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GeoValueIndex map of public property assets generating via Analytic Hierarchy Process and Geographic Information System for Mass Appraisal

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Abstract. The aim of this study is to develop a value-based GeoValueIndex with AHP weights and GIS for the criteria of the Mersin University (MEU) Çiftlikköy Campus real properties, and it is referred to as the "GeoValueIndex" in this study. GeoValueIndex is a symbolic value that combines geographic and non-geographic features of real properties. The data of the real properties on the campus were collected and arranged for mass appraisal. One of the Multi Criteria Decision Analysis (MCDA) methodologies, Analytic Hierarchy Process (AHP), was used to weight the criteria. GeoValueIndex was calculated by multiplying each parcel's geographic and non-geographic data by their weights and adding them. GeoValueIndex Map is obtained by associating GeoValueIndex and parcel in GIS software. GeoValueIndex of real properties save time, effort, and cost in mass appraisal processes. There are many techniques for doing GeoValueIndex operations, and the ones presented in this study are only proposals.

Keywords: Public Property Assets, Mass Appraisal, Analytic Hierarchy Process, GeoValueIndex.
JEL codes: C02, D79, K25, R39.

1. INTRODUCTION

1.1 The state and public property assets

The state properties that include national real estate, Treasury goods, or simply "Treasury", are real properties saved and managed by the State. Private properties are real properties that are under the purview of both real and private legal entities and are governed by private law. Additionally, there are real properties that the State also owns in private property. The state and private properties are different from each other. When the state properties are exerted by appropriating for public institutions, the private properties can be used with the public interest through expropriation. The private

properties cannot be used if there is no public interest. The revenues from state property vary according to time, countries and applied economic and financial policies. These indicate the State's fixed capital[1]. In addition to providing revenues from public properties, the state also receives revenues from privately owned properties. Transactions involving state-owned assets, such as sales, leasing, bartering, adequate pay, and easements, as well as payments for private properties, including property taxes, income taxes, insurance premiums, and value-added taxes, are seen as a regular source of income for the state. Therefore, the most important income sources of countries are real properties.

The state properties are handled according to the budget type of public institutions and organizations[2]. The state properties can be classified as four headings:

- Privately owned by the Treasury;
- Places under the sovereignty and disposal of the State (rocks, hills, mountains, sea, lake, river, etc.);
- Places reserved for public service (police station, school buildings, hospital, library, prayer place, etc.);
- Places in the common use of the public (pasture, highland, winter quarters, threshing and fairgrounds, etc.).

All of these real properties are managed by the State. The real properties that are privately owned by the Treasury and the places under the sovereignty and disposal of the State, which are not subject to registration and restriction, are also referred to as National Real Estate[3]. Public properties are those assets that are registered in the name of a public legal entity and reserved their usages for public interest[4]. These consist of treasury lands, land and buildings belonging to universities, public institutions and organizations, etc. Some of the treasury properties have been allocated to the universities and other institutions. The treasury properties consist of registered private owned properties, the places under the sovereignty and disposal of the State, and related properties. According to the report of the General Directorate of National Real Estate (MEGM), these are 4 million 662 thousand 231 units. The total surface area of these corresponds to approximately 44.4% of Turkiye's surface area. According to the report prepared two years ago, it was seen that the number of real estates increased by 10.9% [5].

State and public properties are very productive resources for countries. However, it is not fully utilized. Realistic policies should be adjusted to life by determining targets for solving land-related problems in order for them to be used efficiently and effectively. Policies can be listed as economic growth, justice and social development, transparent financial situation and environmental sustainability (Zimmermann, 2007). For the innovative management techniques, conformity of new public management examined the examples of Canada (Glor, 2001) and the USA (Lynn, 2005). The new public land management is proposed by including accrual accounting in the public sector. It is remarked that accrual accounting is a system used by the private sector and the management tends adopt to the system (Grover, 2008).

While some of university properties are registered to the public legal entity, some of them are able to be allocated from treasury/forest properties. Considering universities' historical development, campus places were generally established outside the cities (Aydın, 2019). There is a need to put forward strategic campus management within the geographic information system in managing universities properties in a sustainable way (Heijer, 2011). In order to leave a liveable, healthy, and peaceful environment on university campuses to future generations, it is necessary to make correct and appropriate decisions about the use of properties.

Capital power should be revealed by presenting unit square meter values or value indexes in a way that the values of the properties are transparent and be calculated the fair current market value. The current market value is used in several countries such as Finland, Germany, Lithuania, and Sweden (Barańska, 2013; Finnish, 2019; Skatteverket, 2015; Stenkula, 2014). In addition, by including the value in the management of public properties, expensive properties were sold, cheap ones were purchased and service buildings were privatized in Sweden (Lundström and Lind, 1996). It is stated that because the financial systems in the economies of Europe and North America are more transparent, consistent models have been formed in both the public and private property markets. It has been determined that there is economic instability as Asia's public property market is unstable and real estate developers and construction activities dominate the property market (Liow and Yeo, 2018). The Polish public land management system is examined and proposed some changes in the system. The land management of some countries is analyzed and compared with questionnaire data. The importance of the decision-making process is revealed by clearly defining the management's goal and scope (Gross and Zróbek, 2015). The market's current property prices should be assessed for public investments. Property value is used for many transactions such as

[1] See also the study of Söyler (2005) on the state properties.
[2] See also the book of Kardeş (2019).
[3] See also the study of Bozpınar, (2021) on the History of The Ottoman National Real Estate Organization.
[4] See also Kadastro Kanunu (Cadastre Law) (1987).
[5] See also the report MEGM (2022).

expropriation, insurance, nationalization, privatization, and credit facilities as well as balance sheet accounts in public administrations and transfer transactions (Invest, 2021; Karagöz, 2010; Soto, 2017; Yalpır, 2007; Yıllık Program, 2018).

1.2 Mass Appraisal of the Public Property Assets

In land management, the real property value has an important role in making the final decisions and ensuring the balance of tax and income. Because of specifically immigration, the rapid concentration of the population in cities directs the development of cities. Accordingly, the land is constantly evolving and changing. At every stage of cadastral operations, zoning applications (Yılmaz and Demir, 2017), housing, industrial, and agricultural land projects (Sagaydak and Sagaydak, 2022), the value of the property rises. In contrast to this, the construction of places such as waste disposal area, garbage collection centers, natural gas and cylinder filling facilities also has a decreasing effect on the value of the property. The value is a crucial piece of property information in calculating the project fees, finding the purchase and selling fees, calculating the income and tax values, and estimating the expropriation price. These provide a serious source of income for the countries.

The value in the management of public property assets is utilized for the Court of Accounts' follow-up to ensure the effective use of treasury assets via accounting for the property. The public institutions and organizations within the scope of Law No. 5018 the Public Financial Management and Control[6], including universities, present Activity Report. Their reports are published every year. It announces to the public that their responsibilities and duties to the public and the State are fully fulfilled and that the resources in their properties are used economically and correctly. In addition, whether the public properties have decreased or not and whether they are used correctly and appropriately is shown by their value.

The properties listed in the land registry on behalf of the legal entity of the Universities are service assets that fall under the category of public properties[7]. The Council of Higher Education, universities and high technology institutes are classified as special budget administrations (Kamu Mali, 2003). It is important to know the value of university properties so that they may be managed better. Therefore, while university properties are specifically appraised, some transactions are similar in considering public properties (Arslan, 2017). In addition, there is a variety of property the form of Treasury, forests, and others that are allocated on behalf of the legal entity of the Universities. Depending on the growth of the universities, construction areas and land uses are changing in line with the needs. In this case, value change also takes place. According to property criteria, environment and economic conditions value maps need to be renewed periodically. However, as long as the criteria remain constant, the system that will allow only the change in value is considered especially suitable for public properties.

There is legislation specifying the procedures and principles regarding the management of the properties owned and used by universities. In Turkiye, the universities which have the legislation (Dicle, 2010; Hacettepe, 2015; İKÇ, 2015; OMÜ, 2011) manage transactions of their properties better. These transactions are sale, exchange, prior authorization, real estate or construction in return for the flat, establishment of the easement, leasing, adequate pay, evacuation, real estate development and valuation. These are carried out either directly or indirectly with the value. The relevant university presents these in the Activity Report. The university prepares the Activity Report following the principles of accuracy, transparency, consistency, impartiality and openness. The report is announced to the public by the Rector and a copy is sent to the Court of Accounts, the Ministry of Treasury and Finance. The Court of Accounts reviews university report and publishes the audit findings[8].

The value of university property should be found by taking into account all the properties as mass appraisal. Mass appraisal of university property is conducted using both geographic and non-geographic data, which constitute property criteria. This approach enables simpler and faster conduct of mass appraisal studies, where criteria affecting the property value are identified, the weight of each criterion is determined, and the GeoValueIndex generation processes are established.

The GeoValueIndex is similar to the nominal value. The nominal method is one of the real estate valuation methods and based on scoring. A nominal asset value-based land readjustment model was developed. In the

[6] See also Kamu Malî Yönetimi ve Kontrol Kanunu (Public Financial Management and Control Law), (Kamu Mali, 2003).

[7] See also Kamu İdarelerine Ait Taşınmazların Kaydına İlişkin Yönetmelik (Regulation on the Registration of Real Properties Owned by Public Administrations) (Kamu Kayıt, 2006) and Kamu İdarelerine Ait Taşınmazların Tahsis ve Devri Hakkında Yönetmelik (Regulation on Allocation and Transfer of Real Properties Owned by Public Administrations) (Kamu Tahsis, 2006).

[8] See also Kamu İdarelerince Hazırlanacak Faaliyet Raporları Hakkında Yönetmelik (Regulation on Activity Reports to be Prepared by Public Administrations) (Faaliyet Raporu, 2006).

land readjustment, a nominal value was used to represent a land value (Yomralioglu, 1993). A GIS-based application was built for the study in Kaşüstü Town, Trabzon Province, to analyze the value difference in the transformation of agricultural land into a zoning parcel. A nominal unit value map was generated by scoring the landscape criterion on a parcel-by-parcel basis between 0-100 (Başer and Dizdar, 2009). The coefficients for the locational, physical and legal conditions of the plots were calculated on a block basis using the AHP method. The physical and legal situation's coefficients were presented as numbers while mapping the AHP weights of locational features (Unel and Yalpir, 2014). The Cobb-Douglas functional, which is the most popular non-linear function, were used as hybrid with multiple regression and AHP weights for estimating the market value with housing criteria in the sales comparison approach (Lisi and Iacobini, 2018). In İzmir, nominal value maps were produced with AHP weights by taking into account 11 locational and slope criteria, and nominal values of pixels were converted into market values (Kayalık and Polat, 2023a). In Berlin, both land and building-based nominal value maps, which were generated using the AHP weights of 11 various locational and slope criteria, were presented in 3 dimensions by classifying very valuable, valuable, less valuable and least valuable (Kayalık and Polat, 2023b).

In a different study, to estimate values, nominal asset values were created with the help of GIS. The questionnaire application in Yomralioglu (1993)'s study, in which the criteria were scored over 100, was used to determine the criteria weights. Each pixel value of the land was multiplied by the weight of the relevant criterion. The process was repeated for the other criteria and results were added up. Their nominal values which are the weighted total were then found (Nişancı, 2005; Nişancı and Yomralıoğlu, 2002). The data of the criteria affecting the value in the city of Oradea were examined for the nominal valuation. These data were generated as a foundation for nominal value by being organized in GIS software (Droj et al., 2010). The study in the Beyoğlu district of Istanbul was implemented with the nominal valuation method. Geographic criteria were weighted with the Best Worst Method. On the other side, raster maps of geographic data were produced with the Euclidean Distance in GIS software. The nominal land valuation model was created by multiplying the weights by the pixel values (Mete and Yomralioglu, 2019). In Afyonkarahisar, value estimation was made using the nominal valuation method in 120 neighborhoods. Social (6), Environmental (5), Personal (3), and other (5) criteria were used. The weights of the criteria were found though a questionnaire. The weights and the properties scores were multiplied and their totals were calculated. With the help of the k coefficient, the value estimations of the properties of unknown value were made. The value map was produced by interpolating with Inverse Distance Weighting (IDW) of the Geostatistical Analysis module in GIS software (Tiryakioğlu and Erdoğan, 2006).

The innovative land valuation model (iLVM) was developed in order to product land value. Geospatial criteria were regraded with a (0-5) score according to distance by using Euclidean distance in GIS software. The criteria were weighted by experts opinion in the analytical hierarchy process (AHP) method. The value obtained from the weighted total result was substituted in the mathematical model and the land value was estimated. As a result, the value map as well as categorized low-density rural, high-density rural and urban maps were prepared (Bencure et al., 2019).

The aim of this study is to determine the GeoValueIndex, which will create the basis for the valuation of public properties belonging to Mersin University, using the AHP method. Register, parcel, land, location, and usage features were taken as the main heading, and the corresponding data with a total of 31 sub-criteria were obtained for each parcel separately. The data were normalized to a range of [1,2]. The criteria weights found by the AHP method and related data were multiplied. The sum of these multiplies forms the GeoValueIndex of each parcel. The GeoValueIndex map was produced with the help of GIS software. this map which forms the foundation for the valuation processes, represents parcel value.

2. MATERIAL AND METHOD

GeoValueIndex is a result of geographics and non-geographics data processes such as standardization, normalization, and weighting. It has been assessed for mass appraisal scope for the university property assets which is one from the Public Property Assets. The criteria affecting the value of the cadastral parcels in the study area were determined, and the data corresponding to each parcel were obtained by arranging criteria to the data. The weights of the criteria were calculated with the AHP method. GeoValueIndex was calculated for each cadastral parcel (Figure 1).

2.1 The study area: Mersin University, Çiftlikköy Campus

Mersin University (MEU) has three campuses, named Çiftlikköy, Yenişehir and Tece, located in different places in the city center. In order to establish the

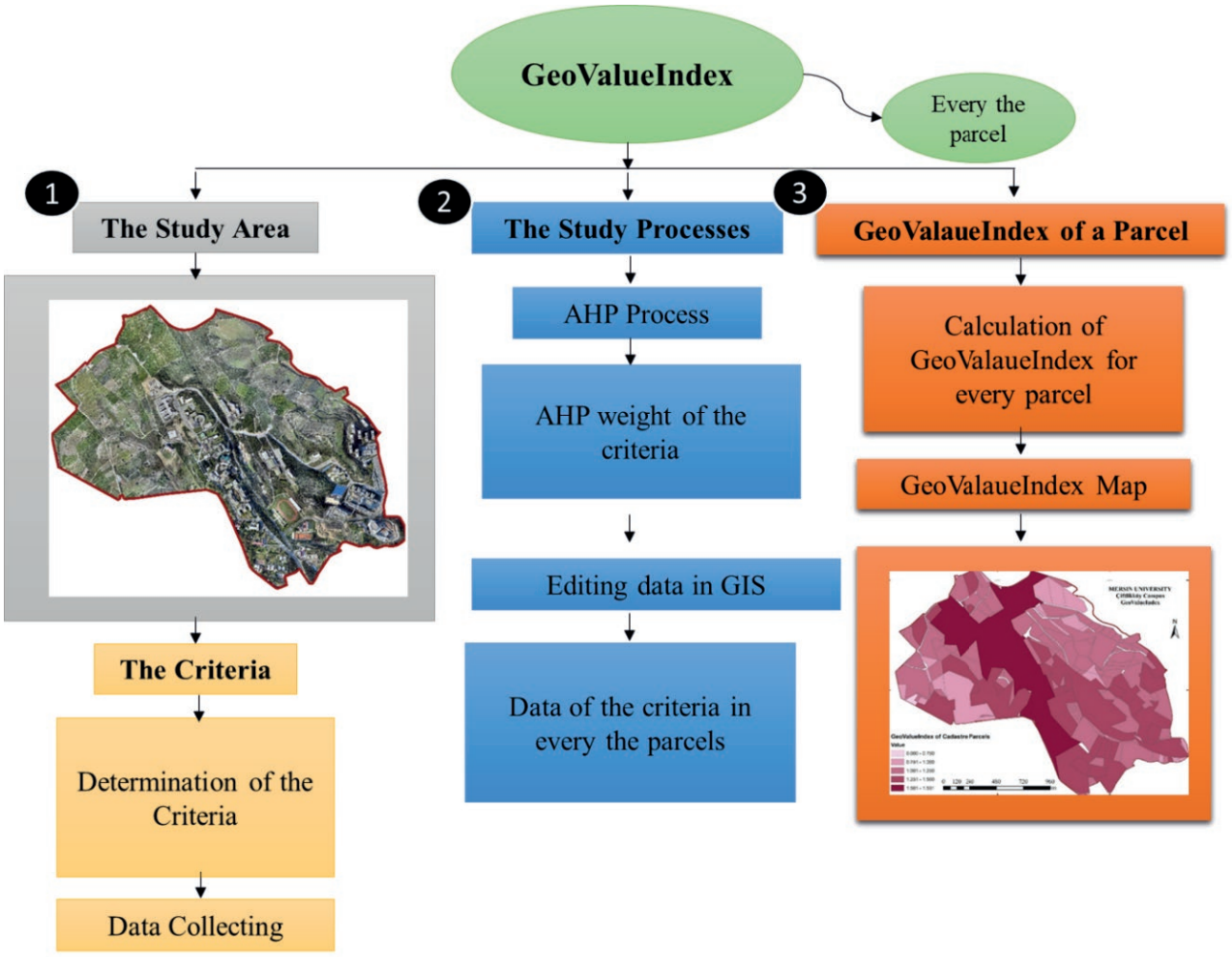

Figure 1. The study diagram.

Land Management and Mass Appraisal Infrastructure, Çiftlikköy Campus, which is the main campus, was taken as a sample. It has an area of 4,181,097 m^2. It is 14 km to the city center, 6 km to the town of Mezitli and 3 km to the Mediterranean. The total closed area on the campus land is 354,346 m^2. 1,820 academics and 1,456 administrative staffs work at Mersin University, where 38,902 students were registered in 2021 (MEU, 2022). There are also social areas in the campus such as medical school, student dormitory, guesthouse, cafeteria, stationery, and sports facilities in here (Figure 2).

The ownership status of the properties located in the Çiftlikköy Campus is varied and there are areas allocated to the Treasury and forest. It has been determined that privately owned properties on the Campus should be expropriated (MEU, 2007; 2019; 2020; 2022). The uses of the properties of the immovable and changes in the academic, administrative, and student numbers should be analysed, from the past to the present. This information will be effective in the selection of criteria by giving an idea in terms of value. Positive value changes can also be observed in the properties around the campus.

2.2 The criteria for mass appraisal

The criteria used in mass appraisal (mass real estate valuation) processes imply the study of characteristics that affect the property value. Although the criteria vary according to the property type and the characteristics, the purpose of the land is also important. For example, there is a planted land in the campus, but its separation as a campus area in the zoning plan means that it will develop in the future and a building will be built on it. In this situation land use and its value are going to vary in accordance with the zoning plan in the future. For

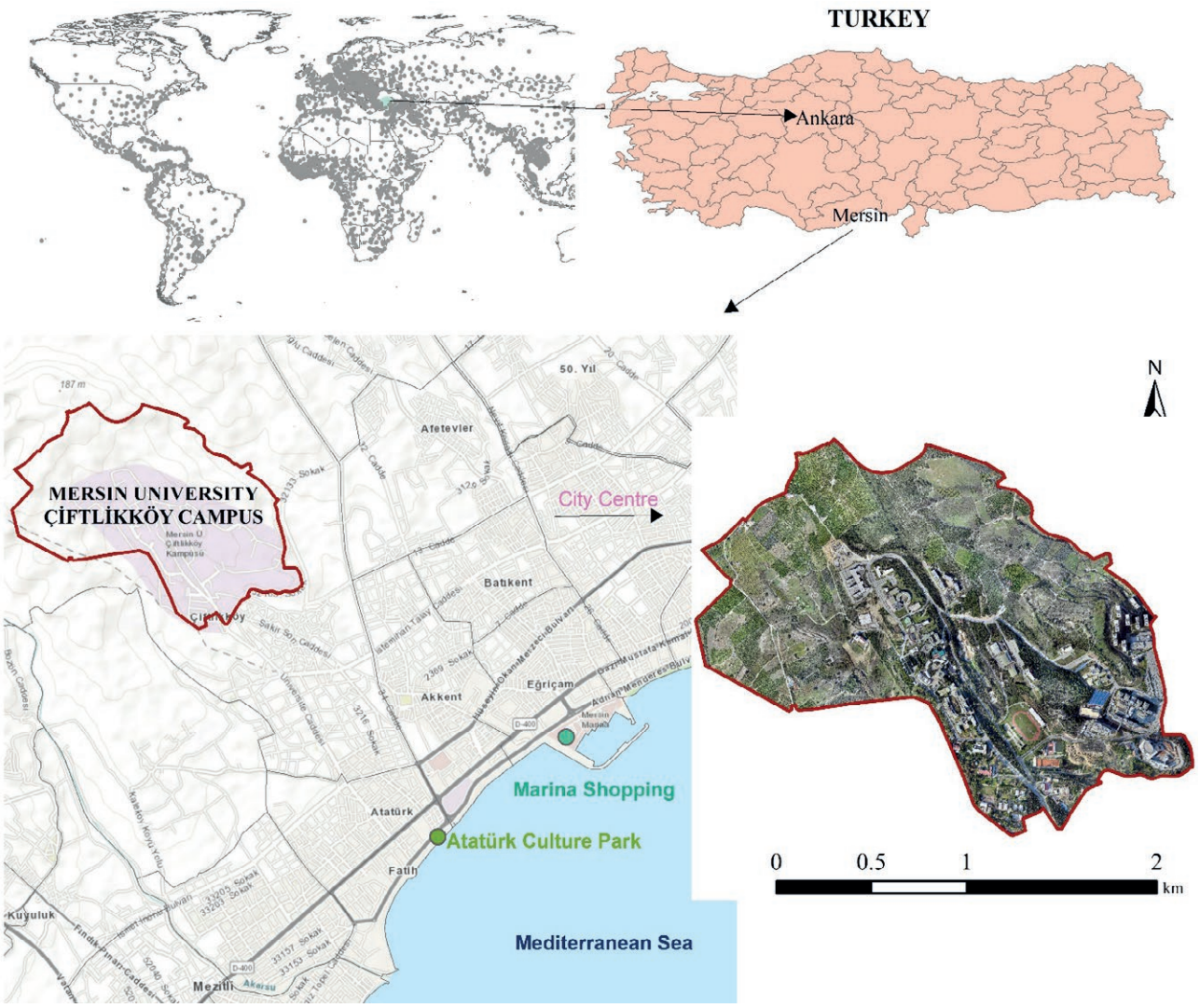

Figure 2. The study area: Mersin University, Çiftlikköy Campus.

this reason, it cannot be regarded as absolute agricultural land. Unfortunately, this also is valid for agricultural lands planned in the zoning and located outside of the residential areas of the city. It is clearly stated that absolute agricultural lands should be protected according to the Soil Conservation and Land Use Law (2005)[9]. However, in such areas, in parallel with the increase in population, the city's drive for growth could be more obvious. It can be classified as the land for which the zoning plan has been applied (plot), the land that has a zoning plan and has not been applied to the land (generally outside of the residential area of the city), land with a master plan, and land without a plan. The zoning (development) plan has detailed information showing the construction conditions and generally scaled at 1/1,000. In addition, it is applied to land. The master plan shows the overall development of the area and is generally scaled at 1/2,000, 1/5,000 or 1/25,000. These regions can be visualised on a map. Therefore, it will be easier to choose the type of real property and to determine criteria based on it.

Many criteria affect real property values (Unel et al., 2017; Ünel and Yalpır, 2019; Yalpır and Ünel, 2019). These criteria' economic worth or weights corresponding to real property value have not yet been properly determined because of supply, demand, choice, culture, regional, etc. The fact that the criteria differ from nation to nation, region to region, and person to per-

[9] See also Toprak Koruma ve Arazi Kullanımı Kanunu (Soil Conservation and Land Use Law) (2005).

son, is extremely effective. In addition, it increases this variability in extraordinary situations such as pandemics, wars, and economic crises. It is required to identify the criteria and the weights that correspond to their economic equivalents by being determined the general social behaviors and habits of each country. In this study, the criteria were listed as a result of the literature review (Açlar and Çağdaş, 2008; d'Amato and Cucuzza, 2022; Kauko and d'Amato, 2008; Mülâyim, 2008; Ünel, 2017; Ünel et al., 2021; 2022). The criteria available in the study area, were used in the mass appraisal processes.

The south of Çiftlikköy Campus is encompassed by residential areas and is within the urban area. The north is covered with agricultural lands and is within a rural area. The campus is located between these two areas and remained on the development border of the city. The campus has a zoning plan and the feature of plot qualified land.

In the literature, the studies also contain that the number of criteria and the criteria used in mass appraisal vary in different regions. In mass appraisal, taking into account all criteria and collecting data is not effective, and it is not possible in terms of time, cost, and effort. General criteria for the country should be determined and the other criteria should be added/removed according to regions. For this, the studies should be carried out to determine the optimum criteria in regions with different characteristics. In other words, the criteria should reflect the socio-cultural structure, preferences and habits of the region. The criteria that will give the highest performance should be used in the analysis (Yalpır and Ünel, 2016).

In the Real Estate Tax Law, the properties are handled in three types as land, plot and building[10]. In Regulation on the Registration of Real Properties Owned by Public Administrations (2006), a "Registration Plan" is created in the form of "Educational and Teaching Buildings and Facilities", "Plot", "Land", "Common Assets" and "General Service Areas" for the registration of properties and the arrangement of summary statements within the scope of general management[11]. In the literature (Emlak Vergisi Kanunu, 1970; Kadastro Kanunu, 1987; Kamu Mali, 2003), there are different groupings and classifications of the criteria that alter according to the type of property. As a consequence, the criteria may be categorized under the following major headings: legal, physical, geographic, and local features (Ünel, 2017). In general terms, the criteria affecting the value of the property can be listed as the type of real property, surface area, corner/intermediate parcel, number of frontages to the road, geometric shape and spatial characteristics. Criteria affecting the value of agricultural land are soil structure, irrigation status, slope, etc. Criteria affecting the plot value are Basement Area Coefficient (BAC), Floor Area Coefficient (FAC), number of floors, building layout, infrastructure status, etc. Criteria affecting the value of building are total construction area, wet floor, number of balconies, elevator, heating/cooling type, etc. For the building; it can be presented as total construction area, wet floor, number of balconies, elevator, heating/cooling type, etc.

It is possible to talk about similar criteria for the mass valuation of university properties. However, the criteria to be processed for Mersin University, Çiftlikköy Campus were evaluated considering the literature and the availability of data. Mersin University was researched within the scope of the project to establish the valuation infrastructure of the Çiftlikköy Campus, and the criteria were listed under six main headings (Table 1). The address information of the cadastral parcels was not used in value indexing processes and was taken into account for correlating with the location. The weights of the main criteria which consist of register, parcel, land, location, and usage features and their subcriteria and were calculated.

2.3 Analytic Hierarchy Process in Multi Criteria Decision Analysis

*"Decision analysis is a set of systematic procedures for analyzing complex decision problems. The basic strategy is to divide the decision problem into small, understandable parts; analyze each part; and integrate the parts in a logical manner to produce a meaningful solution". (*Malczewski, 1999). Spatial decision problems are also more complex and consist of criteria of multiple, conflicting, and incommensurate. Spatial complexity can be dealt with individually with the help of MCDA and GIS. Decision-makers, managers, stakeholders, and interest groups can easily evaluate all criteria via MCDA. Studies between 1990 and 2004 show that MCDA and GIS usage has grown (Malczewski, 2006). When this situation comes to 2022, a perfect match is seen by adding the fuzzy feature which is frequently encountered in conformity analysis (Beshr et al., 2022; Hagos et al., 2022; Raad et al., 2022; Roy et al., 2022).

MCDA is used to solve a variety of decision-making issues, including criterion selection, determination of important criteria, site selection, and evaluation of alternative sites. There are many different methods to use

[10] See also Emlak Vergisi Kanunu (Real Estate Tax Law) (1970).

[11] See also Kamu İdarelerine Ait Taşınmazların Kaydına İlişkin Yönetmelik (Regulation on the Registration of Real Properties Owned by Public Administrations) (Kamu Kayıt, 2006).

Table 1. The criteria affecting the value of MEU property (Ünel et al., 2020; 2021).

A. ADDRESS FEATURES	B. REGISTER FEATURES	C. PARCEL FEATURES	D. LAND FEATURES		
1. Property No 2. Province 3. District 4. Neighborhood 5. Block 6. Parcel	1. Type 2. Area 3. Owner 4. Ownership (Full-Shared)	1. Location on the Block (Corner-Inter.) 2. Geometric shape 3. Access to Road 4. The number of frontage 5. Length of the frontage 6. Technical Infrastructure	*Topography* 1. Elevation 2. Slope 3. Aspect *Geology* 4. Geology	*Hydrography* 5. Frontage Length of Water Line 6. Distance of Water Line 7. Length of Water Road	
	E. LOCATION FEATURES		F. USAGE FEATURES		
	1. Distance to Main Road 2. Distance to City Centre 3. Distance to Mediterranean Sea 4. Distance to Shopping Centre 5. Distance to Green Area 6. Distance to Energy Transmission Line		*Building* 1. Total Building Area 2. Number of Floors 3. Building Age 4. Usage Type	*Water* 5. Pool Area 6. Pool Type	*Vegetation* 7. Tree Type 8. Number of Tree

MCDA independently or in combination with fuzzy forms. AHP, TODIM, TOPSIS, COPRAS, and DEMATEL methods are encountered in mass appraisal (Ball and Srinivasan 1994; Bellver and Mellado, 2005; Bender et al., 2000; Bozdağ and Ertunç, 2020; Çinar and Ünel, 2022; Ferreira et al., 2016; García-Melón et al., 2008; Gomes and Rangel, 2009; Kauko, 2007; Maliene, 2011; Mulliner et al., 2013; Schniederjans et al., 1995; Urbanaviciene et al., 2009; Wong and Wu, 2002; Yılmaz, 2010).

The Analytic Hierarchy Process (AHP) is the most commonly used method of Multi-Criteria Decision Analysis (MCDA). In line with the study aim, a hierarchical structure is built by determining the criteria affecting value, and the problem is simplified. According to how each criterion affects value, pairwise comparison matrices are made, their weights are calculated, and the importance levels of the criteria are determined (Saaty, 1990; 2008). The real estate valuation problems can be listed by determining the importance degrees of criteria, reducing criteria, obtaining weight of spatial places, and predicting value. In this context, AHP method is used to reduce (Ünel, 2017), weighting criteria (Bender et al., 2000; Kauko, 2003; 2007; Kryvobokov, 2005), and estimate residential housing values (Ferreira et al., 2016; Lisi and Iacobini, 2018; Yılmaz, 2010).

The following steps (Saaty, 2008) should be applied to give weights to the criteria (Figure 3). The pairwise comparison matrixes are constituted by taking into account Table 2.

1. The goal is to calculate the weights of criteria that affect real estate value.
2. A hierarchic structure of the criteria is created.
3. The pairwise comparison matrices are constructed.
4. Weights of the criteria are calculated.
5. Controls processes are permeated.

Table 2. The fundamental scale of AHP (Saaty, 2008).

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

According to the Analytic Hierarchy Process (AHP) process steps, mathematical operations start after the pairwise comparison matrix is created by giving between 1-9 scores of the criteria. The weights are cal-

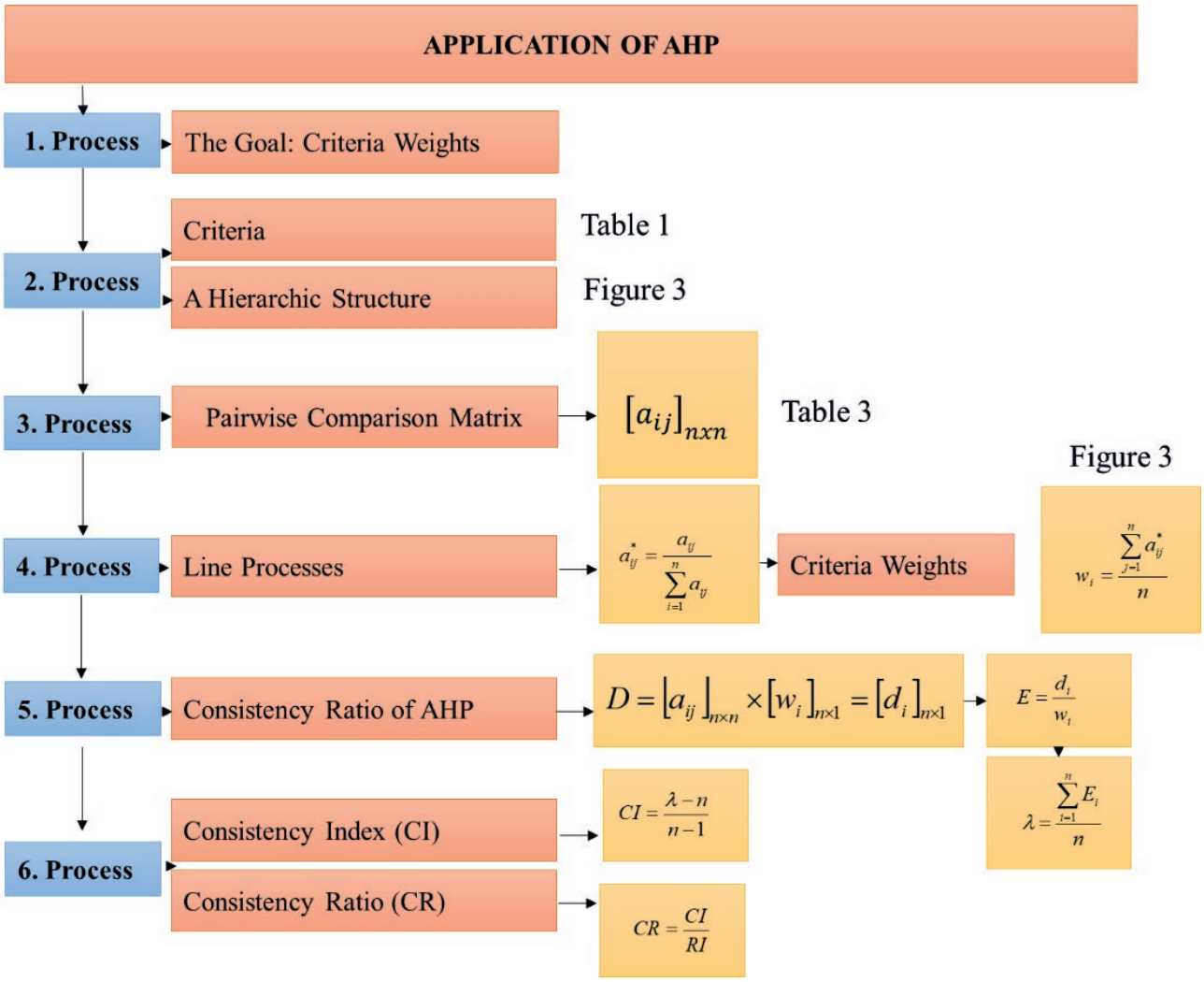

Figure 3. AHP processes and equalities.

Table 3. RI Random Index (Saaty, 1980).

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

culated by dividing each matrix element by the column sum and averaging them.

Consistency Ratio (CR) must be determined in order to check the consistency of the pairwise comparison matrix and AHP weights. For this, nx1 matrices D and E are calculated. The λ value is found with the help of the E matrix and the Consistency Index (CI) is reached using λ. CR is calculated by dividing by the CI Random Index (RI). It is decided whether the AHP processes are consistent or not. RI is taken according to the number of criteria in Table 3 by Saaty (1980). If it is , the criteria comparison is consistent. However, if it is CR>0.10, the result is not consistent, and processes must thus be refreshed.

3. FINDINGS

3.1 AHP weights of criteria

The main criteria affecting the value of the real property on campus consists of register, parcel, land, location and usage information. Each of them also has sub-criteria. The AHP goal is to find the weights of these criteria, which are very important for mass appraisal. The aim of the study is to convert the data which have the real property into the value index of the real prop-

Table 4. Pairwise comparison matrix and line process of the main criteria.

a. Pairwise comparison matrix of the main criteria

#	B. Register	C. Parcel	D. Land	E. Location	F. Usage
B. Register	1	3	4	2	2
C. Parcel	1/3	1	2	1/3	1/3
D. Land	1/4	1/2	1	1/5	1/5
E. Location	1/2	3	5	1	1
F. Usage	1/2	3	5	1	1
Total	2.5833	10.5000	17.0000	4.5333	4.5333

b. Line process in the main criteria

#	B. Register	C. Parcel	D. Land	E. Location	F. Usage	W
A. Register	0.39	0.29	0.24	0.44	0.44	0.3581
B. Parcel	0.13	0.10	0.12	0.07	0.07	0.0978
C. Land	0.10	0.05	0.06	0.04	0.04	0.0583
D. Location	0.19	0.29	0.29	0.22	0.22	0.2429
E. Usage	0.19	0.29	0.29	0.22	0.22	0.2429

erty by using the criterion weights.

In the AHP method, the goal, criteria and hierarchy were determined and the pairwise comparison matrix of the criteria were created by experts. The criteria were compared in pairs according to the hierarchy order and a score between 1 and 9 was given (Table 4a). Line processes were performed by dividing by each cell element by the column total (Table 4b). The weights of each criterion were calculated by taking the average of the rows in the Line processes in Table 4b.

In order to understand whether the pairwise comparison matrix and the AHP weights are consistent, D and E matrix were found. The CI depending on the value was found, and the result (CI) was divided the RI value which is 1.12 corresponding to the 5 criteria number. CR was calculated as 0.0260. Consequently, it was understood that the AHP processes performed with the main criteria were consistent due to (Table 5).

The weights of the main criteria were found. A similar way was applied for the sub-criteria under each of the main criteria. Firstly, a pairwise comparison matrix was created according to the experts' opinion for the sub-criteria. Then, AHP weights were calculated by performing the processes. For example, Register Features (0.3581) and sub-criteria consist of type (0.0883), area (0.1575), owner (0.4824), and ownership (0.2718) (Table 6).

As a result of the multiplication of the main criteria (MC) and the sub-criteria (SC) weights, final weights (FW) were also found 0.0316, 0.0564, 0.1727, and 0.0973, respectively (Figure 4, Table 6). The same procedure was followed for the other main and sub-criteria. The sum of the sub-criteria' final weights is equal to 1. AHP hierarchical structure was presented with final weights (Figure 4).

Table 5. Pairwise comparison matrix of the main criteria.

#	*D*	*E*	*λ*	*RI*	*CI*	*CR*
B. Register	1.86	5.18	5.1167	1.12	0.0292	**0.0260**
C. Parcel	0.50	5.07				
D. Land	0.29	5.04				
E. Location	1.25	5.14				
F. Usage	1.25	5.14				

3.2 Editing geographic and non-geographic data

The criteria affecting the value of public real property in the Mersin University area were determined and their data were collected. The data have different formats such as text, number, and geographic. It has been converted into numbers to correspond to each parcel. Geographic data was imported into GIS software, arranged and reclassified for this use. Geographic data consists of a cadastral map, the zoning plan, an orthophoto map, a digital elevation model, geology, hydrography and building maps. Data such as area, location on the block, geometric shape, number of frontages, and length of frontages were obtained from the cadastral map. The digital

Table 6. AHP weights.

MC	W1	No	SC	W2	W3 (FW)
B.REGISTER	0.3581	B1	Type	0.0883	0.0316
		B2	Area	0.1575	0.0564
		B3	Owner	0.4824	0.1727
		B4	Ownership	0.2718	0.0973
C. PARCEL	0.0978	C1	Location on the Block	0.2052	0.0201
		C2	GeometricShape	0.1144	0.0112
		C3	Access to Road	0.3102	0.0303
		C4	The number of frontage	0.0300	0.0029
		C5	Length of the frontage	0.0300	0.0029
		C6	Technical Inf.	0.3102	0.0303
D. LAND	0.0583	D1	Elevation	0.0395	0.0023
		D2	Slope	0.2315	0.0135
		D3	Aspect	0.1101	0.0064
		D4	Geology	0.0649	0.0247
		D5	Frontage Length of Water Line	0.0649	0.0038
		D6	Distance of Water Line	0.0649	0.0038
		D7	Length of Water Road	0.4241	0.0038
E. LOCATION	0.2429	E1	Distance to Main Road	0.2500	0.0607
		E2	Distance to City Centre	0.2500	0.0607
		E3	Distance to Mediterranean Sea	0.0833	0.0202
		E4	Distance to Shopping Centre	0.0833	0.0202
		E5	Distance to Green Area	0.0833	0.0202
		E6	Distance to Energy Transmission Line	0.2500	0.0607
F. USAGE	0.2429	F1	Total Building Area	0.1159	0.0282
		F2	Number of Floors	0.2636	0.0640
		F3	Building Age	0.1422	0.0345
		F4	Usage Type	0.2636	0.0640
		F5	Pool Area	0.0528	0.0128
		F6	Pool Type	0.0227	0.0055
		F7	Tree Type	0.0696	0.0169
		F8	Number of Tree	0.0696	0.0169
				TOTAL	1.0000

elevation model defines the terrain topography showing the elevation of the campus above sea level. With the help of this model, slope and aspect maps were produced in GIS software (Figure 5).

Within the scope of the study area, non-geographic data were converted into numbers form to enable mathematical procedures. The data are the type of the parcel (land, plot, and buildings), the owner (MEU, treasury, forest, private), ownership status (full/shared), location on the block (corner/intermediate), geometric shape (distorted, medium, smooth), access to the road and technical infrastructure (yes-none). The slope levels that can easily be realized in construction or agricultural activities are taken into account and the scoring was made from high to low according to the increase in slope. The aspect was evaluated by giving a high point to the south frontage and fewer points than the south to the other frontages.

The slope and aspect were produced from a digital elevation model and their situation within each plot is revealed. By using 10 classes of the study of Pennock (2015) on slope map and degree ranges of ArcGIS (2022) software in aspect map, both were also reorganized as 10-classed maps. There are different pixel values in different classes that fall within the boundaries of a parcel. In ArcGIS, the classes within each parcel were found and the numbers of each class were recorded by transferring them to the external environment. The number of classes was divided by the total number of pixels in the parcel. The results were multiplied by the slope class score and the weighted slope value of each plot was obtained. A similar calculation was performed for the aspect.

The building age included in usage features was found by subtracting the year of construction from 2022 and is a criterion that has a negative effect on the value of the real property. While the building age is based on years, the features and units of the other criteria also vary. Therefore, geographic and non-geographic data were normalized between [1,2] with Equation [1] by adding 1 to the min-max normalization progress. The method which is usually called as scaling method, preserves relationships with all data without bias. The data are normalized by performing a linear transformation (Ali and Faraj, 2014; Jain and Bhandare, 2013; Li and Liu, 2011). However, data within a certain range, such as the ownership status and the location of the block, were not subjected to the normalization process because of scored.

$$X' = \frac{x_i - x_{min}}{x_{max} - x_{min}} + 1 \quad [1]$$

X' : Normalized value.
x_i : i. Value in the dataset.
x_{min} : The smallest value in the dataset.
x_{max} : The largest value in the dataset.

3.3 GeoValueIndex Map

The GeoValueIndex was obtained from geographic and non-geographic data for each parcel. Geographical data were organized in GIS software and non-geographical data were standardized by scoring and all data were regulated in matrix format. The criteria were weighted with the AHP method. The normalized data of the par-

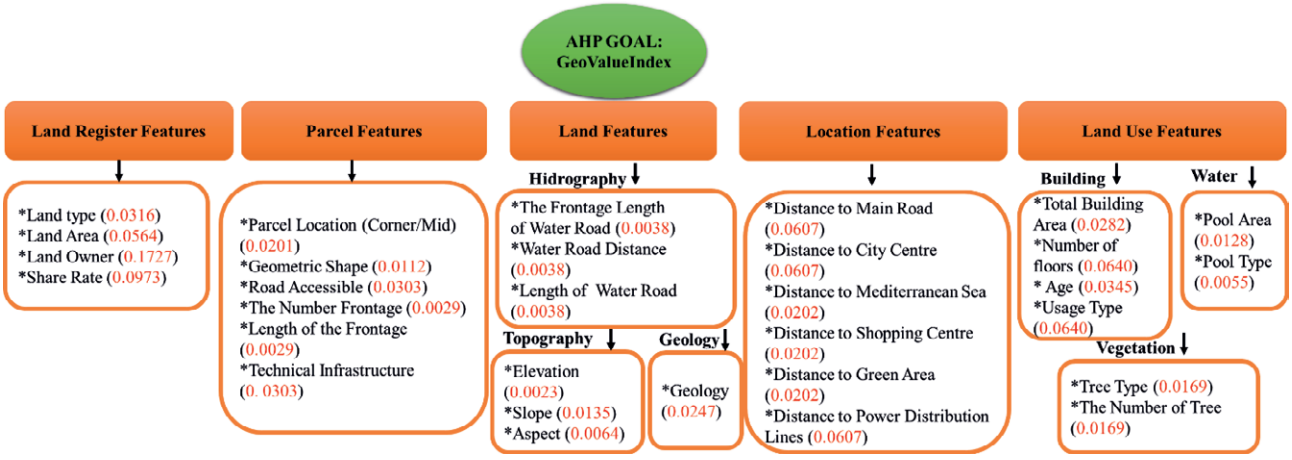

Figure 4. The hierarchy and weights of criteria affecting the value of MEU real property.

cels were collected by multiplying the AHP weights of the criteria (w_i). In this way, the value basis has been made a whole by adding the features of the parcels weighted (Equation 2). GeoValueIndex was found for each parcel to reflect the value on large-scale maps.

$$GeoValueIndex = \sum_{i=1}^{n} (w_i * Normalized\ Data\ of\ Parcel) \quad [2]$$

The cadastral parcels, which are geographical data, and the GeoValueIndex of the parcels were integrated and mapped in the GIS software (Figure 6). The GeoValueIndex belonging to the parcels was obtained by calculating outside of GIS software. For this; All the data belonging to the sub-criteria were prepared in a matrix format for each cadastral parcel. The matrix is arranged in numerical form with parcel numbers in rows and sub-criteria in columns. Since these data were in different units and number ranges, they were all brought to the same range by normalizing. In other words, the parcel and criterion matrix consist of standard data in the range of [1,2]. Since the sum of the sub-criteria' final weights is 1 and building age is the negative effect, GeoValueIndex was obtained in the range of [0.590-1.551] by multiplying the normalized data and the weights.

Standing out in the Çiftlikköy Campus, cadastre parcel number 2166 has the highest GeoValueIndex. The most important reason for this, the parcel is the largest in terms of area. In addition, most of the faculties were built on the parcel. The register features, which is related to use permits and restrictions, is the most important according to other main criteria. Location and usage features have 2nd and 3rd importance according to the weights. Since the sub-criteria weights belonging to them are high, the weight of the owner and full ownership under the register features is also high. The lands registered and allocated in the name of Mersin University are important for the public user, and their score seems to be high as a plus value. As location features, the parcels numbered 2166 and 2168 are close to the main road and the city center. The building usage type and the number of floors are the criteria that have the highest weight in usage features. Many important faculties such as engineering, architecture, science and literature, education, economics and administrative sciences, nursing, conservatory, as well as the rectorate and administrative buildings were built on parcel number 2166. Many advantages of parcel no. 2166, where Çiftlikköy Campus was established, have been identified. The campus has two main entrances, one to the faculties in the south and the second to the southeastern medical faculty.

Since the weights of parcel and land features are lower than the others, elevation, the number of frontages, and the length of the frontage were found to have the lowest weights among the sub-criteria. Therefore, the fact that the parcel is located at a height, the number of frontage is many, and the length of the frontage is long has been determined to add a very low value.

On the other hand, parcels which are with GeoValueIndex less than 1,000 such as 700, 1832, 1926, and 1943 have small areas, no buildings, and are privately owned. It is observed that the GeoValueIndex is lower because the north and northwest of the campus are in rural areas and far from the city center, the sea, the green area, the shopping centre, and road access is low. On the contrary, it is determined that the GeoValueIndex is higher in the south and southeast of the campus due to proximity to urban area and mobility.

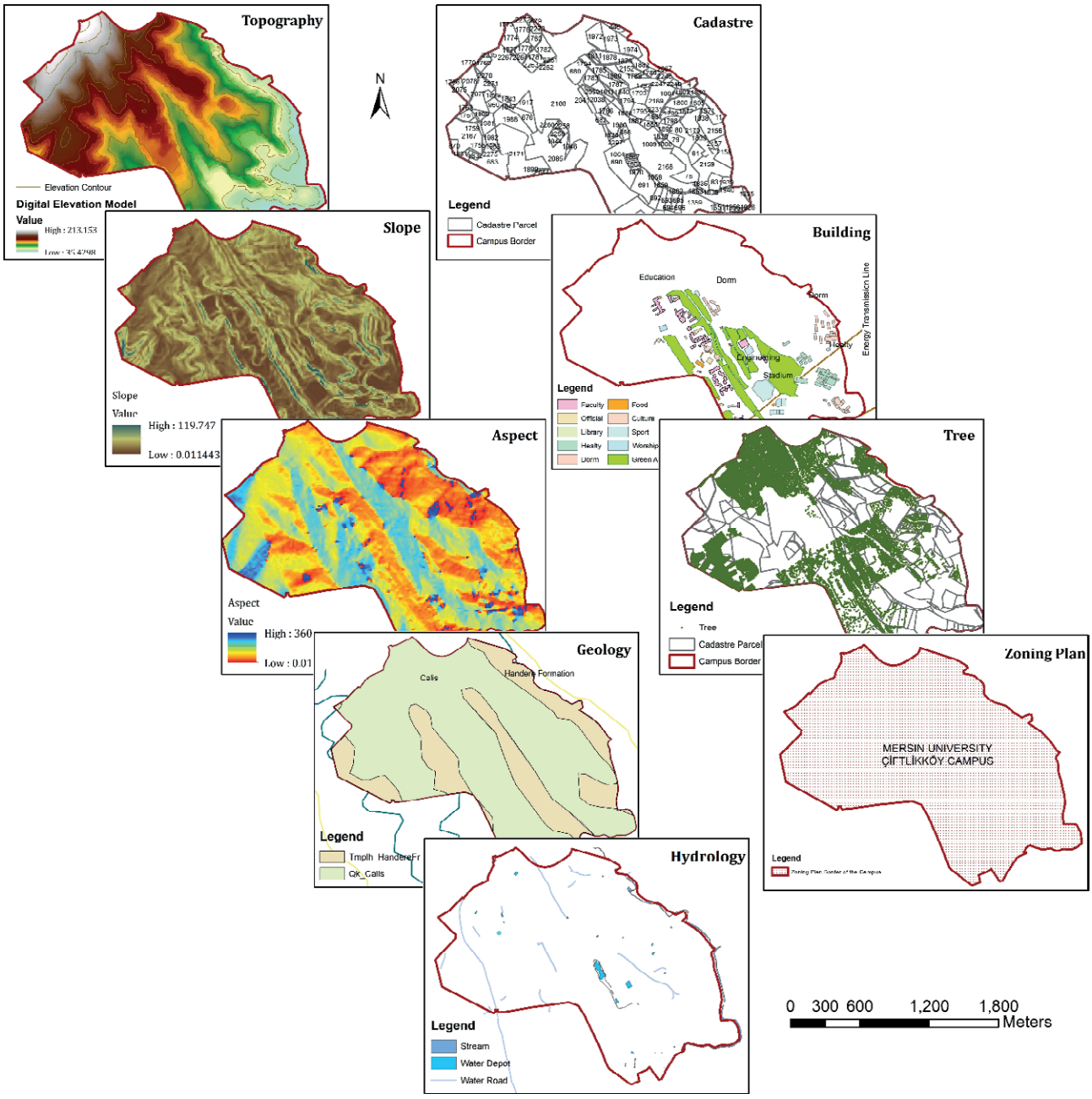

Figure 5. Geographic data.

4. DISCUSSION

The real property value is directly related to its location, features, and users. Constructing a mathematical model to represent this relationship and value is not easy. The variety of the data and the presence of different forms and structures, such as numeric, text, and geographic data, are the reasons for this challenge. The processes in this study were performed by considering real property types such as land plot, residential, commercial, etc., as a whole. In this context, all details of real property are important in terms of determining its value.

The house price index determined by the Turkiye Democracy Center Bank is calculated by using the values estimated in the valuation reports. The Housing Price Index was published on a provincial basis (TCMB,

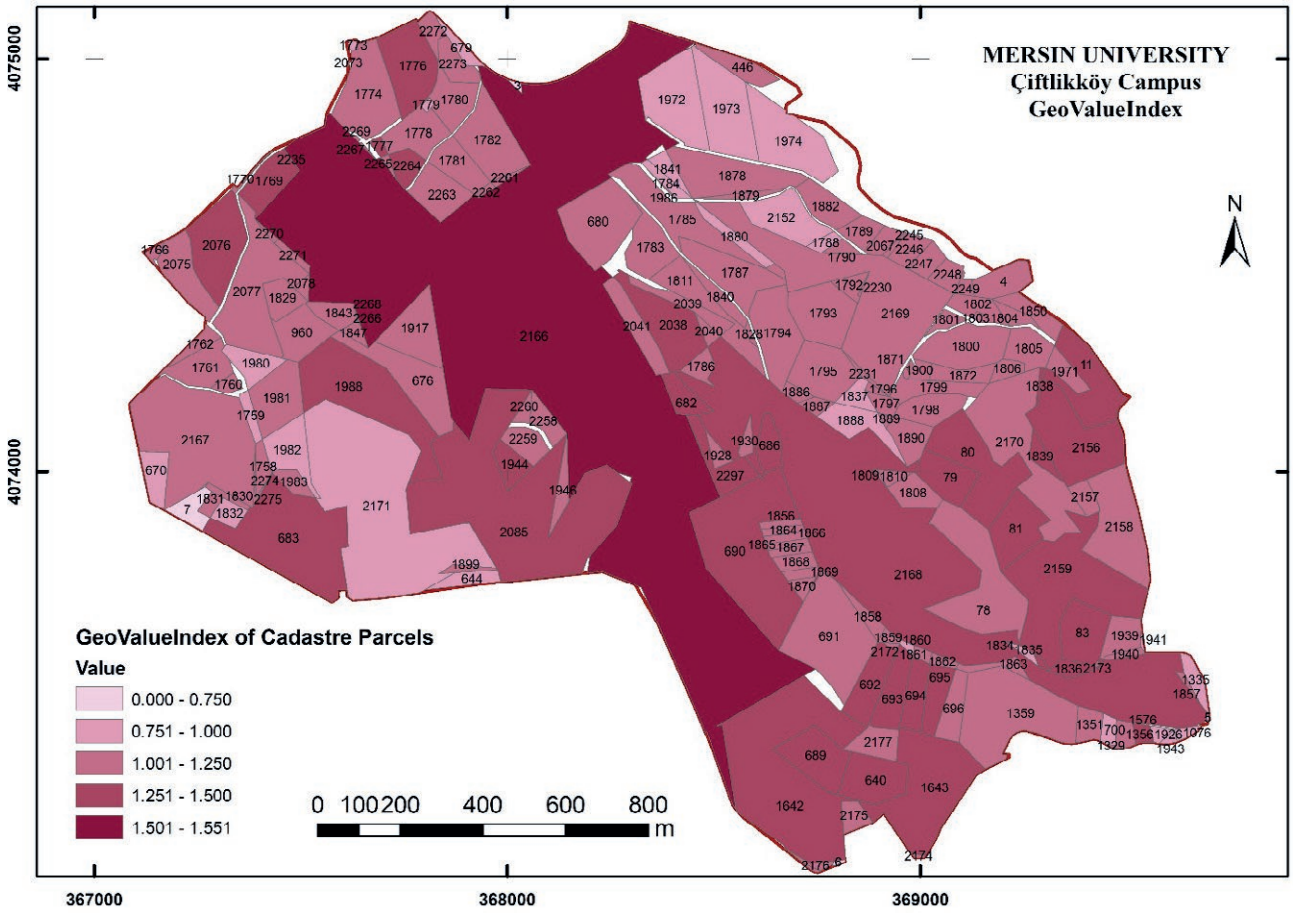

Figure 6. GeoValuIndex Map.

2022). The study, which examined the indices of commercial property, was carried out in the United States. Three types of indexes which are the index that reconstructs market value, the post-processing index and the Index consisting of Real Estate Investment Trusts were examined. These indexes are handled entirely on value (Fisher et al., 1994).

Based on the scoring used in the nominal valuation method, it is similar to the GeoValueIndex. The studies, which are land readjustment (Yomralioglu, 1993), value prediction (Nişancı and Yomralıoğlu, 2002), and the basis for the valuation (Droj et al., 2010; Mete and Yomralioglu, 2019; Unel and Yalpır, 2014) were implemented with the nominal valuation method. In the study of Yomralioglu (1993), a nominal asset value-based land readjustment model was developed. Yomralioglu (1993) found a nominal asset value for land readjustment model, and Bencure et al. (2019) built the innovative land valuation model (iLVM). In these studies, it was determined that questionnaire, AHP and Best/Worst methods were used to find the weights of criteria. It is seen that reinforcement distances are generally determined by Euclidean Distance in GIS software. Value maps were prepared with Inverse Distance Weighting (IDW) of the Geostatistical Analysis module.

In this study, the weights of the criteria were calculated by the AHP method by considering the public real properties. All geographic and non-geographic data were obtained for each parcel in matrix format and multiplied by the criteria weights. As a result, GeoValueIndex was found separately for each parcel. While valuing real estate, GeoValueIndex offers several advantages. It serves as the foundation for the prediction model by taking into consideration GeoValueIndex as the independent variable and the market value as the dependent variable. The conversion from GeoValueIndex to value will be faster and easier within the provision of information that has the market value on the valuation date. The GeoValueIndex of the parcels can be compared with each other. There is also the possibility of updating the GeoValueIndex when there is any change in the criteria. When these processes are applied to privately owned

real properties, calculating values such as tax, insurance, and expropriation will be even easier and each parcel will be subjected to a standard application.

5. CONCLUSION

The real property value is an important parameter for land management. However, it is not possible to estimate the number that makes up the value with a single process. Each property has its own characteristics. It can objectively be used to estimate the value according to these characteristics and the other features. In this study, the features that make up the values of real properties are processed one by one and converted into a single index in line with their different weights. With this index, it will be possible to reach the value in the desired time interval. The advantage of the index is that it is suitable for places that have completed their development, or regional that have not changed for many years, or agricultural lands. It will also form the basis for processes such as taxation, expropriation, and insurance.

There are many criteria that affect the value of public real properties and they vary according to regions. To create the GeoValueIndex or apply the methods of mass appraisal, the data should be in a standard form and mathematical operations are performed with them.

Mersin University Çiftlikköy Campus is in the middle of rural and urban divide. The campus boundary is the study area and corresponds to a parcel in the zoning plan. Since there are already cadastral parcels on the ground, the processes are based on the cadastral parcel. The value index was obtained by creating a model between the criteria weights affecting the value and the data owned by the real properties. In other words, the real value of the real property has been found with the help of the features and their weights and it has been converted into an index. Each parcel has a GeoValueIndex that can generally remain constant. However, precedents, valuation dates and values are constantly changing. If one point can be kept constant in the real estate valuation, others can be returned to it. In this case, it means that the GeoValueIndex of the parcel can be transformed to the value on the valuation date. The real property can be matched by its unit square meter value and each other. Under the conditions that GeoValueIndex and the criteria remain constant, the values of the real property can be easily found at a past, future, and present date. In addition, an objective GeoValueIndex is obtained since the existing features of the real property are taken into account.

In future studies, it can be applied separately to real properties such as land, plot, residential, commercial and industrial, and can be tested with samples. The construction information in residential areas as a separate group can be investigated by considering the depreciation amount. The age of the tree can be found, the plant group can be distinguished, evaluated and examined according to the productivity rate. The weighting can be done by using different methods such as topsis, vikor, and best/worst from multi criteria decision making analysis.

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