A Model Proposal For Sustaınable Urban Transformation

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***Abstract*—Urban transformation applications, which aims to solve urban problems caused by unplanned urbanization and/or urban aging, provide an important opportunity to create more sustainable cities. In this study, the built environment design elements that may be applied to an urban transformation project were identified. Their contribution to economic, environmental and social sustainability was assessed with a survey study implemented by the participation of 323 personnel mainly from AEC sector. Design elements related to each other were collected under different factors by factor analysis and they were named appropriately. The importance weights of the factors and the design elements that constitute these factors have been identified by Analytic Hierarchy Process (AHP). This process was performed with the participation of a group of 60 people consisting of academicians and practitioners, which includes mainly city planners, architects, and civil engineers. It is expected that, created model shall guide the urban transformation stakeholders, in a wide range extending from architects and engineers to contractors, from local governments to citizens, on the path of creating sustainable cities.**

***Index Terms*—AHP analysis, factor analysis, sustainability, urban transformation.**

I. INTRODUCTION

In the past century, in developing countries rapid population growth and immigration from rural to urban areas have led to an unmanaged and unplanned urban growth problem. The great need for buildings emerged during this process, was met with low quality, energy inefficient, unhealthy, comfortless and more importantly disaster vulnerable buildings, due to the country's inadequate capital accumulation. Especially in big cities this process caused to environmental problems such as increasingly diminishing green areas, unlimited and unconscious consumption of natural resources, and intensive use of fossil fuels; as well as to many social and economic problems such as inequality, unemployment, poverty, inadequate infrastructure and services, traffic congestion, violence and crime.

Urban transformation can be defined as the demolition of illegal and unauthorized buildings that do not comply with the planning regulations, or the buildings that have become obsolete, worn and sometimes abandoned in time, and creating new urban settlements that comply with the planning regulations [1]. Urban transformation practices aim to change, transform and improve the urban areas, in accordance with the socio-economic and physical requirements of the day [2]. They present an important opportunity for solving the growing urban problems but pose also significant risks, if the change is perceived as physical transformation only. It is necessary, to regard the urban transformation, as the effect of the physical transformation of the social, cultural and economic structure, and the transformation that this effect brings. According to Özden, the urban transformation should include activities such as upgrading the physical qualities of the buildings and their environments, protecting the cultural heritage, ensuring the social development of the inhabitants, and carrying out economic functions appropriate to the conditions of the area [3]. It should cover a very wide area like housing, work, health, education, transportation and other economic, social and environmental issues.

The fact that sustainable development corresponds to the urban transformation that deals with all these issues in terms of economic social and environmental sustainability, reveals the necessity of addressing urban transformation and sustainability together [4]. In this context, important strategies for urban areas for sustainable development should be included in the targets of urban transformation [5]. Sustainability is a sound approach to improving land values, enhancing environmental quality, meeting socioeconomic needs, strengthening existing social networks, including vulnerable groups and changing the negative impacts on the living environment [4]. On the other hand, since a behavior to be regarded as sustainable requires that all three dimensions of sustainability to be treated as elements that reinforce each other, urban transformation should also be considered as a whole with its economic, environmental and social dimensions.

In this study, it is aimed to determine the degree of importance of built environment design elements and to create a sustainable urban transformation model. For this purpose, the design elements that might be applied in a transformation project, have been identified with a comprehensive literature study. Contributions of these elements to three dimensions of sustainability were assessed by a survey study, with the participation of 323 people. The participants were selected from public and private sector employees who were in charge of the realization of urban transformation projects, and have enough knowledge about sustainability concept. The design elements that are related to each other were gathered under fewer factors by factor analysis. The weights of the factors and design elements were determined with AHP, which was performed with the participation of 60 experts consisting of academics and practitioners, who were city planners, architects, and civil engineers. In the last part of the study, the factors and their weights were evaluated and discussed.

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II. Material and Method

A. Identification of Design Elements and Pilot Study

The sustainability of an urban transformation project is strictly related to how sustainable the design elements are. Many researchers have suggestions for sustainable design elements, and Kim and Rigdon developed a guiding conceptual framework [6]. This framework constituted of three principles, strategies related to these principles and methods related to these strategies. The first principle of this framework is conservation of resources. 50% of the energy and 42% of the water consumed in the world, are used for construction or in use of buildings [7], and the construction sector is an important consumer of natural resources, like timber, metal, sand, and gravel. Life-cycle design is the second principle, and it is based on the idea that resources can be transformed from a useful state to another useful state and the useful life can last without end. The third principle humane design is constituted of the strategies preservation of natural conditions, urban design/site planning and design for human comfort. It is very important, since sustainability is only applicable to the extent, that it can be shared with people's needs and requirements [8]. To cover all design elements that can be applied to an urban transformation project, in this study, besides about 40 methods suggested with this conceptual framework, suggestions of some other researchers [9]-[16] were also considered and 50 design elements have been listed to measure their contribution to sustainability. Experts participating in the pilot study did not suggest any additional design element; rather they stated that some of them could be reduced.

Since it is beneficial to perform a pilot study before a wide-scale study in order to make revisions in the direction and target of the study and to simplify the questions [15], a pilot study was conducted face to face with 20 people. They were in charge of urban transformation projects in Istanbul under the leadership of TOKİ (Housing Development Administration of Turkey). The participants were asked to evaluate the importance of 50 different design elements in terms of their contribution to economic, environmental and social sustainability, on a five-point Likert-type scale. As mentioned earlier, the participants expressed an opinion that some questions had very close meanings to each other and a large number of questions made it difficult to fill the survey form. The correlations between design elements were examined and by combining the elements with strong correlation, the number of the design elements was reduced to 32 in the main study.

B. Factor Analysis

Factor analysis is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables, called factors. In a factor analysis whether the data is suitable is examined with Bartlett sphericity and Kaiser-Meyer-Olkin (KMO) tests. The KMO value above 0.9 indicates excellent fit and the Bartlett test is expected to be significant. Variables, whose load value are below the accepted threshold value, should be excluded in the analysis. Axis rotation in factor analysis aims to make it easier to interpret the factors obtained and to ensure independence [17]-[19]. The Cronbach alpha internal consistency, which ranges in value from 0 to 1 is used to measure the reliability of the factors, and 0.7 refers to an acceptable reliability coefficient [20].

1) Survey study

In this study, factor analysis was conducted on the results of a survey study. By following purposive sampling method, the sample was constituted of professionals in charge of the realization of urban transformation projects and technical personnel who worked in construction activities for several years and know sustainability concept. The size of the sample was determined considering the recommendations of various researchers about the required number of samples for an effective factor analysis [21]-[23]. In this research, 323 questionnaires were taken into the evaluation, which is higher than the recommended numbers.

The research was conducted between November 2015-February 2016 and 32 design elements contribution to the sustainability of an urban transformation project were evaluated by the participants in a 5-point Likert scale. The results were analysed with Statistical Package for Social Science (SPSS) 21.0 program.

First, descriptive analyzes of the participants were carried out. Participants with 60% male and 40% female, had 73% BSc. and 27 % MSc or Ph. D. degrees. They were mainly from Ankara and İstanbul and their professions were architect (18%), civil engineer (37%), city planner (23%), topographical engineer (9%) and others (16%).

In the survey, the design elements contribution to economic, social and environmental dimensions of sustainability were asked separately. Otherwise, it is possible for a participant to make an incomplete assessment. For example, the design element "provision of open and green spaces" firstly brings to mind environmental sustainability. Whereas, open and green spaces contribute to economic sustainability by raising the value of real estate and rentals of the region, and will contribute to social sustainability by protecting the health and well-being of the residents of the region. For this reason, factor analysis was made firstly in each dimension separately and later on design elements under similar factor names were brought together to form a single model.

2) Factor analysis for economic environmental and social sustainability dimensions

TABLE I: Explained Total Variance after Rotation

Comp.	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumul. %	Total	% of Variance	Cumul. %
1	8,588	31,808	31,808	3,106	11,505	11,505
2	2,311	8,559	40,367	2,995	11,093	22,599
3	1,548	5,732	46,099	2,814	10,421	33,020
4	1,211	4,486	50,585	2,482	9,192	42,212
5	1,168	4,326	54,911	2,449	9,072	51,283
6	1,019	3,774	58,685	1,998	7,401	58,685

Factor analysis in all three dimensions were performed at the following stages: Examination of the suitability of sample to factor analysis, performing basic component analysis, rotating the factor axes, and performing reliability analysis. In all dimensions, the KMO scores were over 0.9 (refers to excellent [24]) and the Bartlett tests results were significant (refers to good suitability [25]). Factor analysis on the economic dimension revealed a total of 6 factors describing 58,7 % of the total variance (Table I). An analysis describing 50-75% of the total variance is considered good [26].

The factors were named by determining the common point between the variables that load the factors. The factors in the economic dimension, the design elements constituting them and their load values are presented in Table II.

TABLE II: FACTORS AND FACTOR LOADS OF DESIGN ELEMENTS FOR ECONOMIC DIMENSION

Factor	No	Design Element	Load
1- Transportation and Accessibility	d10	Appropriate design for pedestrian and public transportation	,687
	d9	Appropriate design for drivers	,642
	d7	Open spaces and easy access to them	,633
	d13	Facilities for disabled, elderly and children	,630
	d18	Public facilities and easy access to them	,615
	d14	Design for disabled, elderly and children	,571
2- Built Environment Quality	d29	Appropriate structural forms	,745
	d30	Compliance with environment	,665
	d32	High-density use of land	,630
	d28	Landscaping	,586
	d31	The layout of buildings and streets	,556
	d27	Waste management and pollution control	,512
3- Conservation of Resources	d1	Energy conservation	,765
	d2	Water conservation	,734
	d3	Material conservation	,707
	d8	Efficient use of land	,554
	d4	Building design to increase human comfort	,492
4- Supporting Social Life	d23	Community participation in public decisions	,755
	d22	Communication and sense of community	,704
	d21	Taking security measures	,681
5- Commercial and Economic Opportunities	d17	Establishment of different business	,747
	d25	Housing opportunities for all income groups	,595
	d16	Providing local employment	,591
	d11	Applying mixed-use development model	,588
	d12	Flexible design of buildings	,564
6- Historical and Cultural V.	d26	Preservation of historical buildings	,755
	d24	Protection of local features	,609

At the final stage of the factor analysis, the reliability analyses were performed. The results of the economic variables given in Table III, shows that the analyses are reliable.

TABLE III: RELIABILITY COEFFICIENTS OF THE EXTRACTED FACTORS

	N of Items	Cronbach's Alpha
Factor 1	6	,827
Factor 2	6	,802
Factor 3	5	,763
Factor 4	3	,769
Factor 5	5	,741
Factor 6	2	,723

Similar to economic dimension, factor analyses were done also on the environmental and social dimensions, whose details are not included in this article. In the factor analysis on the environmental dimension 5 factors (transportation and accessibility, conservation of resources, built environment quality, supporting social life and protection of the land) describing 55.8% of the total variance were obtained. On the social dimension also 5 factors (accessibility and quality of social life, conservation of resources, built environment quality, protection of disadvantaged groups, commercial and economic opportunities) describing 56% of the total variance were obtained.

C. Analytic Hierarchy Process (AHP)

AHP is a decision-making and forecasting method, which is used when the decision hierarchy can be defined and which gives the percentage distributions of decision points in terms of factors affecting the decision. The theoretical basis of the method is based on the following four axioms. The first axiom, the reciprocal axiom, requires that, if $P_C(A, B)$ is a paired comparison of elements A and B with respect to their parent, element C, representing how many times more the element A possesses a property than does element B, then $P_C(B, A) = 1/P_C(A, B)$. The second, or homogeneity axiom, states that the elements being compared should not differ by too much, else there will tend to be larger errors in judgment. The third, synthesis axiom states that judgments about the priorities of the elements in a hierarchy do not depend on lower level elements. The fourth expectation axiom, says that individuals who have reasons for their beliefs should make sure that their ideas are adequately represented for the outcome to match these expectations [10].

AHP method consists of five stages. The first stage is identifying the problem, determining the purpose of the problem, and determining the evaluation criteria and sub-criteria. The second stage is the creation of binary comparison matrices in order to determine the significance. Assuming that n is the criterion in forming these matrices, a square matrix of nxn size is formed. The comparison of the criteria is made by the experts of the subject and the importance of the criteria relative to each other is compared using the significance scale from Table 4. In binary comparisons, the 1-9 scale was chosen as the primary scale. The comparison matrix can be formed as the decision that the experts will take as a group, or by taking the geometric mean of the results taken separately from each expert. The third stage is the determination of weights distribution of factors, which is specified by the eigenvectors of the binary comparison matrices. The next stage is to calculate a Consistency Ratio (CR) to measure how consistent the judgments have been relative to large samples of purely random judgments. If the CR is much in excess of 0.1 the judgments are untrustworthy. The last stage of AHP, determining the rankings of the alternatives was not used in this study since any decision problem was not solved [27]-[29].

TABLE IV: IMPORTANCE SCALE

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective.
3	Somewhat more important	Experience and judgment slightly favor one over the other.
5	Much more important	Experience and judgment strongly favor one over the other.
7	Very much more important	Experience and judgment very strongly favor one over the other.
9	Absolutely more important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed.

1) Determination of weights of factors

AHP were performed to determine the weights of the factors. The analyses were carried out in March 2016 through the participation of 60 people, about half of whom were urban transformation practitioners that had also participated in the previous survey and about half of whom were academics familiar with the subject. Because of the difficulty of gathering all the participants together, AHP were done by using a clear and understandable survey form. Firstly, AHP about the three dimensions of sustainability was carried out. The matrix obtained as a result of the comparison economic (EcS), environmental (EnS) and social sustainability (ScS) from the point of view of their contribution to the total sustainability of an urban transformation project, is presented in Table V.

TABLE V: PAIRED COMPARISON RESULTS OF THREE DIMENSION OF SUSTAINABILITY

	EcS	EnS	ScS	Eigen Vector
EcS	1.00	0.42	0.51	0.20
EnS	2.37	1.00	1.31	0.45
ScS	1.94	0.76	1.00	0.35
	CR			0.000

The consistency ratio (CR) for this matrix was found to be 0.000. The eigenvector values in the last column of the matrix show the weights of the factors. According to this analysis, in the total sustainability of an urban renewal project, 20% weight is given to economic sustainability, 45% to environmental sustainability and 35% to social sustainability.

In Table VI the matrix obtained as a result of the paired comparisons performed in economic sustainability dimension is given. The weights of the factors are Transportation and Accessibility (TA) 15%, Built Environment Quality (BEQ) 14%, Conservation of Resources (CRS) 21%, Supporting the Social Life (SSL) 15%, Commercial and Economic Opportunities (CEO) 20% and Historical and Cultural Values (HCV) 16%.

TABLE VI: ECONOMIC SUSTAINABILITY FACTORS PAIRED COMPARISONS

	TA	BEQ	CRS	SSL	CEO	HCV	Eigenvector
TA	1.00	2.17	0.58	0.68	0.80	0.60	0.15
BEQ	0.46	1.00	0.49	0.51	0.56	0.47	0.14
CRS	1.71	2.06	1.00	1.28	1.09	1.01	0.21
SSL	1.48	1.96	0.78	1.00	1.08	0.96	0.15
CEO	1.26	1.77	0.92	0.93	1.00	0.82	0.20
HCV	1.65	2.13	0.99	1.04	1.21	1.00	0.16
			CR				0.005

Similar to economic dimension binary comparison matrices were obtained in environmental and social dimensions. The internal consistency ratio of environmental dimension matrix is found as 0.002 and the weights of the factors were found as Transportation and Accessibility 17%, Conservation of Resources 30%, Built Environment Quality 20%, Supporting the Social Life 23% and Protection of Land 9%. The internal consistency ratio of social sustainability dimension matrix is found as 0,004. The weights of the factors were found as Accessibility and Supporting the Social Life 32%, Conservation of Resources 18%, Built Environment Quality 16%, Protection of Disadvantaged Groups %17 and Commercial and Economic Opportunities 16%.

2) Determination of design elements weights

In order to create a single assessment model and to determine the weights of design elements, first of all, the factors obtained in the economic, environmental and social dimensions were examined and common factor names were determined. These common factors were transportation and accessibility, supporting social life, protection of disadvantaged groups, built environment quality, commercial and economic opportunities and conservation of resources and the environment. The common factors were formed from similar design elements, since the design elements that constitute the factors in economic, environmental and social dimensions were generally similar. Design elements that constitute a few factors were distributed in more than one common factor, like design elements under transportation and accessibility factor in economic and environmental dimensions and under supporting social life factor in the social dimension. The weights of common factors were found by summing dimension weight and factor weight multiplications, in all three dimensions. For example, the weight of the built environment quality factor is found as follows:

$$W_{BEQ} = W_{EcS} x W_{BEQEcS} + W_{EnS} x W_{BEQEnS} + W_{ScS} x W_{BEQScS}$$
$$W_{BEQ} = 0.20x\ 0.29 + 0.45x\ 0.20 + 0.35x\ 0.16 = 0.20$$

After determining the common factors and design elements that constitute them, design elements under common factors were compared in binary to determine their importance weights. Participants made binary comparisons of design elements under each factor separately.

The matrix given in Table VII resulted from the binary comparisons of transport and accessibility factor design elements. According to this matrix, the weights of the design elements were 29% for appropriate design for pedestrians and public transportation (A), 8% for appropriate design for drivers (B), 22% for easy access to open spaces (C), 24% for easy access to public facilities (D) and 16% for easy access to workplaces (E).

TABLE VII: TRANSPORTATION AND ACCESSIBILITY FACTOR DESIGN ELEMENTS PAIRED COMPARISONS

	A	B	C	D	E	Eigenvector
A	1.00	3.61	1.21	1.34	1.66	0.29
B	0.28	1.00	0.37	0.33	0.58	0.08
C	0.83	2.68	1.00	0.94	1.27	0.22
D	0.75	3.05	1.06	1.00	1.50	0.24
E	0.60	1.73	0.79	0.67	1.00	0.16
		CR				0.002

The comparison matrices for other design elements constituting common factors were similarly obtained. The overall weight of any design element was determined by multiplying the design element weight with the factor weight. As a result, the factors, the elements, and the importance weights which given in Fig. 1 was obtained.

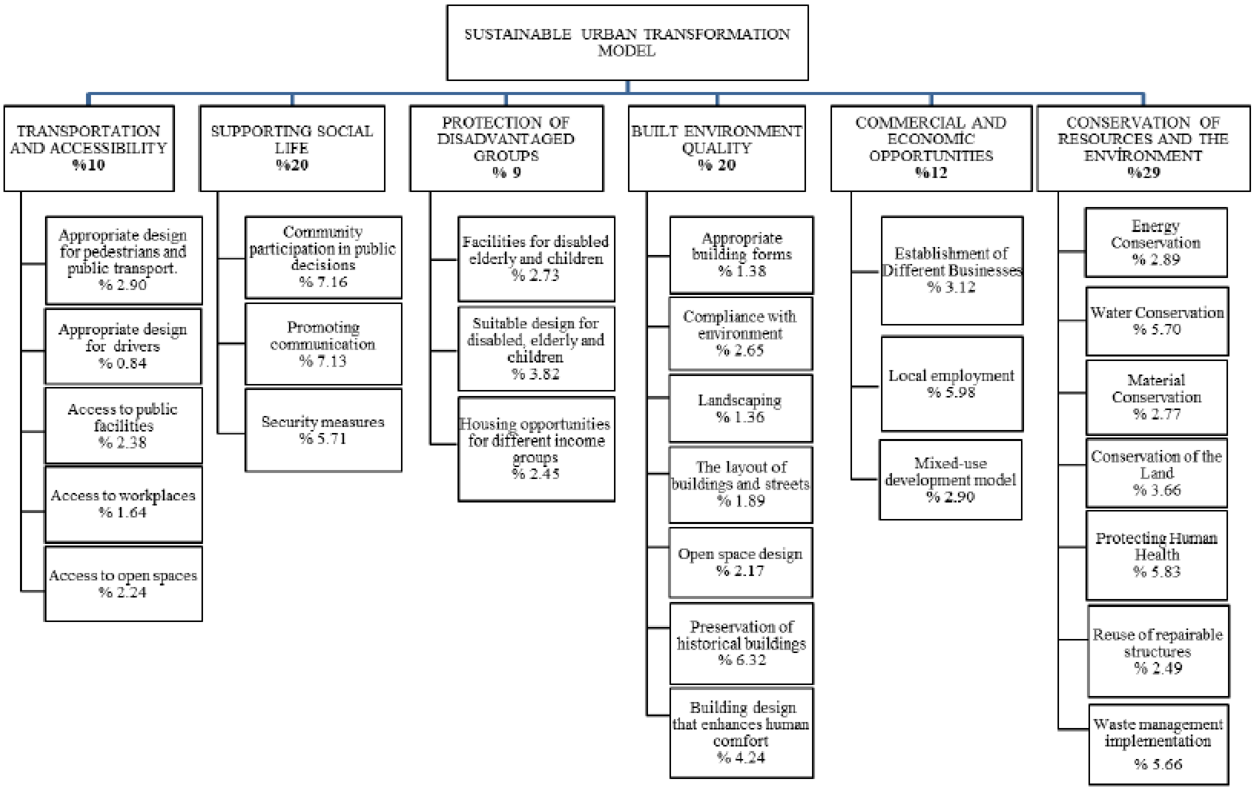

Fig. 1. Sustainable urban transformation model factors, design elements, and their weights.

III. Evaluation of the Model and Discussion

The factors and the weights of the model obtained as a result of the study could be evaluated as follows.

A. Transportation and Accessibility Factor

The design elements constituting this factor addresses directly or indirectly all dimensions of sustainability. Good transportation and accessibility in a region contribute to the vitality of the real estate market and economic prosperity [30]. This factor also contributes to environmental sustainability by reducing the total amount of vehicles [12] and to social sustainability by solving some problems like the stresses caused by excessive traffic congestion, and the isolation of people by means of vehicles [31], [32].

B. Supporting Social Life Factor

Spatial development projects prepared without co-working with local communities, face with large negative public reaction [14], thus community participation not just as beneficiaries, also as partners or actors in the process of a project is very important [33]. Today, especially in metropolitan areas, the weakening of neighborhood relations, the reduction of communication between people and alienation are frequently encountered social problems. In this study, it was observed that unsuccessful urban transformation projects worsen these social problems. In this respect, it is possible to say that the supporting social life factor, which is constituted from community participation in public decisions, promotion of communication and taking security measures, seems to be very important in terms of sustainability. This has resulted in the determination of a high factor weight as 20%.

C. Protection of disadvantaged groups factor

This factor is crucial for ensuring that all segments of society are involved in life which is very important for sustainability. Special measures should be taken to ensure that public facilities can be used by disadvantaged groups such as disabled, elderly and children [34], and movement and access evaluations must include the needs of these groups [35]. 13% of the general population in Turkey are disabled or with chronic disease people between the ages of 16-64, 29% are the child and 8% the elderly. Thus, 9% weight of this factor is important.

D. Built Environment Quality Factor

In an urban transformation area, buildings, preserved historical buildings, streets, open spaces and landscape arrangements form the built environment. It is possible to say that the appropriate design of the built environment contributes to economic sustainability by enhancing the attractiveness of the region, contributes to social sustainability by improving the harmony between residents and urban forms, and contributes to environmental sustainability by forming open and green spaces. This has led the built environment quality factor to gain a significant weighting as 20%.

E. Commercial and Economic Opportunities Factor

This factor is composed of 3 design elements concerning the commercial and economic opportunities. Employment provides income to the individual, and the work environment provides opportunities for social communication and interaction. A variety of business and mixed use contributes to all aspects of sustainability, with creating employment in the area, reducing residents' need for car use, increasing night and daytime vitality of the area, creating opportunities for interaction, promoting daytime and evening activities [35]. The importance of the factor resulted in a significant weight as 12%.

F. Conservation of Resources and Environment Factor

Considering the source of the concept of sustainability, environmental dimension is the most important dimension. Seven design elements that constitute this factor are the elements that contribute to environmental sustainability directly and to economic and social sustainability indirectly. The buildings account for about 40% of global energy consumption and carbon dioxide emissions. For this reason, sustainability in general and energy efficiency, in particular, have become the main elements of building performance measurement [36]. The land used is one of the indispensable natural resources, and effective and efficient use of land is essential to ensure long-term productivity [37]. Recycling and reuse of materials contribute to environmental and economic sustainability, by helping to minimize the use of energy for raw material extraction, material production and transportation [35]. When the listed issues are considered together with the fact that Turkey's natural resources such as energy and water are limited, and in Turkey environmental pollution and pressure on the agricultural and forest lands are increasing day by day, achieving a high factor weight of 29% is significant.

In general, with this study, a sustainable urban transformation assessment model has been formed which consists of 28 design elements under 6 main factors whose weights were determined with AHP. As mentioned before, in the literature there are a lot of research on the specific aspects of built environment and sustainability relation, but there isn't a model like this one. Neighborhood sustainability assessment systems, known as the third generation of green building assessment systems, assess the sustainability characteristics of urban settlements over design elements that are grouped into various categories. LEED Neighborhood Development (ND) and BREEAM Communities are the best known and most widely used systems among them. LEED-ND categories are determined as Smart location and linkage (27 points) Neighborhood pattern and design (44 points) Green infrastructure and buildings (29 points) Innovation and design process (6 points) and Regional priority (4 points) and BREEAM Communities categories are Governance (9.3%) Social and economic wellbeing (41.7%), Resources and energy (% 21,6), Land use and ecology (% 12,6) Transport and movement (% 13,8) [38], [39]. The model obtained in this study is somewhat similar to these systems. However, it differs from them, in terms of being developed specifically for urban transformation. In addition, although in principle the concept of sustainability is universal, it must also be localized in accordance with the specific characteristics and needs of each country or region. In this respect, it is possible to say that, with its general results, in particular, this study reflects the needs of Turkey.

IV. Conclusion

Urban transformation provides an important opportunity to solve urban problems arising from unplanned urbanization and urban aging. On the other hand, since it will be built more permanent structures than the old ones during transformation, it becomes much more difficult to return from the mistakes. To turn the transformation into an opportunity and to eliminate the risks, the transformation must not be considered only as a physical renewal of buildings, rather it must target sustainable urbanization. With this study, it was aimed to establish a model to assess the sustainability of an urban transformation project. The six factor -conservation of resources and environment (29%), built environment quality (20%), supporting social life (20%), commercial and economic opportunities (12%), transportation and accessibility (10 %) and protection of disadvantaged groups (9%)- together with 28 design elements with determined weights constituting them, made up a sustainable urban transformation model. With this model, the relationship between design in urban transformation and sustainability can be understood and presented in a simple way. It is estimated that the results of the study will guide a wide range of urban transformation stakeholders, like contractors, engineers, architects, local residents, and local governments. In future works, it is aimed to identify concrete indicators for each element, and to score an urban transformation project according to the model.

V. Limitations of the Study

The survey study was held mainly in Turkey's two largest cities, Ankara and Istanbul. By applying the same survey in different cities of Turkey and in other countries, the generalizability of the results could be seen better.

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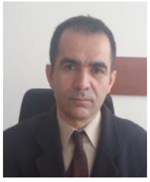

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