SUMMARY DOCUMENT

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Republic of Turkey
Ministry of Industry and Technology
Directorate General of Development Agencies

OUTLINE

1. INTRODUCTION

Socio-economic changes and technological developments alter and shape the structure of spatial relationship at local, regional and national levels. The ease of the mobility of people, goods, information and capital creates specialized networks where distances are not restrictive. These facts make it inevitable to analyze the relationships between settlements in this new dynamic framework in order to determine the structure of the settlement systems.

Within this framework, "**Urban and Rural Settlement Systems in Turkey"** Research Project has been conducted to determine the existing settlement system in Turkey. This project enables;

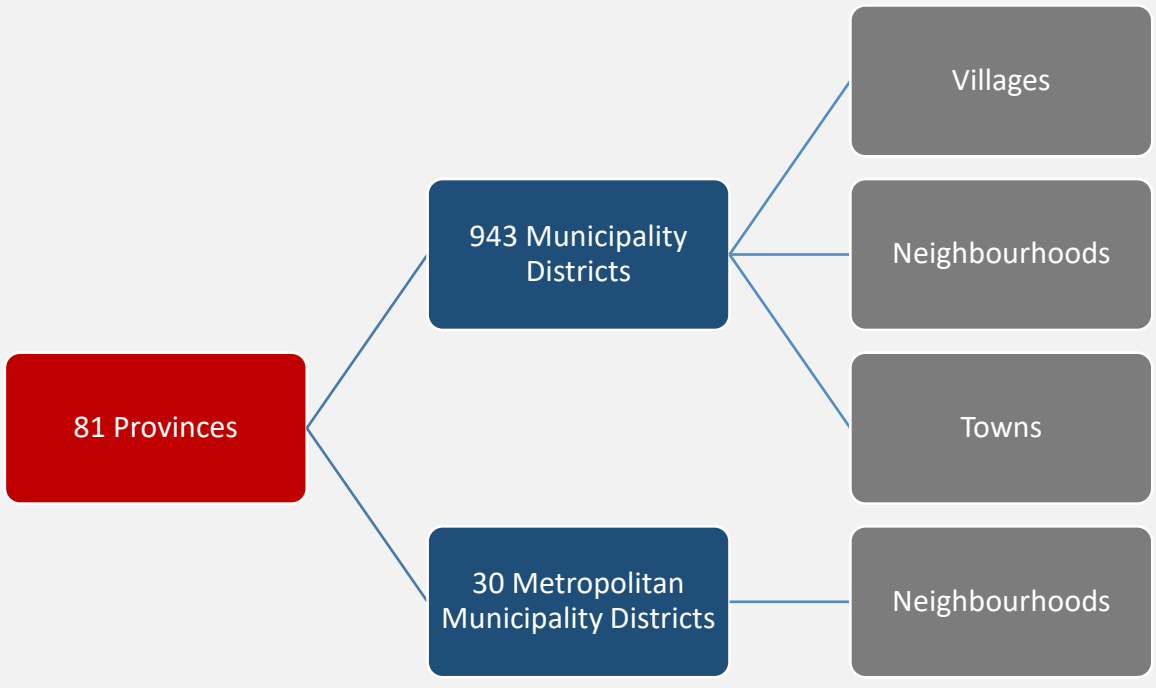
- to reveal the horizontal and vertical socio-economic relations of settlements,
- to determine the nodes, hinterlands and functional regions,
- to discover the socio-economic structure of urban and rural settlements,
- to present dynamic data about relations of settlements via an interactive decision support system.

2. GEOGRAPHIC SCOPE

Geographic scope of the research was determined to include all settlements in Turkey, from the metropolitan areas to the villages, to serve the stated purpose.

Box 1. Settlement Structure in Turkey

Turkey's smallest administrative units of settlements are the villages and neighborhoods each of which are situated in districts. There are also towns in the municipality districts. All the districts are located within the boundaries of provinces. There are 973 districts in Turkey and they are governed by the municipalities. 30 of 973 districts are specified as metropolitan municipality districts.



In the scope of this project, settlements were analyzed in two sections; urban and rural. Analysis unit of urban settlements were the districts (sub-province) and analysis unit of rural settlements were the villages, towns, and neighborhoods. In total, this project takes 81 provinces, 973 districts, 37,036 rural units (including villages, towns, and neighborhoods) into account.

3. DATA SOURCES

The research considers different data sources in two main groups according to the analysis units: urban and rural. For the urban settlements, flow and stock data were obtained from official statistics and administrative records at central level, mostly from public institutions and organizations. These urban settlements data were built on six dimensions: education, health, trade, communication, transportation and cargo in order to consider the mobility of human, goods, service and money among districts, provinces and regions.

Rural data includes five dimensions: education, health, trade, labor force and transportation. The data is collected through field research applied to 37,036 villages, towns, and neighborhoods via a web-based questionnaire to the mukhtars and town mayors. Also, for the transportation flow data, questionnaires are conducted to the officials in districts terminals.

Table 1. Dimensions of Data for Urban and Rural Settlements

Urban	Rural
Education	**Education**
Health	**Health**
Transportation	**Transportation**
Trade	**Trade**
Communication	**Workforce Mobility**
Cargo	

4. METHODOLOGY

The theoretical foundations of studies that aim to determine settlement systems and spatial structure were based on the theory of central places and network analysis. According to the central place theory, goods and services are effectively provided on a hierarchical basis. Centralized settlements offer more goods and services, contain more businesses, and have a higher population than other settlements. The settlements in the upper level contain all the functions in the lower level, as well as some functions that are not available in the lower level. While upper level settlements are less in the number, they can serve in larger areas.

However, rapid developments and changes in the socio-economic structure and relationships of settlements led to the pursuit of a new methodology that includes different approaches like network relations. Network analysis methods examine all relationships between units, demonstrate hidden systematic structures in complex [settlement] systems visually and mathematically. The groups formed by the settlements can be determined with the help of network analysis methods important centers, connections and roles can also be detected visually.

As a result, this project uses a hybrid model of central place theory and network analysis to reveal vertical and horizontal relations, hinterlands and functional areas of settlements with a holistic perspective.

Network analysis was considered as a basis in determining the size of service provision, which is the first step of the study. Generalized degree centrality criterion of network analysis is used to calculate the (service) scores of the settlements.

5. ANALYSIS OF URBAN SETTLEMENTS

Districts are the main analysis unit for the urban settlements. Variables are generated for every dimension and flow relations between provinces are analyzed with network models.

Table 2. Variables Used in Urban Analysis

Data Dimensions	Variable Name	Unit
Education	Student flows in secondary education	Number of students
	Student flows in tertiary education	Number of students
Health	Application to health institutions	Number of applications
Transportation	Road transportation	Number of passengers
	Railway transportation	
	Airline transportation	
	Sea lane transportation	
Communication	Cell phone calls	Number of calls
Trade	Trade flows volume	Turkish Lira
Cargo	Cargo flows	Number of cargos sent

5.1. Network Analysis

The relations between districts, provinces and Nuts-2 regions for secondary education, tertiary education, health, transportation, trade, cargo and communication were examined in detail with several centrality measures of network analysis.

Box 2. Centrality Measures

Centrality measures are the criteria that consider the positions, roles and importance levels of the units in the network analysis from different perspectives.

“Degree centrality” is a measure of how important a unit is in terms of the relationships it has. In directional and weighted networks, such as relations between settlements, connections take the form of input and output, and the concept of degree transforms into two forms: **"in-degree"** expressing input and **"out-degree"** expressing output. In this case, the in-degree is the sum of the weighted flows coming to a settlement, and the out-degree is the sum of the weighted flows going out of that settlement.

"Eigenvalue centrality" measures the importance of a unit in the network not only by the weighted amount of flows it receives, but also by considering the total flows of other units it is connected with. In other words, this criterion highlights the places that have strong ties with the central settlements with the flows it collects.

"Geographical dispersion index" is a new concept generated for the project and be considered as a contribution to the literature. This index expresses the average distance traveled by a settlement to receive that service. The distance here is the bird flight distance between settlements.

"Generalized degree centrality" considers both the number of ties connected to the unit and the weights of the ties connected to the unit. This measure was used for the determination of service centers.

Figure 1. The First 100 Flows in Trade Relations Between Provinces and In-degree Centrality

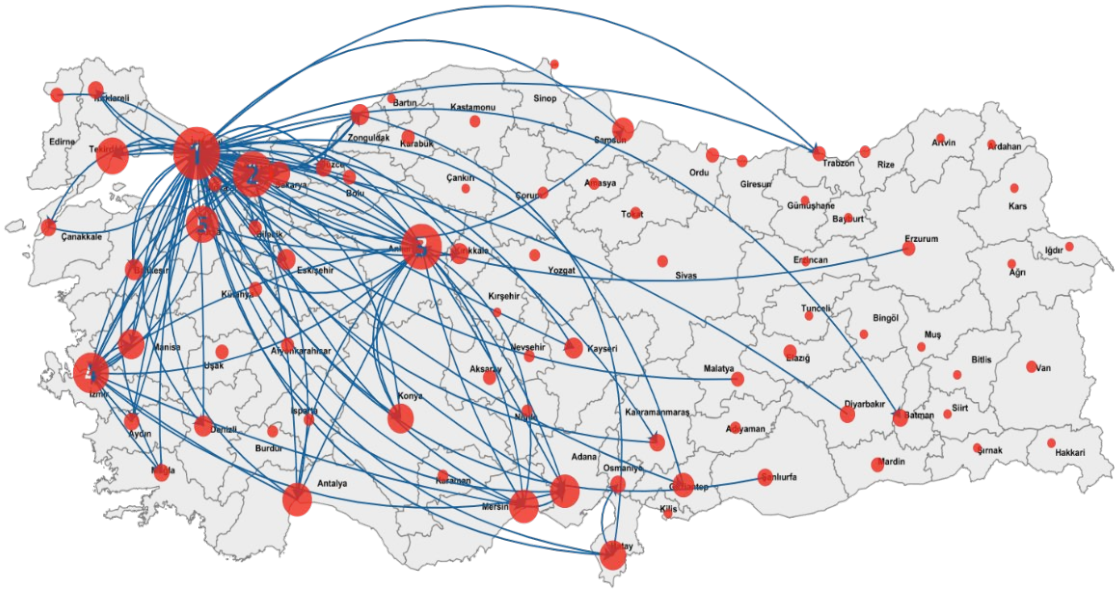
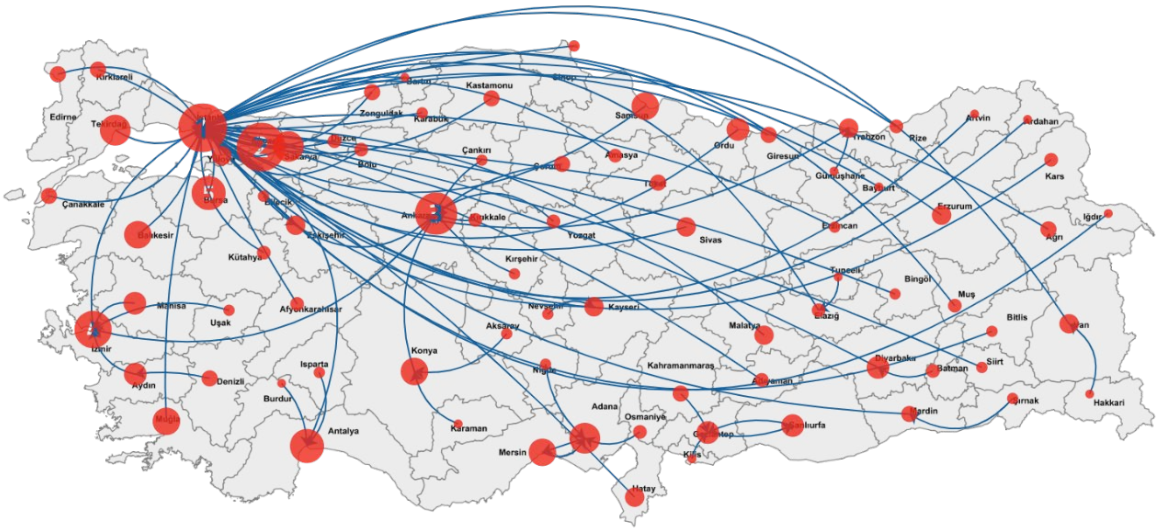


Figure 1 shows the first 100 relations between provinces. Since each of 81 province has connections with other provinces in the trade network, there are 6,480 ties and only the first 100 are reflected on the map. These ties, which make up 1.5 percent of the flows, account for 56 percent of the total trade volume in Turkey.

Here, it is seen that the ties are concentrated in the western part of the country. While there are intense flows to Istanbul from everywhere in the country, provinces such as Kocaeli, Ankara and Izmir are other important commercial centers of the country and they have intense mutual relations among themselves.

The circular sizes of the provinces on the map reflect the in-degree centrality scores of the provinces. The sum of the monetary flows coming to the provinces as a result of commercial activities in the trade network gives the in-degree centrality scores.

Figure 2. The Most Intense Communication Relations of Each Provinces and Eigenvalue Centrality



Since communication relations can be generated for various reasons, it is important to reflect the general socio-economic relations. Figure 2 shows the most important relations of each provinces and the circular sizes reflect the eigenvalue centrality. In eigenvalue centrality, there is an emphasis on the strenght of the ties with central provinces. As Istanbul is the most central province, other provinces which have strong ties with Istanbul also have high scores such as Sakarya and Tekirdag.

Figure 3. The Most Intense Relations of Each Province in Tertiary Education and Geographic Dispersion Index

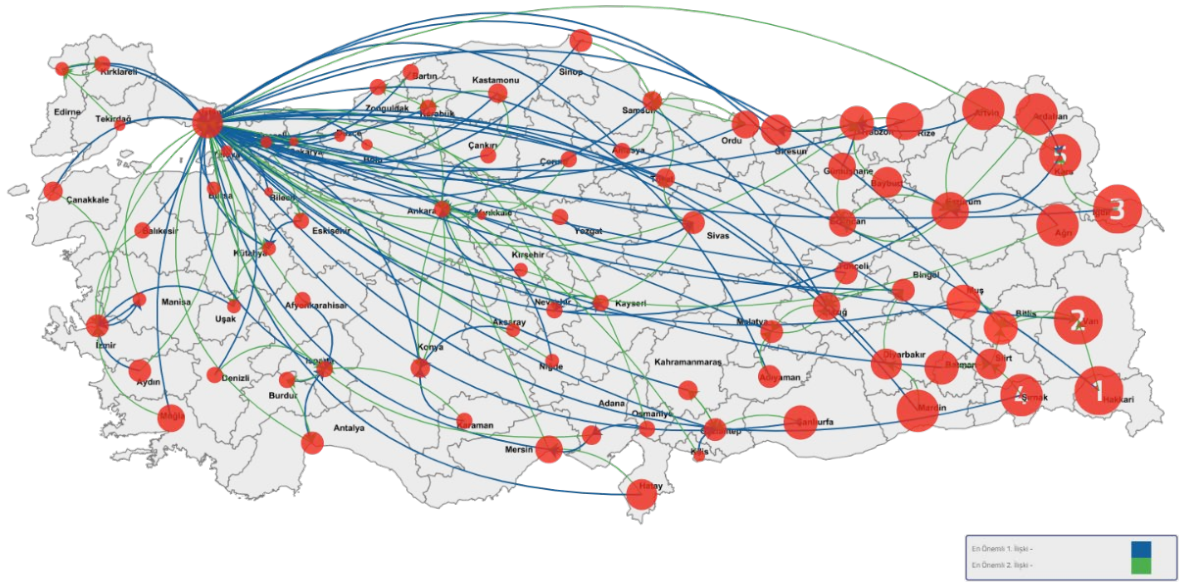


Figure 3 shows the two most important ties of the provinces for tertiary education while blue ties are the most intense ties and the green ties are the second intense ones. The circular sizes reflect the geographical dispersion index which here expresses the average distance taken to access tertiary education. Accordingly, it is seen that the eastern regions of the country take longer distances, the

provinces that go to Istanbul or other distant centers in the first place prefer the closer ones in the second place, and those who prefer close centers in the first place tend to prefer distant centers in the second place.

5.2. Determination of Urban Service Centers

Settlements that provide service to at least one other settlement, for at least one dimension (education, health, communication, etc.) is considered a service center. Here one important point is that the definition and determination of service centers don't consider the volume of service provided within the settlements.

In order to attain a service score for every settlement, here for the districts, generalized degree centrality is utilized. The steps for the determination of urban service centers is summarized in Figure 4.

Figure 4. Steps for Determining Urban Service Centers

5.2.1. Generalized Degree Centrality

The number of settlements served by a settlement corresponds to the degree centrality within the framework of the network analysis. Opsahl et al. (2010) developed a centrality criterion that considers both the number of edges and the weights of the edges connected to the point. This criterion is called generalized degree centrality ($C_D^{w\alpha}$):

$$C_D^{w\alpha} = k_i \times \left(\frac{s_i}{k_i}\right)^{\alpha}$$ Where;

k_i : number of settlements served by settlement i,

s_i : total size of service provided by settlement i to other settlements,

α : calibration parameter.

An approach has been developed for determination of the calibration parameter "α". This approach can be summarized as; using the most appropriate α value by looking at the suitability of service size values (C_{hd}^{wa}) obtained by using alternative α parameter values to the distribution known as Zipf's law or rank-size rule.

In this context, using the general reduced gradient method, the natural logarithm of the general centrality scores obtained with alternative alpha values is placed on the x-axis, and the natural logarithm of the rank of the settlements according to these scores is placed on the y-axis. The value that equals the slope of the linear regression function to -1 or giving the closest value to -1 was selected as the "fine tuning" calibration parameter. Calibration of the aforementioned parameter is a unique approach developed within the scope of the project.

5.2.2. Obtaining the Integrated Service Scores and Integrated Network

The structure of urban service centers was first analyzed by examining the socio-economic relations between settlements in every service dimension. After the generalized centrality scores of service dimensions were obtained, they are standardized to 0-1 levels and weighted.

For the determination of the weights for the seven service dimensions, global clustering coefficients of the networks are used. Table 3 shows the weights of each service dimension network.

Table 3. Weights for Service Dimensions

Variables	Clustering coefficients	Weights
Communication	0.99	0.21
Tarde	0.97	0.20
Cargo	0.85	0.18
Transportation	0.41	0.09
Health	0.77	0.16
Secondary Education	0.25	0.05
Tertiary Education	0.54	0.11

Overall service scores for every settlement are obtained by calculating the weighted sums of standardized generalized degree centrality scores.

The overall service score function for urban settlements (H_α^j) is:

$$H_\alpha^j = \delta_{E_{ort}}.E'^{j}_{ort_\alpha} + \delta_{E_y}.E'^{j}_{y_\alpha} + \delta_S.S'^{j}_{\alpha} + \delta_U.U'^{j}_{\alpha} + \delta_{\text{İ}}.\text{İ}'^{j}_{\alpha} + \delta_T.T'^{j}_{\alpha} + \delta_C.K'^{j}_{\alpha}$$

Where:

H_α^j : composite generalized degree centrality score for settlement *j*,

$E'^{j}_{ort_\alpha}$: normalized generalized degree centrality score for settlement *j,* in secondary education,

$E'^{j}_{y_\alpha}$: normalized generalized degree centrality score for settlement *j,* in tertiary education,

S'^{j}_{α} : normalized generalized degree centrality score for settlement *j*, in health,

U'^{j}_{α} : normalized generalized degree centrality score for settlement *j*, in transport,

$\dot{I}'^{j}_{\alpha}$: normalized generalized degree centrality score for settlement *j*, in communication,

T'^{j}_{α} : normalized generalized degree centrality score for settlement *j*, in trade,

K'^{j}_{α} : normalized generalized degree centrality score for settlement *j,* in cargo,

δ_k : weight for the variable *k*

(k: secondary education, tertiary education, health, trade, communication, transportation and cargo*)*

Figure 5. First 300 Relations of Districts in Integrated Network

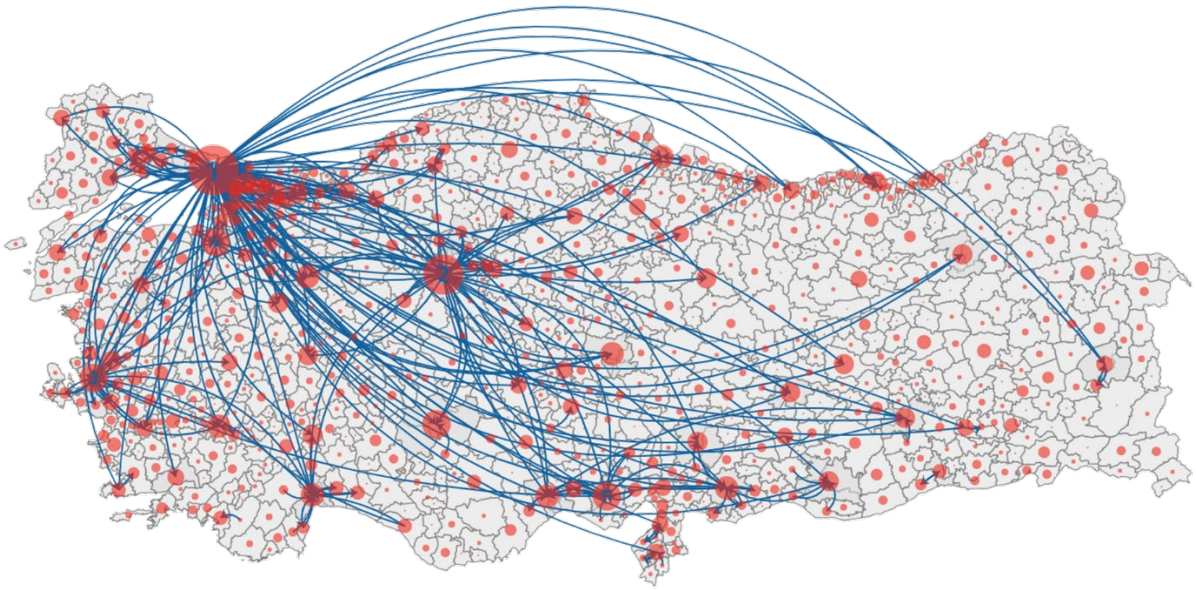


Figure 5 shows the first 300 ties between urban settlements in integrated network. The size of the circles demonstrates the generalized degree centrality scores. It is seen that the flows in the first 300 are concentrated in the Marmara Region with the impact of Istanbul. Inspite of the distance, there are mutual relations of the eastern settlements with Istanbul.

After obtaining the integrated network and overall service scores, the service center categories were determined by applying head and tail breaks and natural breaks clustering algorithms on the scores obtained since the data conforms to the rank-size rule and therefore it presents a heavy-tailed distribution.

By applying both head and tail break and (Jenks) natural break clustering algorithms to the overall service scores of each settlement and taking the average of the results of these two algorithms, 13 service center groups were obtained. Figure 6 demonstrates geographical distribution of these service centers and Figure 7 gives the number of settlements in each category. It is seen that the settlements in the eastern part of Turkey usually are among the lower level groups.

Figure 6. Urban Service Centers in Turkey

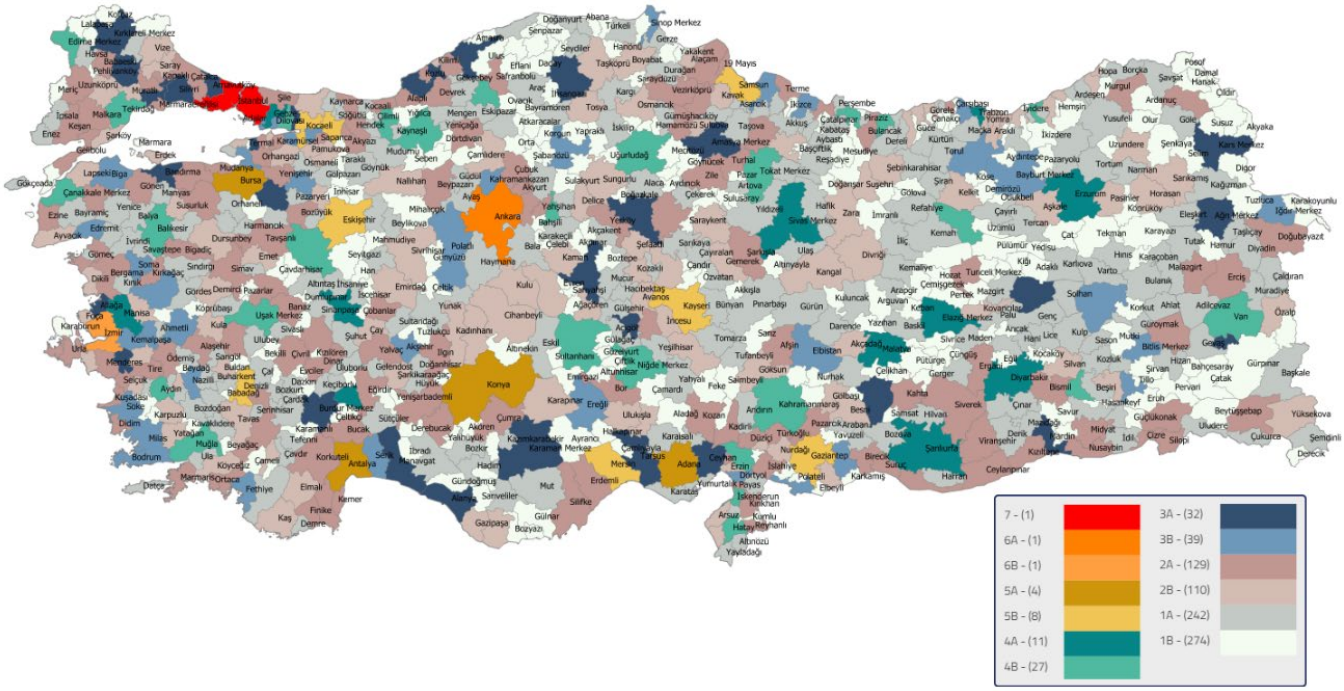
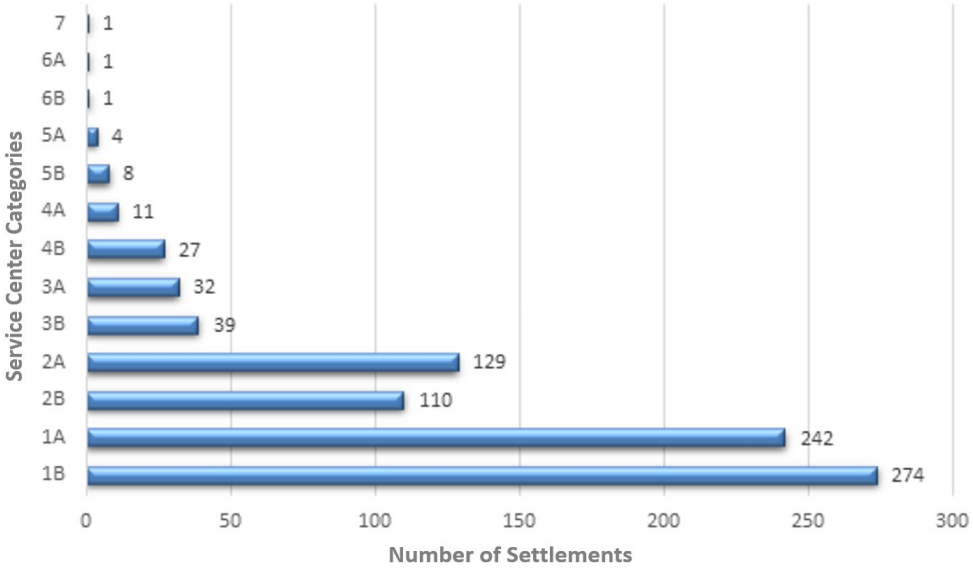


Figure 7. Urban Service Center Categories by The Number of Settlements



6. ANALYSIS OF RURAL SETTLEMENTS

Service relations among 37,036 villages, neigbourhoods and towns were examined in five service dimensions which are listed below:

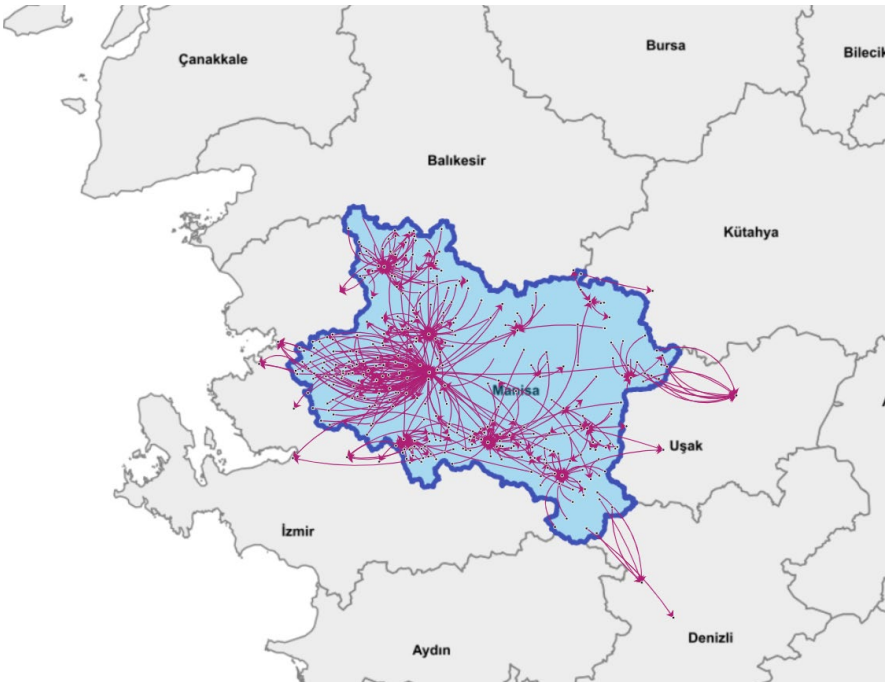
- *Education*
  - *Primary, Secondary, High School, Technical High School*
- *Health*
  - *Family Health Center, Hospital, and Pharmacy*

- *Trade*
    - *Daily (Food, Clothing and Household Appliances, Repair and Maintenance Works)*
    - *Non-Daily (Construction Materials; Seeds, Fertilizers and Pesticides; Spare Parts; Fuel; Bank, Deposit and Credit Transactions)*
- *Labour Mobility*
    - *Daily*
    - *Non-Daily (Seasonal*
- *Transportation*

6.1. Service Relations of Rural Settlements

Analysis of rural settlements is mainly based on analyzing the service providing relations of rural settlements. In other words, where the rural settlements meet their needs other than itself and the intensity of those relations were considered.

Figure 8. Daily Regular Workforce Mobility in Rural Settlements of Manisa



Due to the massive amount of relations of 37,036 rural settlements, flows cannot be demonstrated covering all over the country. Figure 8 is an example of daily regular workforce mobility flows of rural settlements in Manisa province. It can be seen that the general flows occur within the province but there are some exceptional flows to the neighboring provinces. On the other hand, Figure 9 illustrates the seasonal agricultural workforce flows from the province Igdır. Flows usually fronted to the other provinces even to very distant Istanbul.

Figure 9. Seasonal Agricultural Workforce Mobility in Rural Settlements of Igdır

6.2. Determination of Rural Service Centers

As for the determination of rural service centers, generalized centrality scores of each rural settlement for every service dimension were calculated. After the standardization of the scores to 0-1 level, weighted sums are obtained in order to get the overall service scores of the rural settlements.

The overall service score function for rural settlements ($H^{j}_{kSwN\alpha}$) is:

$$H^{j}_{kSwN\alpha} = \beta_E . E'^{\,j}_{SwN\alpha} + \beta_S . S'^{\,j}_{SwN\alpha} + \beta_T . T'^{\,j}_{SwN\alpha} + \beta_{IA} . IA'^{\,j}_{SwN\alpha} + \beta_{IB} . IB'^{\,j}_{SwN\alpha} + \beta_U . U'^{\,j}_{SwN\alpha}$$

Where;

$H^{j}_{kSwN\alpha}$: composite generalized degree centrality score for settlement *j*,

$E'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j,* in education,

$S'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in health,

$T'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in trade,

$IA'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in daily workforce,

$IB'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in seasonal workforce,

$U'^{\,j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in transport,

β_k : weight for the variable *k.*
(k: education, health, trade (daily, non-daily), labor (seasonal and permanent) and transportation*)*

The primary factor weights of the variables which are obtained by applying principal component analysis and the related weights of the variables are shown in Table 4.

Table 4. Primary Factor and Variable Weights

Variables	Primary factor weights	Variable weights (β_k)
$E'^{j}_{SwN\alpha}$	0.7430	0.2353
$S'^{j}_{SwN\alpha}$	0.8151	0.2581
$TA'^{j}_{SwN\alpha}$	0.7684	0.2433
$TB'^{j}_{SwN\alpha}$		
$IA'^{j}_{SwN\alpha}$	0.2674	0.0847
$IB'^{j}_{SwN\alpha}$	-0.2593	0.0821
$U'^{j}_{SwN\alpha}$	0.3047	0.0965
Total	3.1578	1.0000

After obtaining the overall service scores, 6 service center categories for rural settlements were determined by applying head and tail break and Jenks natural breaks algorithm. Figure 10 shows geographical distribution of these service centers and Figure 11 gives the number of settlements in each category.

Figure 10. Rural Service Centers in Turkey

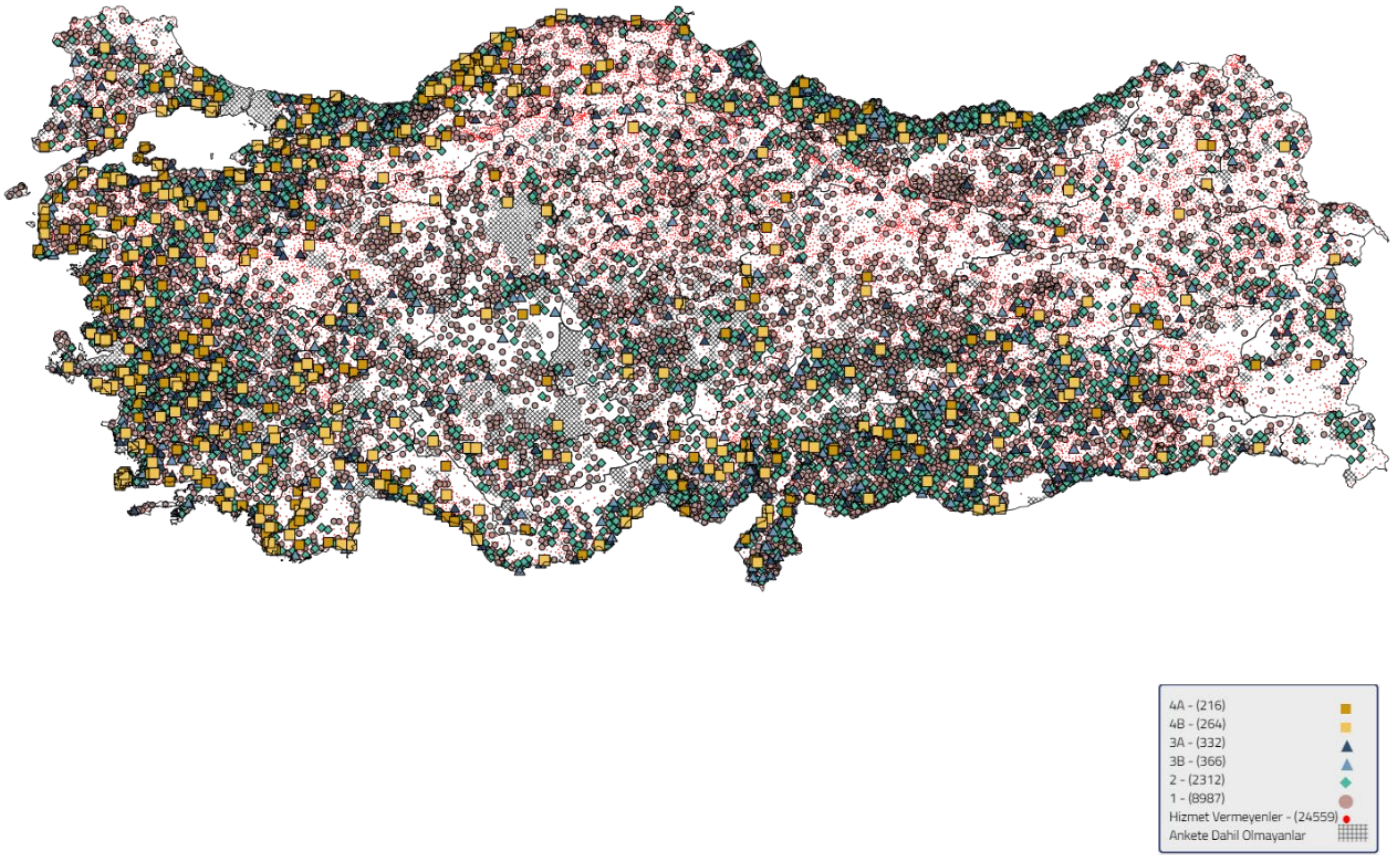
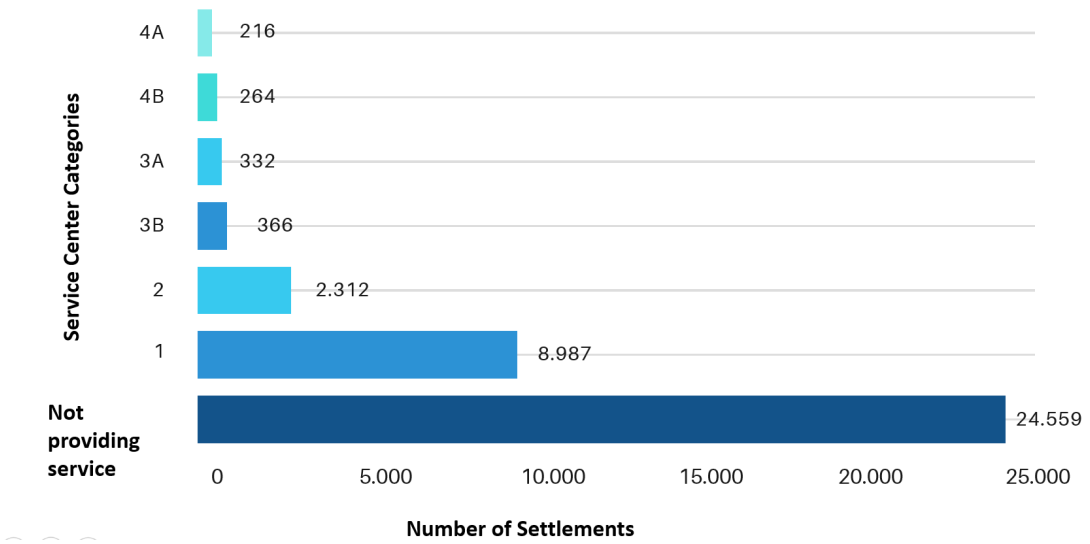


Figure 11. Rural Service Center Categories by The Number of Settlements



Within the scope of the study, 12,478 out of 37,036 rural settlements provide services to at least one different settlement, in at least one of the service dimensions. There are 24,559 rural settlements which do not provide any service to other settlements in any of the dimensions.

7. INTEGRATION OF URBAN AND RURAL SERVICE CENTERS

Although urban and rural service centers were determined, there are also settlements reflecting semi-urban semi-rural features. Within the scope of YER-SIS, settlements with these characteristics were also considered and these were classified as transition settlements.

274 settlements which have the lowest degree among the urban service centers (1B) and 216 settlements which have the highest degree among rural service centers (4A) are considered as transitional settlements from rural to urban due to their similar characteristics.

Table 5. Primary factor and variable weights for the Transitional Settlements

Variable	Primary factor weights	Variable weights (β_k)
$E'^{j}_{SwN\alpha}$	0.8842	0.2588
$S'^{j}_{SwN\alpha}$	0.9124	0.2670
$TA'^{j}_{SwN\alpha}$	0.5520	0.1615
$TB'^{j}_{SwN\alpha}$		
$IA'^{j}_{SwN\alpha}$	0.0441	0.0129
$IB'^{j}_{SwN\alpha}$	0.2196	0.0643
$U'^{j}_{SwN\alpha}$	0.8049	0.2355
Total	**3.4171**	**1.0000**

In order to integrate rural and urban settlements within transition from rural to urban common data which was produced in the same standards is needed. Within the scope of field research data for all types of settlements was obtained. By using field research data generalized centrality scores were calculated, standardized to 0-1 levels and weighted by applying principal component analysis and the related weights of the variables are shown in Table 5.

By calculating the weighted sums as it was for urban and rural service centers, transitional settlements were graded and rural and urban service centers structures were integrated. After obtaining the integrated overall service scores, the transitional service center categories were determined by applying head and tail breaks and natural breaks clustering algorithms.

$$G^{j}_{kSwN\alpha} = \theta_E . {E'}^{j}_{SwN\alpha} + \theta_S . {S'}^{j}_{SwN\alpha} + \theta_T . {T'}^{j}_{SwN\alpha} + \theta_{IA} . {IA'}^{j}_{SwN\alpha} + \theta_{IB} . {IB'}^{j}_{SwN\alpha} + \theta_U . {U'}^{j}_{SwN\alpha}$$

Where;

$G^{j}_{kSwN\alpha}$: composite generalized degree centrality score for settlement *j*,

${E'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j,* in education,

${S'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in health,

${T'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in trade,

${IA'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in daily workforce,

${IB'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in seasonal workforce,

${U'}^{j}_{SwN\alpha}$: normalized generalized degree centrality score for settlement *j*, in transport,

θ_k : weight for the variable *k*

(k: education, health, trade (daily, non-daily), labor (seasonal and permanent) and transportation*)*

Figure 12. Transitional Service Center Categories by The Number of Settlements

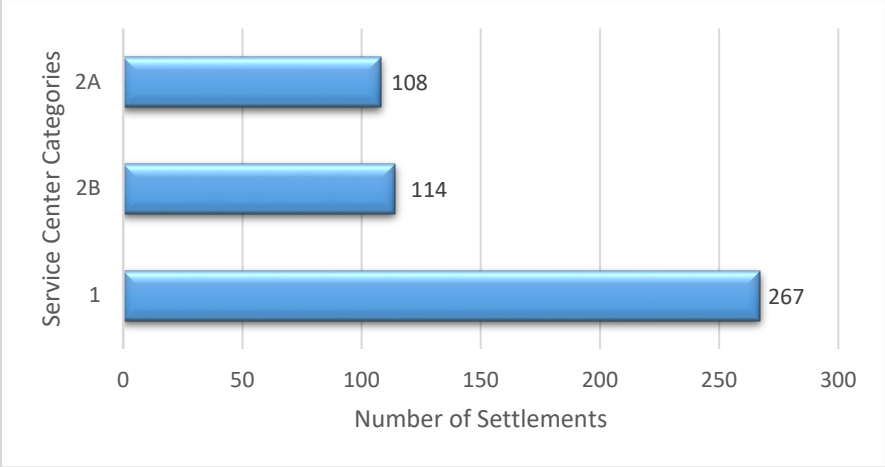


Figure 12 shows the number of settlements in each transitional service categories. Among the 489 transitional service centers, 108 settlements were in category 2A which is the highest level of transitional categories. Within 108 settlements in 2A, 103 are urban and 5 are rural settlements. Among the 114 settlements at 2B category, 27 are rural, 87 were urban settlements. And at the lowest degree of transitional settlements, there are 83 urban, 184 rural settlements.

8. HINTERLANDS AND FUNCTIONAL AREAS FOR URBAN SETTLEMENTS

The hinterlands and functional areas for urban settlements were specified by considering the service scores and groups of the service centers. It is taken as a prerequisite for each urban settlement to be connected to "one" other settlement which has a higher composite urban service score than itself. This prerequisite for can be stated as follows:

$H_\alpha^i < H_\alpha^j$ Where:

H_α^i : composite urban service score for score for settlement i,

H_α^j : composite urban service score for score for settlement j.

In this framework, the settlement i is "connected" to the settlement from where it receives the highest service rate.

$$b_K^{i,j} = \begin{cases} 1, H^{i,j} = max\{H^{i,1}, H^{i,2}, H^{i,3}, \dots, H^{i,n}\} \\ 0, H^{i,j} \neq max\{H^{i,1}, H^{i,2}, H^{i,3}, \dots, H^{i,n}\} \end{cases}$$ Where;

$b_K^{i,j}$: Connectivity of settlement i to settlement j,

$H^{i,j}$: Composite service flow size that settlement i receives from settlement j,

n : is the total number of settlements serving to the settlement i.

As a general rule, the service received from the settlement *i* itself is not taken into account. On the other hand, every urban settlement except Istanbul, which is at the top of the service center structure, is connected to only one urban settlement and it is obligatory to be connected to a settlement.

When this approach is applied to all urban settlements without any restrictions, it is observed that all settlements are connected to Istanbul, which is at the top of the urban service centers, either directly or after a few ties (Figure 13).

However, for the effectiveness of policy formulation, planning and investment programming at the regional level, it is essential to identify smaller scale relationships. For this reason, additional constraints related to distance and service center groups are included in the analysis in determining the hinterlands and functional areas.

Figure 13. Hinterlands and Functional Regions without Constraints

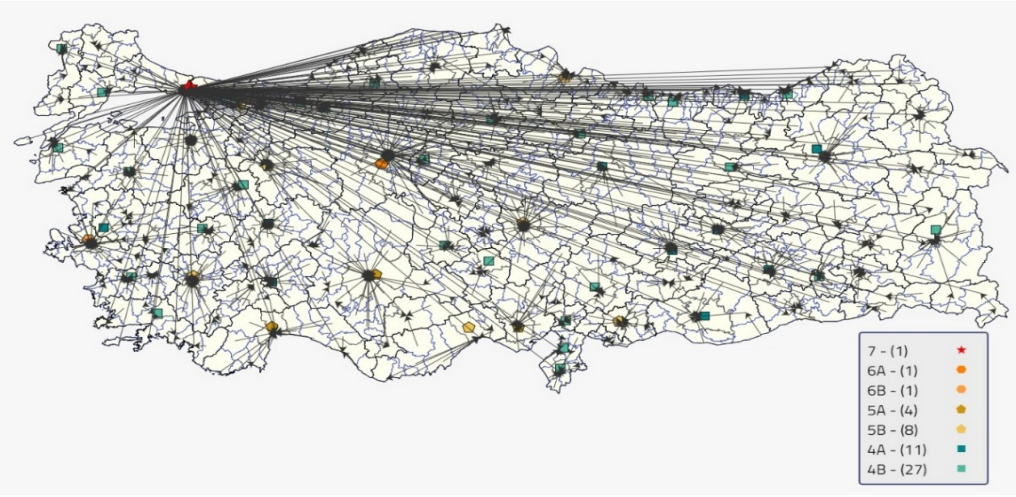
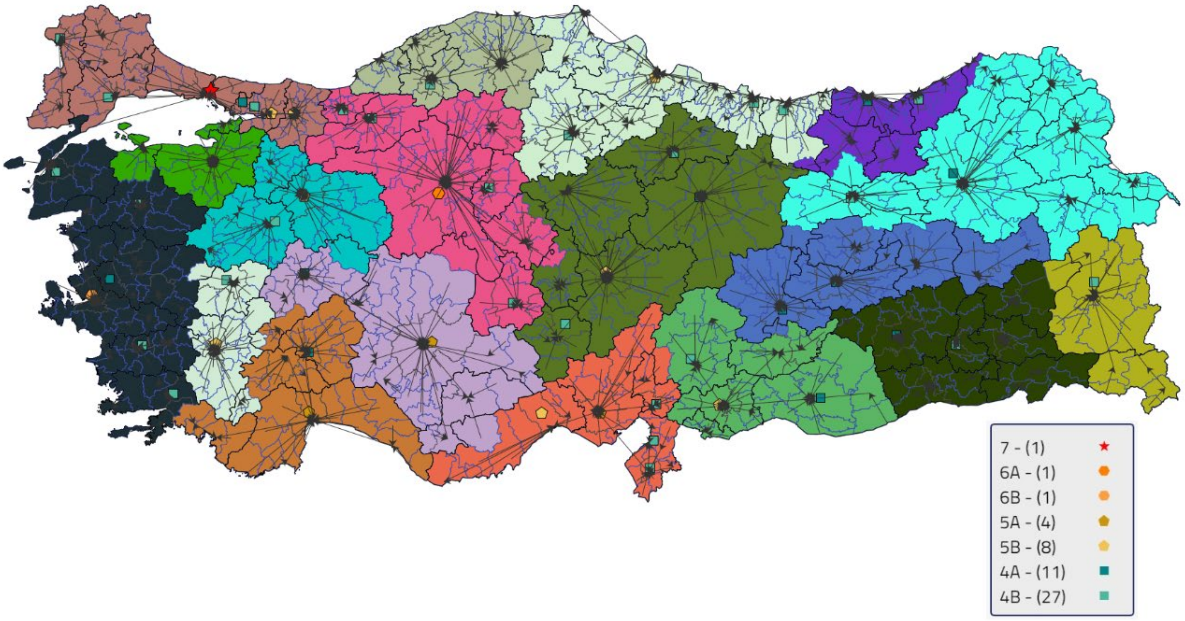


Figure 14. Hinterlands and Functional Regions with Constraints



Constraints:

- In order to ignore the many weak relationships between settlements, the threshold ratio for the minimum service size was determined as 0.02 in the study. In determining this ratio, the distribution of the service receiving rates among the settlements was examined, and it was observed that there were a large number of weak relationships below this rate.
- Second constraint is the provincial neighborhood. If the provinces don't have a border, they cannot be connected to each other.
- The last constraint is that the settlements that are in the top 4 urban service center groups cannot be connected to other settlements, since they will be considered as regional centers. However, there is an exception; if the distance between settlements is below a certain threshold value, higher grouped settlements can be connected to settlements at their level or higher levels. In this framework, the threshold value was determined as 150 km, taking into account the average distances between top 4 level settlements.

By applying those constraints, 18 functional areas are obtained in Turkey as shown in Figure 14.