

# A Mathematical Model Suggestion for Land-Use Based on Urban Infrastructure

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ABSTRACT: Especially after 20th century in Turkey, it has been observed that unplanned settlements have increased regardless of planning criteria with the acceleration of immigration to large cities. Because of this, the earthquake hazard has increased the risk threat as the most frightening actor. Therefore, there is no inconvenience in expressing that the land-use based on urban infrastructure is the primary factor determining earthquake behaviour. In this article, all the data, analyses and results which are the basis for urban transformation decision, have been analysed together with the results of local and universal applications that shed light on the rates of urban infrastructure areas. The constituted system is defined as appropriate urban transformation model (AUTM). The parameters of AUTM in a relational-matrix together with the boundary values.

Keywords: Land-use; urban transformation; urban infrastructure and social facilities.

**INTRODUCTION:** The urban process or urbanization fact covers as much history as the future. Sometimes occurs together, sometimes occurs on the basis of decisions about a concession and undergo constant change through design or use.<sup>1</sup> It can be considered that urban planning plays an important role in designing the urban landscape as well as in reducing the damage caused by earthquakes and other disasters. The planning decisions made specific to each city form are essential of the urban design of the region. On the other hand, designs without awareness can affect the region's earthquake behaviour negatively, resulting in a relatively inefficient use of especially green areas and social infrastructure areas.

There is no common and universal argument over land use norms in urban areas. Each country, region and settlement can have different rates of urban space under the influence of their own dominant style as well as historical, social backgrounds and lifestyles. By renovation meant essence is not to be destroyed substantially. Unlike that of, renovation is developing a sustainable study in the light of social, cultural, environmental impacts and civilization criteria. Urban renewal is a term of transforming to apprehend its own form without losing the main base with an appropriate manner of historical- cultural heritage.<sup>2</sup> Any argument developed on land use differs changes with parameters such as the original characteristics of the region, the cultural and historical development of the region and the modulation of the location.

In this study, all the data, analyses and results that are taken together with urban planning codes, the results of the local and universal applications which are the basis for the urban transformation decisions and shed light on the rates of the urban infrastructure areas are expressed as the appropriate urban transformation model (AUTM). The AUTM aimed primarily at reaching what land-use rates should be. A suggestion is developed for the method to be followed at the point of making sustainable transformation decisions by helping to determine the proportion of land allocated to urban infrastructure and social facilities. At this stage, at the point of the only urban infrastructure criteria, if the result has a negative interpretation for making a transformation decision, the analysis is completed. Otherwise, if there is a positive approach for transformation, the appropriate urban transformation model study would be started with the additional parameters and determined numerical inputs.

The parameters of the mathematical model are in an active connection with the boundary values which are specified by international and national suggestions. If the results of analyses provide the boundary value conditions, the analysis is completed and evaluations are made in terms of the AUTM. If not, the numerical inputs are revised and analyses are continued until the limit value conditions are met.

In this context; a project area in Istanbul city, Bagcilar district, Kemalpasa quarter which is declared as risky area by 2013/4689 decision of Council of Ministers within the frame of Law Number 6306, has been examined to obtain the reason of transformation and tried to be reached the most proper transformation solution with investigating the urban land-use norms

on universal and local platforms. Also in this study; all parameters of land-use of residential, commercial and residential + commercial functions have been subjected under the definition of urban infrastructure.



Figure 1: Urban infrastructure diagram.

In the urban infrastructure diagram in Figure 1, while the existing situation in the project area is shown at the current model and its data, the appropriate model includes its own data and the boundary values which are set by national, international and recommended criteria.

Table 1: Urban infrastructure data index.

No	Types of current model	Types of app. model
1	Project area (m <sup>2</sup> )	Project area (m <sup>2</sup> )
	Current residential land-	Appropriate residential
2	use area (m <sup>2</sup> ) (le- gal+illegal)	land-use area percentage (%)
3	Current residential land- use area percentage (%) (legal+illegal)	Appropriate residential land-use area (m <sup>2</sup> )
4	Current commercial land- use area (m <sup>2</sup> ) (le- gal+illegal)	Appropriate commercial land-use area percentage (%)
5	Current commercial land- use area percentage (%) (legal+illegal)	Appropriate commercial land-use area (m <sup>2</sup> )
6	Current residen- tial+commercial land-use area (m <sup>2</sup> ) (legal+illegal)	Appropriate residen- tial+commercial land-use area percentage (%)
7	Current residen- tial+commercial land-use area percentage (%) (le- gal+illegal)	Appropriate residen- tial+commercial land-use area (m <sup>2</sup> )
8	Current total land-use area (m <sup>2</sup> ) (legal+illegal)	Appropriate total land-use area percentage (%)
9	Current total land-use area percentage (%) (le- gal+illegal)	Appropriate total land-use area (m <sup>2</sup> )

In this study; 18 parameters including 9 of the current situation and 9 of the appropriate model were analyzed and evaluated (Table 1).

#### MATERIALS AND METHODS:

**1. Current Urban Infrastructure Data Bank:** Table 2; presents the current urban infrastructure. The current land-use area obtained from the feasibility studies of the region where the urban transformation per-

formed is shown in the variable input column. These variable inputs correlated with one another mathematically are in the dependent input column and calculations results are shown in the output column as percentage.

Table 2:	Urban infrastructure data of current
	model.

No	Туре	Varia- ble Input	Depen -dent Input	Output
1	Project area (m <sup>2</sup> )	Х	-	-
2	Current residential land-use area (m <sup>2</sup> ) (legal+illegal)	х	-	_
3	Current residential land-use area per- centage (%) (le- gal+illegal)	-	_	X
4	Current commer- cial land-use area (m <sup>2</sup> ) (legal+illegal)	Х	-	-
5	Current commer- cial land-use area percentage (%) (legal+illegal)	-	_	х
6	Current residen- tial+commercial land-use area (m <sup>2</sup> ) (legal+illegal)	Х	-	-
7	Current residen- tial+commercial land-use area per- centage (%) (le- gal+illegal)	-	_	X
8	Current total land- use area (m <sup>2</sup> ) (le- gal+illegal)	-	х	-
9	Current total land- use area percentage (%) (legal+illegal)	-	-	х

**1.1 Current residential land-use area data:** The existing buildings in the project area have been constructed in building plots where the construction right is recognized and out of the building plots where the construction right is not given. Incorporating these illegal and unlicensed constructions into the accounts, such as in the building plot area, gives misleading results during calculation of the true FAR (floor area ratio) and footprint area values. That is, the validity of the existing FAR and footprint values calculated with the sum is controversial. Because in such a case, the mentioned values can cause the illusion that the results are within the proper planning criteria.

The project area is allocated to 'residential' district according to 1/1000 development plan (Figure 2). Despite the fact that there is not a completely separated area for commercial or residential+commercial (mixed-use), some buildings have commercial function units independently especially on the ground floor.



Figure 2: Development plan of Kemalpasa risky area.

According to this; current residential (legal+illegal) area is as in the following table and covers 73.91% of the area (Equation 1).

Current residential land-use area (m <sup>2</sup> ) (legal+illegal)	÷	Project area (m <sup>2</sup> )	=	Current residential land-use area percentage (%) (legal+illegal)	(1)
34 101 03		46 139 00		73 91%	

The calculations of the compendium list prepared during feasibility studies demonstrate 35.21% of the existing residential constructions are illegal (Table 3).

Table 3: Residential land-use of Kemalpasa risky area.

Area	m <sup>2</sup>	Percentage (%)	Relative Per- centage (%)
Current residential land-use area (legal)	22,096.17	47.89%	64.80%
Current residential land-use area (ille- gal)	12,004.86	26.02%	35.20%
Current residential land-use area (le- gal+illegal)	34,101.03	73.91%	100.00%
Project area (m <sup>2</sup> )		46,139.0	00

The current residential illegal land-use area is 26.02% of the project area and relative percentage is 35.20 of the residential land-use area. The fact that more than 1/4 of the project area and 1/3 of the residential land-use area is constructed illegally. 73.91% of the entire

project area occupied by the residential areas can be accepted as an effective criterion to make a transformation decision.

**1.2 Current commercial land-use area data:** In the project area; there is no existing commercial area. For this reason, the ratio of current commercial land-use area is calculated as 0.00% (Equation 2).

Current commercial land-use area (m <sup>2</sup> ) (legal+illegal)	÷	Project area (m <sup>2</sup> )	=	Current commercial land- use area percentage (%) (legal+illegal)	(2)
0.00		46,139.00		0.00%	

**1.3** Current residential+commercial land-use area data: The current residential+commercial (legal + illegal) land-use area is calculated as 8.77% of the project area (Equation 3).

Current residential+comm ercial land-use area (m <sup>2</sup> ) (legal+illegal)	÷	Project area (m <sup>2</sup> )	=	Current residential+com mercial land-use area percentage (%) (legal+illegal)	(3)
4,047.77		46,139. 00		8.77%	

The calculations of the compendium list prepared during feasibility studies demonstrate 29.70% of the current commercial constructions are illegal (Table 4).

Table 4: Residential+commercial land-use of Kemalpasa risky area.

Area	m <sup>2</sup>	Percentage (%)	Relative Percentage (%)
Current residen- tial+commercial land-use area (legal)	2,845.67	6.17%	70.30%
Current residen- tial+commercial land-use area (illegal)	1,202.10	2.61%	29.70%
Current residen- tial+commercial land-use area (legal+illegal)	4,047.77	8.77%	100.00%
Project area (m <sup>2</sup> )		46,139.00	)

The current residential+commercial illegal land-use area; 2.61% of the project area and relative percentage is 29.70% of the total residential+commercial land-use area. Almost 1/3 of the residential+commercial land-use area being constructed illegally can be considered as a decisive factor in the point of taking a decision for transformation.

1.4. Current total land-use area data: The current total land-use area is the sum of residential, commer-

cial, residential+commercial land-use areas in the project area and it is calculated that it constitutes 82.68% of the project area (Equation 4).

Current total land-use area (m <sup>2</sup> ) (legal+illegal)	÷	Project area (m <sup>2</sup> )	=	Current total land-use area percentage (%) (legal+illegal)	(4)
38,148.80		46,139.00		82.68%	

Current total illegal land-use area is 28.62% of the project area and 34.62% of the total land-use area of the urban infrastructure. 1/4 of the project area and 1/3 of the total land-use area specific to the urban infrastructure, more than 4/5 of the whole project area (82.68%) being filled with construction area, demonstrate the necessity of a transformation study (Table 5).

# Table 5: Current model urban infrastructurerates.

Types of Land- Use	Land-Use Area (m²)	Per- centage (%)	Relative Percent- age (%)
Residential (legal)	22,096.17	47.89%	64.80%
Residential (illegal)	12,004.86	26.02%	35.20%
Residential (legal+illegal)	34,101.03	73.91%	100.00%
Commercial (legal)	0.00	0.00%	0.00%
Commercial (illegal)	0.00	0.00%	0.00%
Commercial (legal+illegal)	0.00	0.00%	0.00%
Residen- tial+commercial (legal)	2,845.67	6.17%	70.30%
Residen- tial+commercial (illegal)	1,202.10	2.61%	29.70%
Residen- tial+commercial (legal+illegal)	4,047.77	8.78%	100.00%
Total (legal)	24,941.84	54.06%	65.38%
Total (illegal)	13,206.96	28.62%	34.62%
Total (le- gal+illegal)	38,148.80	82.68%	100.00%

In the direction of the values in the upper table of the current area, it is necessary to make a proper transformation in the region where the predicted or declared as risky area because of high rate of illegal construction and sporadic development.

As a result; in the light of data and calculations of current urban infrastructure;

- the fact that low-rise squatter houses constitute the majority of the region and that the unplanned urbanization is the determining factor in the area,
- an area larger than 1/3 of the residential use has been occupied by illegal and unlicensed buildings,
- the occupation of residential use is a huge proportion such as 73.91% of the area,
- approximately 1/3 of the residential+commercial land-use area is illegal,
- 1/4 of the entire project area and 1/3 of the total area specific to the urban infrastructure is constructed in contravention of zoning regulations,
- more than 4/5 of the whole area (82.68%) is used in development site (licensed and unlicensed).

Because of all these it is considered necessary to carry out an urban transformation work.

**2.** Appropriate Urban Infrastructure Data Bank: As a result of the urban infrastructure analysis of the current model, assuming that the decision to make the urban transformation study is positive, the proper model analysis for the Kemalpasa risky area has been commenced.

In the urban infrastructure data bank section of the appropriate model, the variable input (VI) column determined according to the need of the region where the urban transformation is to be performed. The usage needs of some data are shown in the legend (L) column. The data indicating is mathematically correlated with one another are in the dependent input (DI) column. The results of the analysis and calculations are in the output (O) column. In addition, the values created from the national and international criteria and suggestions, which determine the adequacy of these outputs, are in the boundary value (BV) column. Whether the outputs are within the limit value standards in the condition (C) and suitability (S) columns (Table 6).



Figure 3: Systematic of obtaining data in appropriate model.

No	Туре	VI	L	DI	0	С	BV	S
1	Project area (m <sup>2</sup> )	-	-	Х	-	-	-	-
2	Appropriate residential land-use area percent-	X	-	-	-	-	-	-
	age (%)							
3	Appropriate residential land-use area (m <sup>2</sup> )	-	x	-	х	х	х	х
4	Appropriate commer- cial land-use area per- centage (%)	X	-	-	-	-	-	-
5	Appropriate commer- cial land-use area (m <sup>2</sup> )	-	x	-	x	х	х	x
6	Appropriate residen- tial+commercial land- use area percentage (%)	X	-	-	-	-	-	-
7	Appropriate residen- tial+commercial land- use area (m <sup>2</sup> )	I	x	I	x	х	X	x
8	Appropriate total land- use area percentage (%)	-	-	x	-	-	-	-
9	Appropriate total land- use area (m <sup>2</sup> )	-	-	-	x	x	х	x

 Table 6: Urban infrastructure data of appr. model.

In Figure 3 the systematic of obtaining data in appropriate model is categorized. Each data belonging to the appropriate model is described in "international" and "national" platform in the light of the related regulations, applications and present results. Literature searches worldwide are gathered together to determine "appropriate value according to AUTM". And finally, at the part of "analysis of the project area" is tried to be reached the proper value of the data in the studied area.

### Table 7: Boundary values for INPUTS.

No	Туре	Interna- tional	Na- tional	Sugges- tion
1	Appropriate resi- dential land-use area percentage (%)	$\checkmark$	$\checkmark$	$\checkmark$
2	Appropriate com- mercial land-use area percentage (%)	$\checkmark$	-	$\checkmark$
3	Appropriate resi- dential+commercia l land-use area percentage (%)	-	-	$\checkmark$
4	Appropriate total land-use area per- centage (%)	-	-	

Table 7 contains the international-national references and the suggestions made in the framework of the AUTM related to the 4 types (input data) of the urban infrastructure data that meet the boundary value requirements. It shows which reference source the parameters are derived from.

In addition to the 4-input data shown in Table 7, the output data, which is the result of the equations of each data, are restricted to boundary value conditions by considering international-national standards and suggested values in the same context (Table 8).

Table 8: Boundary values for OUTPUTS.

No	Туре	Interna- tional	Na- tional	Sugges- tion
1	Appropriate resi- dential land-use area (m <sup>2</sup> )	$\checkmark$	$\checkmark$	$\checkmark$
2	Appropriate com- mercial land-use area (m <sup>2</sup> )	$\checkmark$	-	$\checkmark$
3	Appropriate resi- dential+commercia l land-use area (m <sup>2</sup> )	-	-	$\checkmark$
4	Appropriate total land-use area (m <sup>2</sup> )	-	-	

Analyzes of the 4 types in the output data shown in Table 8 are discussed below in the frame of the appropriate model data systematic.

**2.1** Appropriate Residential Land-use Area Data: Residential land-use area which is specific to urban infrastructure is allowed to make housing construction.



### Figure 4 : Interaction diagram of residential landuse area data.

As shown in the interaction diagram of residential land-use area, residential FAR (floor area ratio) and residential footprint area are the first-order affecting factors (Figure 4).

For residential land-use area data, as shown in the input in Table 7 and the output data in Table 8 the international-national and suggested boundary value references are used.

International values for the residential land-use area data: In residential areas, the ratio of the land-use area for housing development to the urban area is shown on the international field in Table 9.

Table 9: Residential land-use area by country.

USA	CANADA	ENGLAND	SWITZERLAND
51.17 %	63.7%	56.0%	52-65%
3,4 & 5	5	4, 5, 6, 7 & 8	5

The cities of the countries on which these values are based are in line with the region covered by the article. In other words, they are the mega-cities where the population of the people is high. According to this, it is seen that less than 50% of the residential land-use area is not found, whereas in Canada 63%, in Switzerland it is 65%.

*The residential land-use area data in Turkey:* There are residential land-use area distributions in some regions of Turkey on the basis of the studies by Gürel and Çetiner in Table  $10.^{4\&9}$ 

Table 10: Percentage of residential land-use areaby cities in Turkey.

Region	Residential land-use (%)
Balıkesir	63.24%
Ankara (Or-An)	58.40%
Erzurum	47.00%
İzmit	44.86%
Edirne	44.00%
Kütahya	53.60%
Aydın	46.00%
Erzincan	56.90%
Elâzığ	55.90%
Antakya	77.30%
Kars	39.30%
Denizli	62.00%
Average	54.04%

For example; residential land-use in Denizli and Balıkesir is over 60.00%, while in Ankara (Or-An), Erzincan, Elazığ and Kütahya is over 50.00%. The average residential land-use area value is calculated as 54.04%.

The residential land-use area data in AUTM: Urban infrastructure areas are percentage values in mathematical model. The most important criterion for determining and limiting these rates is "type of region ". The type region is one of the most influential legend of the appropriate urban transformation model and is divided into 3 which are residential, commercial, residential+commercial. So, before the calculations are started, the type of region needs to be defined.

In Table 11, boundary values of area distributions according to type of region are given. The ratio of the total land-use area determined to the urban area is limited to 55.00%.

Table 11: Land-use percentages according to typeof region.

Type of region	Residen- tial	Commer- cial	Residen- tial+ com- mercial	
Legend	1	2	3	
Max. Residential land- use (%)	50.00%	5.00%	10.00%	
Max. Commercial land-use (%)	5.00%	50.00%	5.00%	
Max. Residen- tial+commercial land- use (%)	10.00%	10.00%	50.00%	
Max. Total land-use (%)	55.00%	55.00%	55.00%	

According to the type of region:

- Residential regions (Legend 1)
  - It is the area where the resident functional areas are concentrated in the development plans.
  - Total land-use area is max. 55% of the project area
    - ° Max. %50 residential
    - ° Max. %5 commercial (in case of commercial function in residential regions)
    - ° Max. %10 residential+commercial (in case of residential+commercial function in residential regions)
- Commercial regions (Legend 2)
  - It is the area where the commercial functional areas are concentrated in the development plans.
    Total land-use area is max. 55% of the project area
    - ° Max. %5 residential (in case of residential function in commercial regions)
    - ° Max. %50 commercial
    - Max. %10 residential+commercial (in case of residential+commercial function in commercial regions)
- Residential+commercial regions (Legend 1)
  - It is the area where the +commercial functional areas are concentrated in the development plans.
    Total land-use area is max. 55% of the project area
    - <sup>o</sup> Max. %10 residential (in case of residential function in residential+commercial regions)
    - <sup>o</sup> Max. %5 commercial (in case of commercial function in residential+commercial regions)
    - ° Max. %50 residential+commercial

In the light of this data;

• Appropriate percentage of residential land-use area (%): In legend 1 should not exceed 50.00%, in legend 2 should not exceed 5.00% and in legend 3 should not exceed 10.00% of the project area. The

values set for the percentage of residential land-use area provide the idealized criteria according to international standards in AUTM, and even go beyond, showing an approach to the purification of urban fabric from dense building blocks.

• Appropriate residential land-use area boundary value (m<sup>2</sup>): According to Table 11 proper residential land-use area limit value should be no area larger than 50.00% of the project area in legend 1, 5.00% of the project area in legend 2 and 10.00% of project area in legend 3.

The residential land-use area data in the project area: Since the current project area is located in the "residential region", legend 1 is marked and the proper residential land-use area is selected as 45.50%.

Project area (m <sup>2</sup> )	X	Appropriate residential land- x use area percentage (%)		Appropriate residential land- use area (m <sup>2</sup> )	(5)
46,139.00		45.50%		20,993.25	
		45.50 (%) ≤ 50	.00	(%)	

 $20{,}993.25~m^2 \le 23{,}069.50~m^2$ 

In equation 5, according to the residential land-use area limit value set at 50.00%;  $20,993.25 \text{ m}^2$  (45.50% of the project area) is less than the limit value  $23,069.50 \text{ m}^2$  (50.00% of the project area) and bound-ary value condition is provided.

Despite being able to get a value of 50.00% it is selected 45.50%. Because it is related to the residential FAR and the residential footprint area (m<sup>2</sup>), which are the first parameters that are affected by the proper residential land-use area (m<sup>2</sup>) (Figure 4). The mentioned parameters are not elaborated in this article. However, they are subjected to the boundary value requirements brought together from national and international sources such as urban infrastructure parameters.

In case the provision of municipality planning codes of the risky area are taken as a basis, the residential land-use area is to be  $21,904.05 \text{ m}^2$  and 47.47% of the project area. <sup>10 & 11</sup>

**2.2** Appropriate Commercial Land-use Area Data: Commercial land-use area can be expressed as areas that can be constructed for social, cultural facilities, trade and service sector such as shopping malls, hotels and other accommodation facilities, cinema, theater, museum, library, exhibition hall, restaurants, casinos, shopping centers, business centers, office, bazaar, multi storey shops, entertainment units such as wedding hall, administrative buildings, multi-storey car park, banks, financial institutions, dormitories, courses.  $^{12}$ 



Figure 5: Interaction diagram of commercial landuse area data.

As shown in the interaction diagram of commercial land-use area, commercial FAR (floor area ratio) and commercial footprint area are the first-order affecting factors (Figure 5).

For commercial land-use area data, as shown in the input in Table 7 and the output data in Table 8 the international-national and suggested boundary value references are in use.

International values for the commercial land-use area data: In residential areas, the ratio of the land-use area for commercial to the urban area is shown on the international field in Table 12.

Table 12:	Commercial	land-use	area by	v country.
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Country	Urban area ratio (%)
USA	$2.65^{3, 5, 13, 14}$
Canada	$2.90^{5}$
Iran	6.3 <sup>15</sup>
Australia	$2.6^{16}$
Italy	$9.50^{4}$

These areas indicate the commercial land-use areas in the residential settlements and represent values ranging from 3% to 10%. For example, this ratio is 2.65% in the United States and 9.50% in Italy.

*The commercial land-use area data in AUTM:* Table 11, which shows the percentage distributions of project area, represents boundary values. In the light of this data;

- Appropriate percentage of commercial land-use area (%):\_Legend 1 should not exceed 5.00%, legend 2 should not exceed 50.00% and legend 3 should not exceed 10.00% of the project area.
- Appropriate commercial land-use area boundary value (m<sup>2</sup>): According to Table 11 proper commercial land-use area limit value is suggested to be no area larger than 5.00% of the project area in legend 1, 50.00% of the project area in legend 2 and 10.00% of project area in legend 3.

The commercial land-use area data in the project area: The legend 1 is selected for calculations because the project area is in the "residential district" and just like at current situation no commercial land-use area is not reserved.

Project area (m <sup>2</sup> )	Appropriate commercial land- use area percentage (%)	Appropriate commercial = land-use area (m <sup>2</sup> )	(6)
46,139.00	0.00%	0.00	
	$0.00(\%) \le 5.00$	) (%)	
	$0.00 \text{ m}^2 \le 2.30$	6.95 m <sup>2</sup>	

In equation 6, according to the commercial land-use area limit value set at 5.00%;  $0,00 \text{ m}^2$  (0,00 % of the project area) is less than the limit value  $2.306,95 \text{ m}^2$  (5,00% of the project area) and boundary value condition is provided.

**2.3** Appropriate residential+commercial land-use area data: Residential+commercial land-use areas are available for mixed-use. Generally commercial units located on the ground floor independently, typical floors are reserved for residential use at buildings in residential+commercial land-use areas.



#### Figure 6: Interaction diagram of residential+commercial land-use area data.

As shown in the interaction diagram of residential+commercial land-use area, residential+commercial FAR (floor area ratio) and residential+commercial footprint area are the first-order affecting factors (Figure 6). For residential+commercial land-use area data, as shown in the input in Table 7 and the output data in Table 8 the internationalnational and suggested boundary value references are utilized.

The residential+commercial land-use area data in AUTM: In local authority planning codes of Turkey at the zoning statement document defined residential+commercial functions. Besides that, town planning codes permit to build commerce functional on the ground floor in the residential areas. So, there are some independent commercial parts in land zoned for residential use. Even if the zoning statement is approved for residential use, some plots could be utilized for mixed-use according to its own local planning codes.

Table 11, which shows the percentage distributions by project area, has area boundary values. In the light of this data;

- Appropriate percentage of residential+commercial land-use area (%): In AUTM is suggested not to exceed 10.00% in legend 1, 10.00% in legend 2 and 50.00% in legend 3 of the project area.
- Appropriate residential+commercial land-use area boundary value (m<sup>2</sup>):\_According to Table 11 proper residential+commercial land-use area limit value is suggested to be no area larger than 10.00% of the project area in legend 1, 10.00% of the project area in legend 2 and 50.00% of project area in legend 3.

The residential+commercial land-use area data in the project area: Since the current project area is located in the "residential region", legend 1 has been identified and the proper residential+commercial land-use area has been selected as 5.40%.

Project area (m <sup>2</sup> )	X	Appropriate residential+comme rcial land-use area percentage (%)	=	Appropriate residential+comme rcial land-use area (m <sup>2</sup> )	(7 )
46,139. 00		5.40%		2,491.51	
		<b>5.40</b> (%) ≤ 10	0.0	0 (%)	

 $2,491.51 \text{ m}^2 \le 4,613.90 \text{ m}^2$ 

In equation 7, according to the residential+commercial land-use area limit value set at 10.00%; 2.491,51 m<sup>2</sup> (5,40 % of the project area) is less than the limit value 4.613,90 m<sup>2</sup> (10,00% of the project area) and boundary value condition is provided.

Despite being able to get a value of 10.00%, it is selected 5.40%. Because it is related to the residential+commercial FAR and the residential+commercial footprint area (m<sup>2</sup>), which are the first parameters that are affected by the proper residential+commercial land-use area (m<sup>2</sup>) (Figure 6). Percentage of residential+commercial land-use area (%) is the primary factor affecting these parameters being in boundary values.

In case the provision of municipality planning codes of the risky area are taken as a basis, the residential+commercial land-use area is to be 1,517.70 m<sup>2</sup> and 3.29% of the project area.<sup>10 & 11</sup> **2.4** Appropriate total land-use area data: In this study the total land-use area data is the sum of all areas devoted to residential, commercial and residential+commercial land-use areas.



Figure 7: Interaction diagram of total land-use area data.

As shown in the interaction diagram of total land-use area, total landscape area is the first-order affecting factor (Figure 7). For total land-use area data, as shown in the input in Table 7 and the output data in Table 8 the international-national and suggested boundary value references are utilized.

The total land-use area data in AUTM: The boundary values of the area distributions according to zoning districts are given in Table 11; the limit of the main function of each zoning district is 50.00% and the remaining zoned areas are distributed proportionally between side functions. The ratio of the total land-use area to be determined to the urban area is limited to maximum 55.00%. The 55.00% value indicates the sum of residential, commercial and residential+commercial applications. So, according to the AUTM, up to 55.00% of a planning zone can be constructed.

According to the researches, it has been determined that a project area is divided into three main sections in general. Accordingly, if a classification is made;

- Under the title of urban infrastructure: Land-use areas (for residential, commercial and residential+commercial)
- Under the title of transport: Roads
- Under the title of social and technical infrastructure: Public improvement areas

According to this sorting, land-use areas are to be assessed in secondary plan comparison of roads and public improvement areas. Because for humanitarian living conditions the priority is the maximum amount of public improvement areas and the participation of road areas at the appropriate level in the planning area. That's why; the ratio of the "total land-use area" to the urban area should be decided on the basis of the ratio of the road area to the urban area and the ratio of the public improvement areas per capita. This resulted in the AUTM calculations not to exceed 55% of the entire project area.

- Appropriate percentage of total land-use area (%): In AUTM is suggested not to exceed 55.00% of the project area.
- Appropriate total land-use area boundary value (m<sup>2</sup>):\_According to Table 11 proper total land-use area limit value is suggested to be no area larger than 55.00% of the project area.

*The total land-use area data in the project area:* The total land-use area is calculated (selected) as 50.90%.

Project area (m <sup>2</sup> )	Appropriate total land-use area percentage (%)	=	Appropriate total land-use area (m <sup>2</sup> )	(8)
46,139.00	50.90%		23,484.75	
	$50.90 (\%) \le 55.$	00 (	(%)	
	23.484.75 m <sup>2</sup> < 25.	386	.45 m <sup>2</sup>	

In equation 7, according to the total land-use area limit value set at 55.00%; 23,484.75 m<sup>2</sup> (50.90 % of the project area) is less than the limit value 25,386.45 m<sup>2</sup> (55.00% of the project area) and boundary value condition is provided.

In case the provision of municipality planning codes of the risky area are taken as a basis, the total land-use area is to be 23,421.75 m<sup>2</sup> and 50.76% of the project area.  $^{10\,\&\,11}$ 

Despite being able to get a value of 55.00%, it is selected 50.00%. Because it is related to the landscape area (m<sup>2</sup>), which is the first parameter that is affected by the proper total land-use area (m<sup>2</sup>) (Figure 7). The mentioned parameter is not elaborated in this article. However, it is subject to the boundary value requirements brought together from national and international sources such as urban infrastructure parameters.

 Table 13: Appropriate model urban infrastructure rates.

Type of Land- Use	Percent- age (%)	Land- Use Area (m <sup>2</sup> )	Condi- tion	Bounda- ry Value
Residen- tial	45.50%	20,993.2 5	<b>VI</b>	23,069.5 0
Commer- cial	0.00%	0.00	١٧	2,306.95
Residen- tial+ commer- cial	5.40%	2,491.51	V1	4,613.90
Total	50.90%	23,484.7 5	<	23,069.5 0

In the project area, the percentage and metric values of residential, commercial and residential+commercial land-use areas determined according to the selected type of district (residential settlement) are in the range of the limit values (Table 13).

**RESULTS AND DISCUSSION:** One of the most important factors that should be taken into consideration during the urban planning or after the urban transformation decisions are the parameters of the urban infrastructure. These parameters are thought to be the guiding principle of density, which is the basic instrument of planning, as well as the important factors of the first or indirect effects of FAR, footprint areas, building heights, parking lots, over ground and underground construction areas. If the area to be constructed in a zone does not exceed the boundary value conditions of the appropriate urban transformation model, the population density in the area would be kept at the ideal level so that the parameters of the public improvement areas is to be in use adequately.

 Table 14: Urban infrastructural data comparison

 chart

Type of Land- Use	Current situation		Appropriate situation			Boundary values	
Area	Land- use m <sup>2</sup>	(%)	Land- use m <sup>2</sup>	(%)	C ·	Land- use m <sup>2</sup>	(%)
Resi-	34,101.	73.	20,993.	45.	\	23,069.	50.
dential	03	91	25	50	-	50	00
Com- mercial	0.00	0.0 0	0.00	0.0 0	$\leq$	2,306.9 5	5.0 0
Resi- dential + com- mercial	4,047.7 7	8.7 7	2,491.5 1	5.4 0	<1	4,613.9 0	10. 00
Total	38,148. 80	82. 68	23,484. 75	50. 90	$\leq$	25,386. 45	55. 00

In this study, 19 parameters which are related to the existing and suitable situations of urban infrastructure are emphasized and analyzed. In the 4.6 hectares of project area of Bagcilar District Kemalpasa quarter, which is declared as a risky area within the framework of the law number 6306, is tried to depict by land zoned for residential. commercial. residential+commercial areas obtained from feasibility studies and percentages covered by these areas are calculated. As a result of these feasibility studies, according to the mathematical model flow diagram, the appropriate urban transformation model analysis has been adopted by considering that it is necessary to make a transformation decision for the region. In this model, 4 input and 4 output parameters limited in international, national and suggestion form are emphasized and numerical inputs that allow these parameters of the modeled region to stay within the boundary value conditions defined.

Table 14 presents a comparative table of the current situation of the Kemalpasa risky area, the appropriate situation obtained from the mathematical model result, and the possible town planning codes results of local authority.

**CONCLUSION:** When considering the data in Table 14, which is essential to 'urban infrastructure' parameters of appropriate model, the urban transformation needed area is assessed together with the results of which standard and value range required for the region in accordance with the AUTM:

- Residential land-use area: It is seen that in the current situation, the rate of illegal construction is 73.91% and considerably higher than the determined boundary value (50.00%) in the AUTM. According to local authority planning code provisions, 47.47% of the project area is allocated to the residential land-use area and 45.50% is the lowest rank which determined in the appropriate situation.
- Commercial land-use area: There is no area reserved for commercial functions in the current situation and in the development plan. When appropriate model is defined, calculations are made assuming that the regional settlement will be residential same as the plans.
- Residential + commercial land-use area: While it is 8.77% in the current situation, the mathematical model result is drawn to the point of 5.40% in the appropriate model calculations.
- Total land-use area: In current situation; 38,148.80 m<sup>2</sup> and 82.68% of the project area is developed by overbuilt constructions. Most of the buildings constructed in contravention of zoning regulations. In accordance with the town planning codes 23,421.75 m<sup>2</sup> and 50.76% of the area is to be developed site. By the way it is 23,484.75 m<sup>2</sup> and 50.90% in the appropriate model.

As a result; among the urban infrastructure components have been analyzed within the framework of the appropriate urban transformation model. The percentage of the residential land-use area was reduced from 73.91% to 45.50%, the residential+commercial land-use area was withdrawn from 8.77% to 5.40%, and the commercial areas are not included as in the current situation. The building zone of 82.68% and 38,148.80 m<sup>2</sup> has been reduced to 23,484.75 m<sup>2</sup> and 50.90% in appropriate model.

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