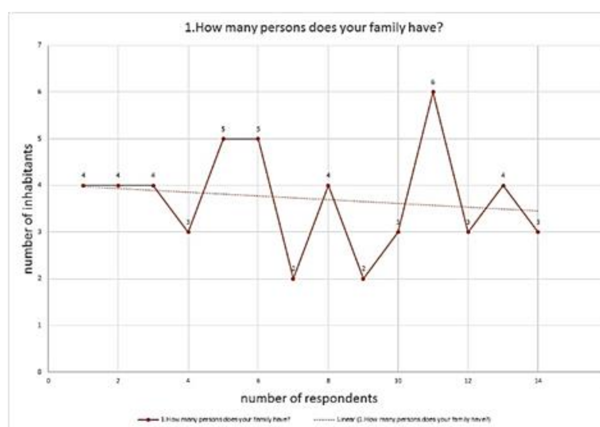

Figure 2. A; B

The number of residents for each family in on average 4 and the average time of living in the apartment for socialist buildings (according to the questionnaire) in the city of Kruja is 17.07 years.

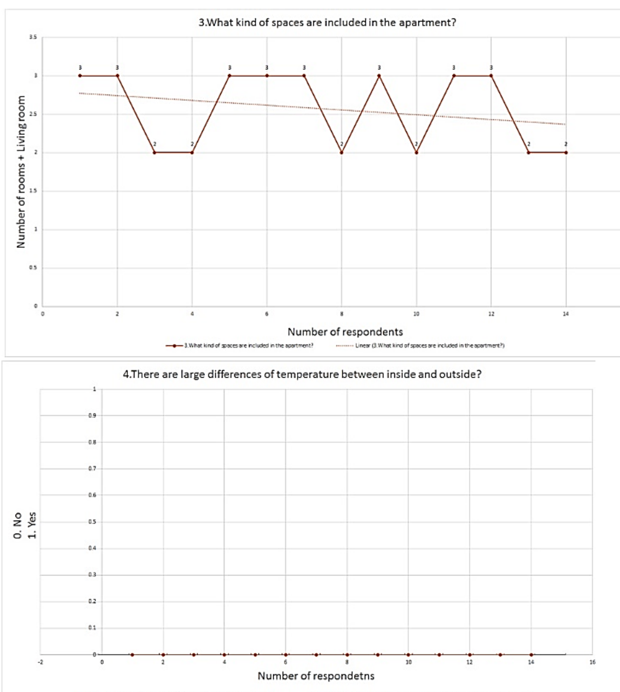

Figure 3. A; B

The majority of the apartments have 1 bedroom +1 living room. This is explicable with the downward trend of the graph (Fig. 3 A). According to the questionnaire the residence does not feel big temperature differences between outside and inside the apartment (Fig. 3 B).

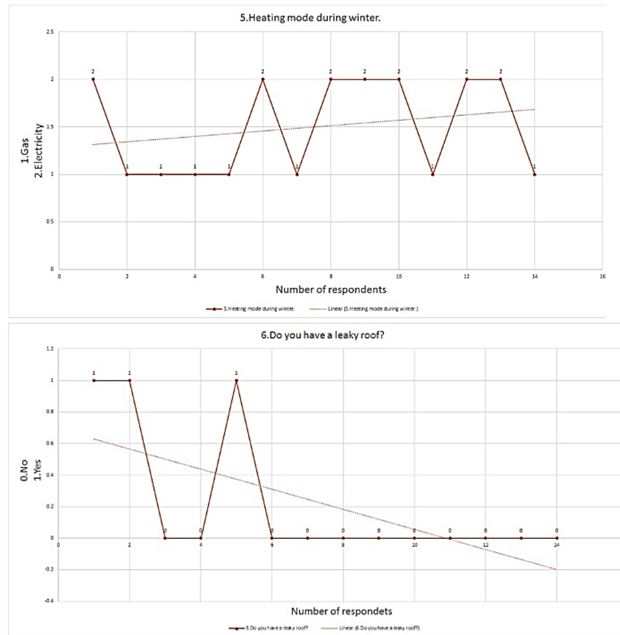

Figure 4. A; B

The majority of the residence prefers to use electricity as the main source for heating the apartment; meanwhile some of them prefer gas. This issue is much related to the economical aspect of the families. Those who prefer electricity as the main source of heating spend more income than the others who prefer gas (Fig. 4 A). Some of the apartments which are located mostly in the upper floors of the dwellings have problems with the leaky roof and the humidity but in general the trend is going down (Fig.4 B).

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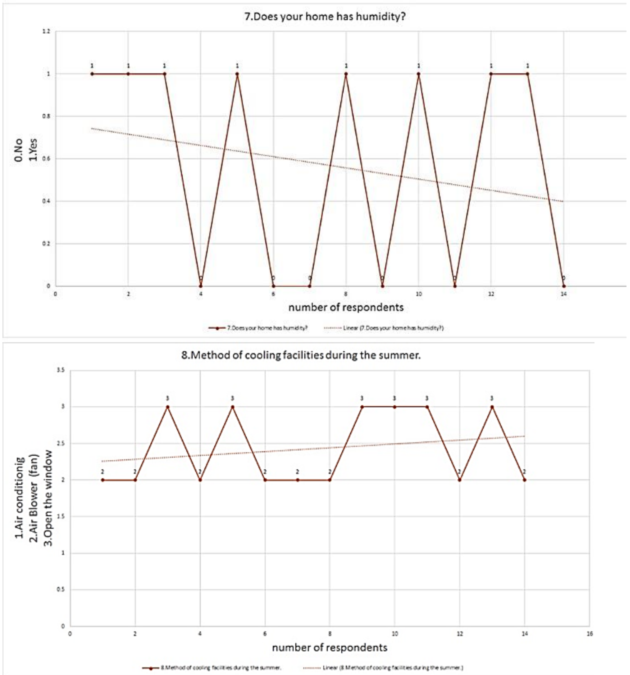

Figure 5. A; B

The humidity issue is more balanced and more specifically pointed in Fig. 5 A. The trend is also going down not in favor of the moistures. The chart in this case is more balanced because are taken into account also the apartments which are located in the ground floor of the buildings. Those ones gain large percentages of humidity from the soil.

The methods of cooling facilities during the summer are very simple by means of air blower and by direct ventilation (opening the window). Due to the economic gap not all the inhabitants can afford air conditioning in the inner apartments (Fig. 5 B).

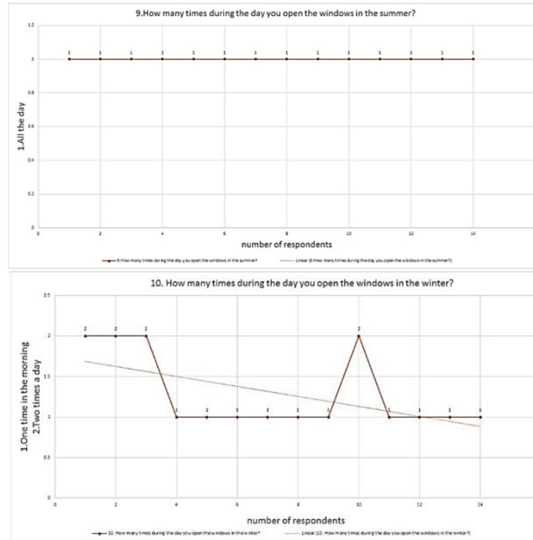

Figure 6. A; B

The inhabitants prefer to open the window in the summer time during all the day. The lack the air conditioning system is the reason why they are obligated to open the window all day long, trying to get into the comfort zone (Fig. 6 A). During the winter the majority of the inhabitants prefer more to ventilate their apartment ones in the morning

(Fig.6 B).

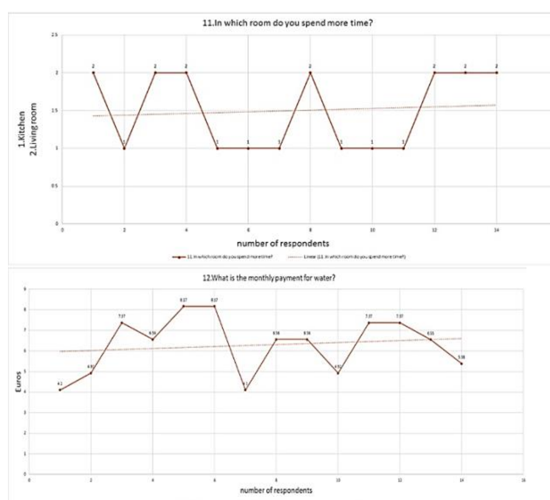

Figure 7. A; B

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The time spending in the inner apartment is relatively balanced between kitchen and living room. The trend is in favour of the living room (Fig.7 A). The average monthly expenditure for water is 6.29 Euros (Fig.7 B) and for the electricity is 57.66 Euros

(Fig.8 A).

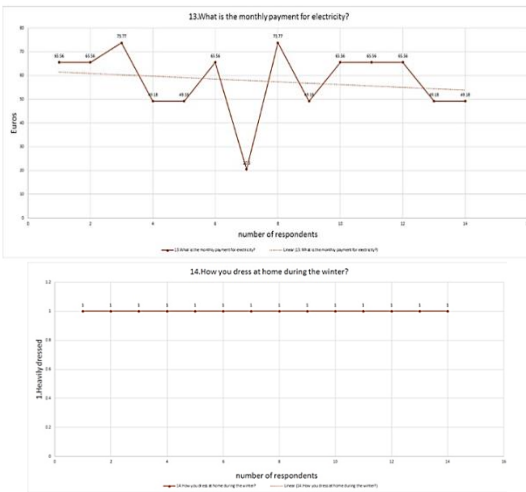

Figure 8. A; B

The residents react to the lack of comfort temperature inside the apartment in the winter. They are heavily dressed in this season (Fig. 8 B) Meanwhile in the summer time most of them are lightly dressed

(Fig. 9 A).

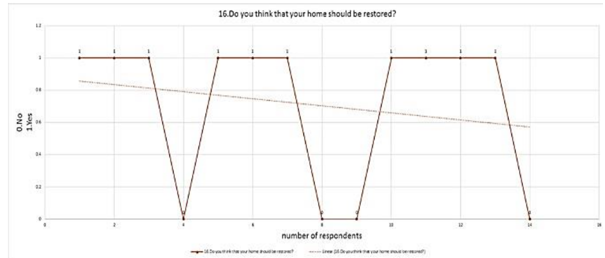

Figure 9. A; B

Most of the inhabitants want to restore their apartment. This is due to the poor comfort conditions (Fig. 9 B).

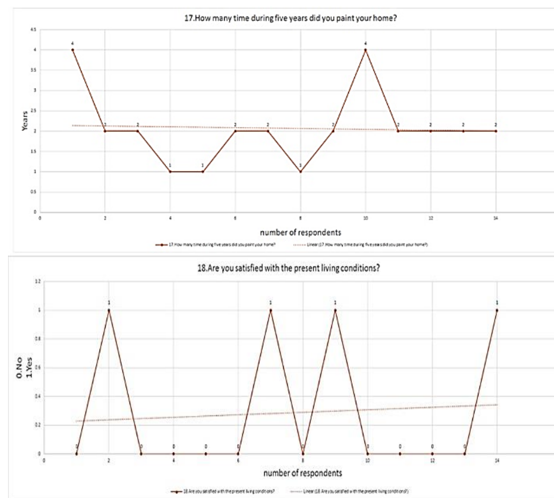

Figure 10. A; B

The number of times that inhabitants paint their home is a very important factor which shows the current condition of the apartment, and is directly related to the level of humidity. If the factor is high, the housing conditions are relatively good (Fig. 10 A). The trend is relatively linear. Furthermore this issue is closely related to the level of satisfaction. Most of the inhabitants are not satisfied with the current condition of their apartment (Fig. 10 B).

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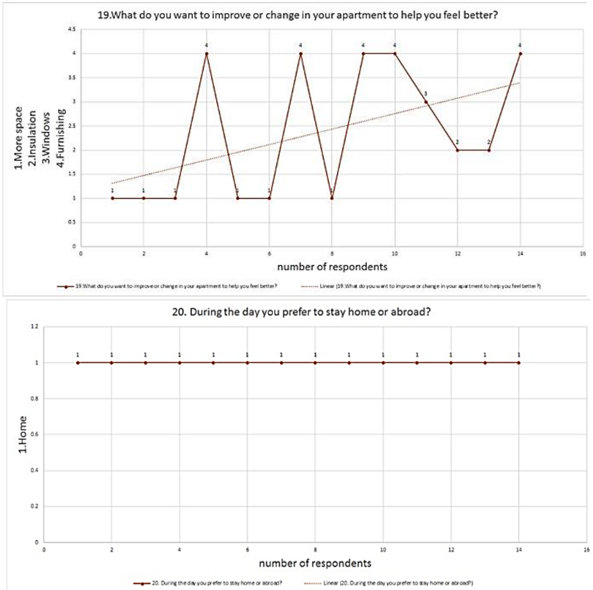
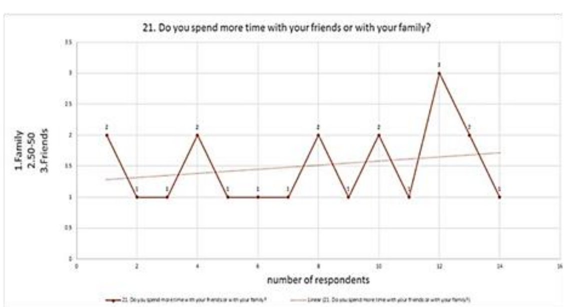


Figure 11. A; B

The quality of life is much related to the improvement in the apartment. The need for more space is crucial for the inhabitants. Most of them require more space in their apartment. In the absence of space they want to improve the furniture in the inner flat (Fig. 11 A). The inhabitants of the socialist buildings prefer to stay at home most of the time and not abroad. There are two factors that influence in such decision; economic level and social behaviour (mentality) of the inhabitants. They do not prefer to socialize much (Fig. 11 B).



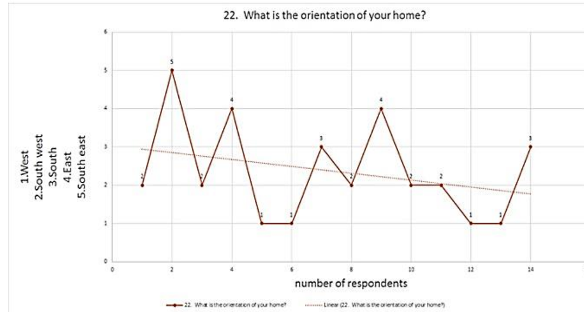


Figure 12. A; B

Specifically speaking they prefer to spend most of their time with the family. Spending time with society remains as a second alternative (Fig. 12 A). The main positioning of the apartments is south east. Due to Kruja's climate [22] this is relatively a very good orientation (Fig. 12 B).

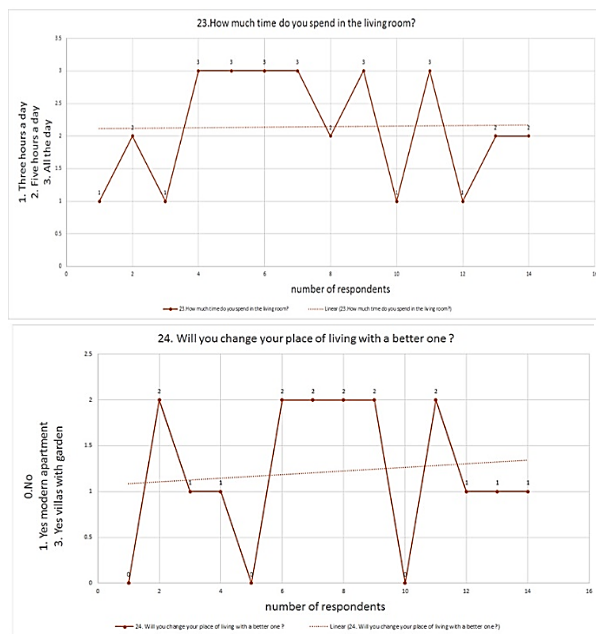


Figure 13. A; B

The inhabitants prefer mostly to spend the day in the living room (Fig. 13 A). They are not satisfied with the present living conditioned. About 79% of them want to change their apartment with a better one,

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modern apartment or villas with garden (Fig. 13 B).

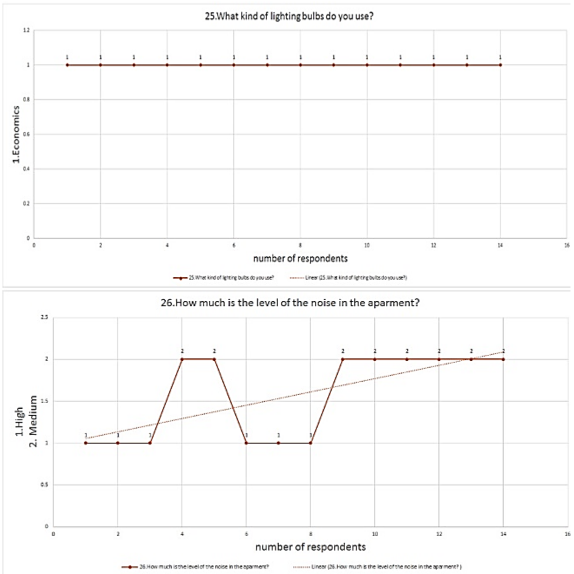

Figure 14. A; B

The first choice of inhabitants is economic lighting bulbs (Fig.14 A). Meanwhile they are relatively disturbed regarding the noise level in the area (Fig. 14 B).

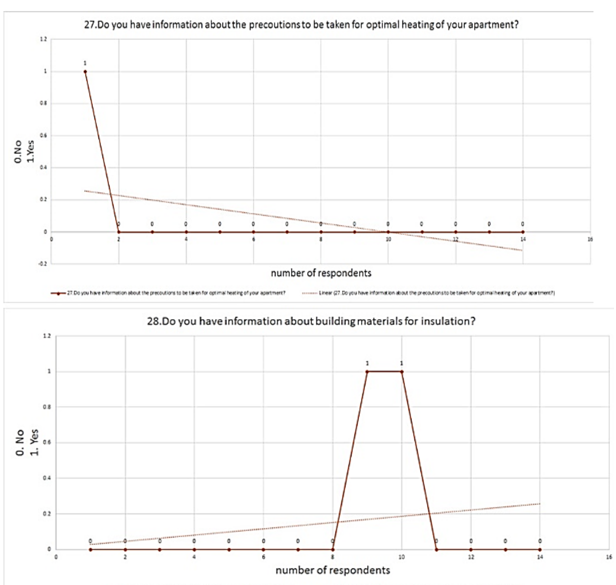

Figure 15. A; B

The inhabitants does not have adequate information regarding the precautions to be taken for optimal heating of the apartment (Fig. 15 A), building materials for insulation (Fig.15 B), recycling and the impact of it in the community (Fig. 16 A; B).

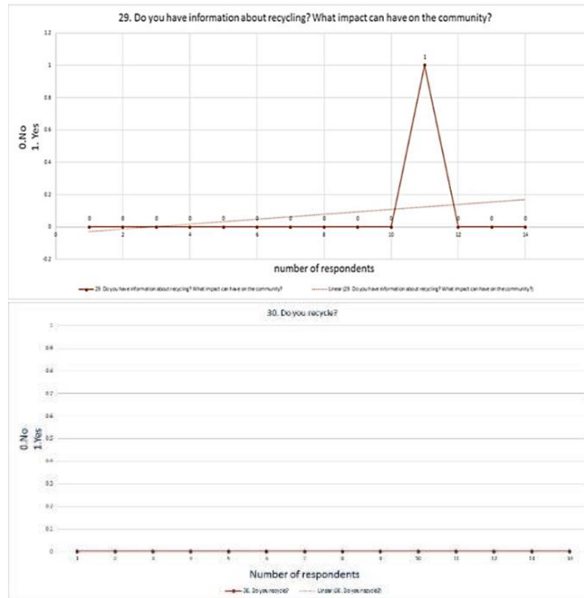

Figure 16. A; B

IV. EVALUATION MODELS FOR SOCIALIST BUILDINGS

Model nr.1

Dependent Variable: P3
Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing)
Sample: 1 14
Included observations: 14
Left censoring (value) at zero
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.722222	0.527733	5.158332	0.0000
P11	-0.404762	0.219974	-1.840047	0.0658
P21	-0.388889	0.229542	-1.694194	0.0902

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Source: Working on Eviews 8 by the author

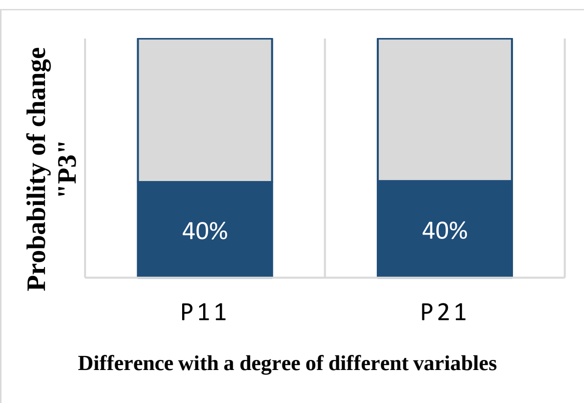
The equation of the probabilistic model is:

$$\textbf{Probability}\ \{P_3\} = \frac{e^{\{Y\}}}{1 + e^{\{Y\}}}$$

Where Y parameter varies according to linear logic equation:

$$\mathbf{Y = 2.722222 - 0.404762{*}P11 - 0.388889{*}P21 + \varepsilon_i}$$

According to model tests, it is observed that the model referring to statistic "Log likelihood" is statistically significant with significance level p <5% (ie with 95%reliability).This means that such a model stands in its overall approach to the logical and probability of variables. But if it is analysed the statistical significance of each variable in the model, student statistics (t-test) shows that with significance level p <10% (iewith90% reliability), all independent variables are important in explaining the indicators of quality of life given through question “P3” of the questionnaire. The probabilistic effect is graphically shown as follows:



Source: by the author [23]

According to this model (Tobit multivariable probability regression), from the results shown in the graph above are identified these links:

Quality of life indicator “P3” correlates negatively (oblique) and statistically significant with variable “P11”. An incensement with one degree of the “P11” variable will bring the change to a degree of “P3” with a probability of 40% (under conditions where other variables are kept constant). When the surface diagram in the apartment falls the demand of spending more quality time (towards the living room) in the apartment increases [23].

The “P3” quality of life indicator is negatively correlated (oblique) and statistically significant with the “P21” variable. An increase of one degree of the "P21" variable will bring the change to a degree of “P3" with a probability of 40% (under conditions where other variables are kept constant). If the demand to socialize grows, the demand for extra space in the apartment will decrease. Logically the time spent in the apartment will decrease.

Model nr.2

Dependent Variable: P5
Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing)
Sample: 1 14
Included observations: 14
Left censoring (value) at zero
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.489107	0.315389	7.892181	0.0000
P17	0.321351	0.120043	2.676963	0.0074
P22	-0.277778	0.109168	-2.544490	0.0109

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Source: Working on Eviews 8 by the author

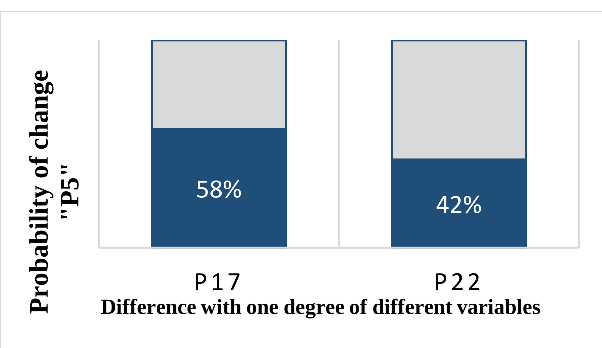
The equation of the probabilistic model is:

$$\textbf{Probability}\ \{P_3\} = \frac{e^{\{Y\}}}{1 + e^{\{Y\}}}$$

Where Y parameter varies according to linear logic equation:

$$\mathbf{Y = 2.489107 + 0.321351 * P17 - 0.277778 * P22 + \varepsilon_i}$$

According to the model tests it is observed that the model referring to the "Log likelihood" is statistically significant with significance level p <5% (ie with 95%reliability). This means that such a model stands in its overall approach to the logical and probability of variables. But if it is analysed the statistical significance of each variable in the model, student's statistic (t-test) shows that with significance level p <5% (iewith 95% reliability), all independent variables are important in explaining the variation of the quality of life indicator given through question "P5" of the questionnaire. The probabilistic effect is graphically shown as follows:



Source: by the author [23]

According to this model (Tobit multivariable probability regression), from the results shown in the graph above are identified these links:

The quality of life indicator "P5" correlates positively (fairly) and statistically significantly with the variable "P17". An increase of one degree of the variable "P17" will result in a change of one degree of "P5" with a probability of 58% (under conditions where other variables are kept constant). The trend of heating mode during winter is going in favor of electricity meanwhile the demand for home painting is increasing. Consequently if residents use more electricity for heating the apartment they will have an increasing demand over the years to paint the apartment [23].The electric heating will delay the time of painting the apartment because is a clean pollution-free heating, contrary to gas.

The quality of life indicator "P5" is negatively correlated (oblique) and statistically significant with the variable "P22". An increase of one degree of the variable "P22" will result in a change of one degree of "P5" with a probability of 42% (under conditions where other variables are kept constant). At the moment that the apartment's position changes with a unit from west to the south-east, there will be a decrease in electricity demand. The orientation of the dwelling is crucial in order to benefit as much as possible energy from the sun. If the building is orientated to the south it will bring a growth in the sun's energy benefit.

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Model nr.3

Dependent Variable: P24
Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing)
Sample: 1 14
Included observations: 14
Left censoring (value) at zero
Convergence achieved after 5 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.381490	0.359779	3.839832	0.0001
P6	-0.497040	0.179456	-2.769700	0.0056
P8	0.300021	0.117717	2.548660	0.0108
P17	-0.389683	0.109154	-3.570042	0.0004
P18	0.376308	0.147015	2.559653	0.0105
P23	-0.151206	0.075899	-1.992183	0.0464

Source: Working on Eviews 8 by the author

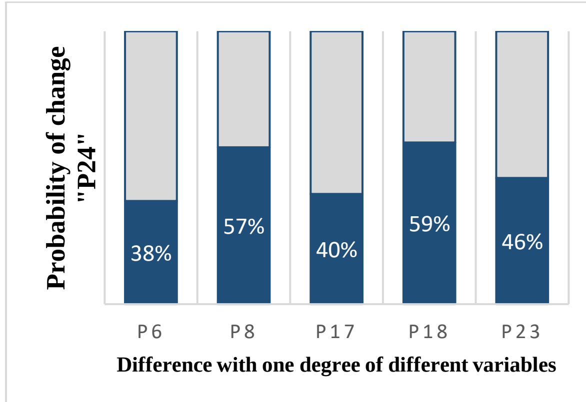
The equation of the probabilistic model is:

$$\textbf{Probability}\ \{P_3\} = \frac{e^{\{Y\}}}{1 + e^{\{Y\}}}$$

Where Y parameter varies according to linear logic equation:

$$\mathbf{Y = 1.381490 - 0.497040*P6 + 0.300021*P8 - 0.389683*P17 + 0.376308*P18 - 0.151206*P23 + \varepsilon_i}$$

According to the model tests it is observed that the model referring to the "Log likelihood" is statistically significant with significance level p <5% (ie with 95% reliability). This means that such a model stands in its overall approach to the logical and probability of variables. But if it is analyzed the statistical significance of each variable in the model, student statistics (t-test)shows that withsignificance level p<5% (iewith 95% reliability) all independent variables are statistically significant in explaining the indicators of quality of life given through question “P24” of the questionnaire. The probabilistic effect is graphically shown as follows:



Source: by the author [23]

According to this model (Tobit multivariable probability regression), from the results shown in the graph above are identified these links:

The quality of life indicator “P24” is negatively correlated (oblique) and statistically significant with the variable “P6”. An increase of one degree of the "P6" variable will bring a change with one degree of "P24” with a probability of 38% (under conditions where other variables are kept constant). If the condition of the roofs improves, the need to change the apartment will decrease.

The quality of life indicator "P24" correlates positively (fairly) and statistically significantly with the variable "P8". An increase of one degree of the "P8" variable will bring a change with one degree of “P24” with a probability of 57% (when other variables are kept constant). If the demand for alternative cooling solutions increases, the need to change the apartment

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will increase. This issue is directly linked with the actual condition of the dwellings, lack of insulation and mostly lack of instruments of cooling (air conditioning system), due to difficult economic situation of the inhabitants.

The quality of life indicator “P24” is negatively correlated (oblique) and statistically significant with the variable “P17”. An increase of one degree of the variable "P17" will bring a change with one degree of “P24” with a probability of 40% (under conditions where other variables are kept constant). If the need to paint the apartment within 5years increases, the need to change the apartment will decrease. If the need to paint the apartment increases (within 5 years) it means that the apartments are performing better and there is no need to be painted often.

The quality of life indicator "P24" correlates positively (fairly) and statistically significantly with the variable "P18". An increase of one degree of the “P18” variable will bring a change of one degree of “P24” with a probability of 59% (under conditions where other variables are kept constant). If the level of dissatisfaction is high, the need to move out of the apartment will increase [23].

The quality of life indicator "P24" is negatively correlated (oblique)and statistically significant with the "P23" variable. An increase of one degree of the "P23" variable will bring a change of one degree of the "P24" with a probability of 46% (under conditions where other variables are kept constant). If the demand to spend more time in the living room decreases, the demand to move out of the apartment will increase. Residents in this case do not feel comfortable to spend quality time in their apartment [23].

Model nr.4

Source: Working on Eviews 8 by the author

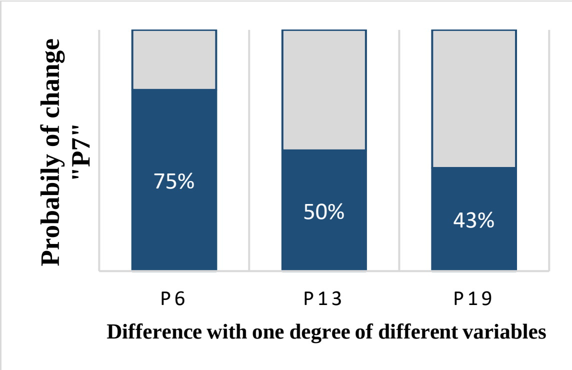
The equation of the probabilistic model is:

$$\textbf{Probability}\,\{\boldsymbol{P_3}\} = \frac{\boldsymbol{e}^{\{\mathrm{Y}\}}}{\mathbf{1} + \boldsymbol{e}^{\{\mathrm{Y}\}}}$$

Where Y parameter varies according to linear logic equation:

$$\mathbf{Y = -\ 1.674986 + 1.102523{*}P6 + 0.000373{*}P13 - 0.291293{*}P19 + \varepsilon_i}$$

According to the model tests we see that the model referring to the "Log likelihood" statistic is statistically significant with significance level p <5% (ie with 95% reliability). This means that such a model stands in its overall approach to the logical and probability of variables. But if it is analyzed the statistical significance of each variable in the model, student statistics (t-test) shows that p <5% significance level (ie with 95% reliability) are statistically significant for the independent variables "P6" and "P13"; meanwhile the independent variable“P19”is not statistically significant in explaining the variation in the quality of life indicator given through the“P7” of the questionnaire. The probabilistic effect is graphically shown as follows:



Source: by the author [23]

According to this model (Tobit multivariable probability regression), from the results shown in the graph above are identified these links:

The quality of life indicator "P7" correlates positively (fairly) and statistically significantly with the variable "P6". An increase of one degree of the variable "P6" will bring a change of one degree of "P7" with a probability of 75% (under conditions where other variables are kept constant). If the complains of the residence increase related to the leaking roof, the level of the moisture in the apartment will increase.

The quality of life indicator "P7" correlates positively (fairly) and statistically significantly with the variable "P13". An increase of one degree of the variable "P13" will bring a change of one degree of "P7" with a probability of 50% (under conditions where other variables are kept constant). If the monthly electricity bill increases, the level of moisture in the apartment is higher. The inhabitants need to consume more energy to balance the situation, in order to eliminate excessive moisture and to get slightly into the comfort zone.

CONCLUSIONS

Many conclusions can be found due to the poor conditions of the socialist dwellings, lack of adequate living space for the residents, inhabitant's occupancy behaviour and social interactions between them in the city of Kruja, referring to prepared mathematical models.

Due to the lack of adequate living space inside the apartment, the residents of the socialist building in the city of Kruja find it difficult to spend quality time in the apartment especially towards the living room. The inner surface of the flats is much related also to the need to socialize. Logically if the time spent in the dwelling is low (as a consequence of not meeting the adequate living space) residents will have more time to socialize with each other.

The residence should focus on spending more electricity on heating in case they do not want to paint the flat frequently. The apartments that have lower electricity bills are those mostly oriented in south-east.

The need to change the apartment is very evident among the residents of the socialist buildings. If there is improvement in: roofs of the buildings , in the demand for alternative cooling instruments, in the need to paint the apartment as little as possible within 5years, in the level of satisfaction, in spending quality time toward living room, the need to change the apartment will be lower. Improving these factors can be a very good start of forcing the residents not to abandon their apartments, increasing the quality of life.

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Improving the level of the moisture in the dwellings will bring an incensement of financial benefits of the residents related to the electricity bills.

In order to avoid the shrinking city of tomorrow, it is necessary to upgrade as soon as possible the quality of life indicators.

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