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Tracking the University Campus Development by Using Remote Sensing and Satellite Imagery: Two Case Studies from Turkey

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Abstract

University campus plans and the development of facilities and surroundings due to design principles are crucial for assuring project integrity and consistency. Tracking and observing the development is challenging for the institutions' designers, controllers, and managers. Remote sensing and satellite images offer tools and techniques to identify the lands and cover by the time to analyze the spatial development patterns. This research paper analyzes the land cover and land use changes at Kırklareli University and Kırşehir Ahi Evran University between 2006-2018, which were founded and developed at the same time with similar factors. A literature survey for campus planning and design briefs of two universities are presented to state the university campuses' objectives and criteria, which are the main rulers for development. The research method utilizes remote sensing and satellite images to observe and quantify the spatial patterns and trends in land use and land cover changes. The study results indicate that both universities have significant land use changes, including converting land to built-up areas, urban expansion, and natural land degradation. The analysis also shows the imperviousness and grassland change in both regions. However, the study's success in observing the development by remote sensing data and satellite images differs due to cases. The study method and findings present a contributing framework to track the development, give feedback and record the actual situation for decision-makers and planners. Besides, the method will also be developed by conducting further analysis with the implementation of generative techniques of remote sensing and comparing them to the institutions' records.

1. INTRODUCTION

A University campus plan is essential for creating a comfortable, functional, and visually appealing learning environment. University campuses can exist by creating varied links with the city through its various functional and physical contents. The plan should consider student population, building placement, and traffic flow to create a cohesive and efficient campus. Depending on their proximity to, distance from, and contact with the city, they can be classified as urban or suburban universities [1]. In these situations, the university's contact and relationship with its location city are different [2]. It is important to balance the need for green spaces and open areas with constructing academic and residential buildings. Additionally, the plan should prioritize accessibility for all students and ensure that essential services such as dining and healthcare facilities are easily accessible [3]. The campus plan should also consider the features and needs of the city community, including cultural and environmental factors, to create an integrated campus. Ultimately, a campus plan will provide an environment that maintains learning, growth, and community for all students, faculty, and staff.

In the 18th century, Princeton University was where the term "campus" was first used [4]. When campuses are situated inside or outside a city, they have varied implications. The size of the city also varies the engagement with the university campus. For instance, universities founded in small towns have a greater influence on the environment [5]. However, in major cities, this link is more pronounced in the immediate

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neighborhood and less pronounced in the surrounding areas. There are significant educational institution models from other civilizations as well as illustrations of buildings like madrasahs and colleges. Nevertheless, before the 1940s, there was little study or research on the broad problem of campus planning [6]. Before this, Dober (1992) examined three crucial campus-related themes in his research, including four separate series [3]. These topics included planning, architecture, landscape difficulties, key planning modules, and building standardizations. Due to the circumstances now, the question of how universities build their relationships with the cities they are situated and transcend beyond serving as a scientific center is being reevaluated [7]. In light of this assessment, it is expected that any founded institution will connect with the community. In addition to having facilities for instruction, research, and services, universities are built as self-sufficient campuses with all the essential housing, retail, sporting, health, and cultural units [8]. Universities use these activities to organize activities and events that the general public, academics, and students may participate in.

Around 140 state and foundation universities were founded in Turkey after 2000, increasing the total number of universities to 208 [9]. Some were founded in towns with previous universities, while others were the first institutions to be founded there. The formation of 16 universities in 2006, 22 universities in 2007, 15 universities in 2008, 9 universities in 2009, and 17 universities in 2010 can be blamed for the rapid rise in higher education institutions [10]. Under their project criteria and prepared strategic plans, the newly founded universities have begun to develop and build on one or more campuses of various sizes.

When universities are founded in Turkey, their campuses are designed using institutionally created strategic plans. Evaluation of building assessments, educational programs, campus, and environmental challenges requires needs analysis [11]. All state universities founded in Turkey offer services by approving the strategic plans they created and implementing them throughout the short, medium, and long term [12]. For many social, administrative, and geographic reasons, Turkey's university system provides diversity, and creating a dynamic university structure necessitates extensive and methodical planning [1]. Additionally, because of the city's fast development, several colleges have gone through this drawn-out process of transferring outside the city. Universities outside the cities must also offer many of the chances that the city offers internally and externally [13]. Whether the university campus is in the city or outer city, the improvement and development of the campus establishment need to be tracked for further evaluations like success, integrity, consistency with the design project, and decisions on new investments and rehabilitations. Thus, a methodology should be implemented for analysis.

Land use and cover analysis can be valuable tools for university campus development. It can help identify the current land use patterns, assess the potential for new land use scenarios, and evaluate the impacts of proposed changes [14]. It can be implemented into evaluation for university campus development, helping to ensure that new development is sustainable, cost-effective, and meets the needs of the campus. In this study, the objectives are to explore the potential of land cover and land use analysis for tracking the development of university campuses and state the changes and compatibility of construction comparing the university campus plan projects. Kırklareli University and Kırşehir Ahi Evran University Main campuses were studied within the framework of the study. Since both universities were founded, campus plan projects were completed nearly in the same time interval as the last period's examples of Turkey.

First, the study method is stated with brief literature on land use and land cover analysis by remote sensing, especially the Copernicus Project. The Copernicus Project is the European Union Project that aims to establish compressive earth-observing environments for various disciplines and users. Secondly, the design briefs of the case studies are presented, implementing the main framework of university campus planning. Case studies are designed to state the features shaping the campus plans of universities that define built-up strategies. The materials generated from the satellite images, Copernicus, and design projects are shown and evaluated. The discussion about the findings and conclusion are conducted to explore the changes, integrity, and consistency of development and to underline the potential and utilization of remote sensing for observing the development of university campuses.

2. METHOD

Research on land use and land cover changes (LULCC) have caused much concern since they help formulate policies and strategic plans in many contexts and at various sizes. [15]. Among many applications of satellite imagery, and-use-land-cover (LULC) forms an integral part. LULC plays a pivotal role in urban planning and land resource management and provides useful insight into the growth rate indexes of different population spectrums [16].]. Accurate information on land use land cover (LULC) can facilitate various research activities related to floods, droughts, migration, and climate change at several scales [14]. With the advent of cloud computing platforms, time series extraction techniques, and machine learning classifiers, new opportunities arise in more accurate and large-scale LULC mapping [17]. A land cover analysis is fundamental for various applications like ecology, environment, agriculture, transport, and spatial planning [18]. Since data acquisition, processing, and results in diffusion have been investigated for decades, technological advancements and tools of geographic information systems (GIS), remote sensing (RS), and machine learning (ML) have been used to classify various land uses and land covers at various levels [15].

The EU's Copernicus project aims to create a comprehensive earth observation system that will deliver precise and timely data on the environment and security for various uses. The European Commission (EC) and the European Space Agency are partners in the Copernicus project, sometimes called the Copernicus Programme (ESA). It began in 2014 with an estimated budget of €4.3 billion for the years 2014 to 2020, and since then, with an additional €13.2 billion in funding, it has been extended until 2027 [19]. Land use analysis with Copernicus can be performed using the Copernicus Land Monitoring Service (CLMS) data, which provides comprehensive and up-to-date information on land cover and land use in Europe and other world regions [20]. The Copernicus Land Monitoring Service provides land use and land cover data through a range of products, including high-resolution satellite imagery, land cover maps, and biophysical variables such as vegetation indices and land surface temperature. These products can be used for various applications, including urban planning, agriculture, forestry, water management, and environmental monitoring.

The research flow is shown in Figure 1. First, the design briefs with a literature survey for campus planning are presented. The framework, transportation layouts, building regions, and criteria of the campus plan are explored. Secondly, the components of the materials are captured and refined for evaluation, including the master plan, satellite images, and land cover data from Copernicus Project. It is possible to expand to investigation of remote sensing repositories for land use and cover analysis, however Copernicus Project is decided because of reliability. The findings are evaluated, and further discussions are conducted to explore the developments, changes, and design consistency. The conclusion underlines the study's outcomes, states the potential use of land cover and use analysis potentials, and lacks used cases.

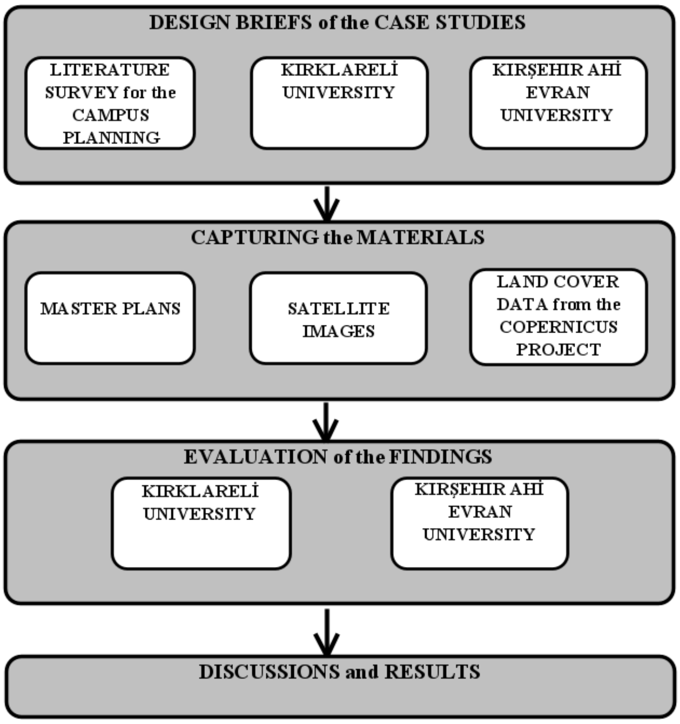

Figure 1. *Research Flow*

3. DESIGN BRIEFS OF CASE STUDIES

Planning typologies are varied and go by several titles in literature. (1) Dispersed settlement, centralized settlement, molecular settlement, network settlement, and linear settlement are a few instances; (3) Outside the city, dispersed planned, centrally planned, radial planned, clustered planned, network, and multi-polar; (2) core-based approach, linear approach, and grid approach; (4-inside the city), which may be given linearly and is evolving in organic tissue, building blocks, and network [1], [8], [21], [22].

Working, housing, rest and leisure, and transportation are the services that should be present on campus [21]. Together, these tasks need to build a connection inside a pattern. Urban colleges may have the choice or duty to provide services like housing and food as part of the urban infrastructure. As a result, in the case of urban colleges, strategic decisions are taken depending on the size of the campus area and the urban texture. Entrances, highways, squares, and parking lots are the four basic categories that may be used to categorize the components of the campus's circulation system [8]. According to their intended use, roads are divided into lanes for vehicles, pedestrians, and bicycles. For the transportation network, each type of road has a particular length and width measurement. The entire campus should be designed with simple access in mind, with pedestrian walking distances taken into consideration, and should not be impacted by vehicle traffic. A campus that values people and the environment is innovative, research-focused, and provides both indoor and outdoor areas should be expected, given that universities are centers for development, research, and innovation. To be a sustainable campus that offers access to open and recreational areas at a pedestrian size, the physical design of the institution is a key principle [23]. Therefore, it is important to consider access and usage options to public places at a pedestrian scale while evaluating the transportation network.

The university campus's internal pedestrian and vehicular transportation networks are planned during the urban design phase. Connection points and modes to the urban transportation network are assessed in this planning. Entrance gates and other transportation components created for the designated regions meet these fundamental ideas and campus mobility standards. As previous functions evolve and transform through time, university structures and the area around them may experience new circumstances. For instance, colleges founded as urban institutions in Europe first provided higher education in college buildings in urban areas before relocating to broader communities outside of the city that could expand and thrive [2]. Important topics in the design of educational campuses are listed as follows [24]: urban characteristics, climatic characteristics, access, traffic, services and amenities, land use, pedestrian and vehicle circulation, building placement and features, sustainability and flexibility, and phasing.

3.1. Kırklareli University Campus Plan

The design studies of the Kayalı Campus were completed at the end of 2009, and construction and development works started in parallel with the completion (Figure 2). It was founded on May 29, 2007, and as of present, 24.000 students are enrolled in its 12 faculties and three institutes [25]. Some other faculties and schools of the university in diverse villages of Kırklareli include Lüleburgaz, Vize, Pınarhisar, and Babaeski. Kayalı Campus has a total area of around 3.450.000 m2, of which the proposed campus occupies less space. From the north, the area lies near Kayalıköy Dam's Pond. The campus land is divided into two parts by valley morphology from northwest to southeast, with one part at the north with an area of 2.500.000 m2 and the other at the southwest. The pre-ground examination of the land showed that rock distribution on the surface makes excavating difficult. The slope is near 2.00% in the direction from the southwest and northwest in the north part of the area. The government agencies must approve the overall settlement areas for sustainable and manageable development of newly founded universities.

Kırklareli University Kayalı Campus settlement plan was based on functional areas and a transportation scheme that associated regions with their respective distances and orientations. The main settlement area should not exceed approximately 1.000.000 m2, and a compact development plan was designed to consider infrastructure costs. A settlement plan was developed that emphasized accessibility criteria and energy efficiency goals, encouraged bicycle use, and focused on common areas that would serve as the center of activity and connect building areas with different centers. A main pedestrian road was created that did not exceed 2% slope in the southwest to northeast direction, and building areas were associated with this pedestrian road's northern and southern facades. Two different squares were planned on it, with the first square located to the east being shaped by functions such as the rectorate, library, and cultural congress. In contrast, the student center and central classroom buildings defined the second square located to the west.

The main settlement area defines an area of approximately 700.000 m2 and does not interrupt the pedestrian road that will receive sufficient transportation services. The Kırklareli University campus plan is a settlement where building zones that offer parallel development opportunities to the terrain and education conditions prioritizing pedestrian transportation are defined and functionally related. The access road, which provides transportation to the terrain, splits right and leaves at a main intersection, transporting vehicles to the square defined by the library, rectorate, and cultural congress center. The entrance road, which provides access to the land, divides into right and left directions at a main intersection and provides transportation to the square. The building areas on both sides of the main pedestrian axis are approximately 250 meters deep and have a width between 200 and 300 meters, depending on the characteristics of the buildings they contain. In addition to the main settlement area, the second vehicle road has created a development area with 7 building zones within an area of approximately 250.000 m2. The pedestrian path starts with the student center in the north and ends with the sports areas passing through the development area in the south. In the east, the main axis starts with the campus entrance and ends with the amphitheater.

Figure 2. *Kırklareli University Campus Plan*[1]

3.2. Kırşehir Ahi Evran University Campus Plan

The design studies of the Bağbaşı Campus were completed at the end of 2008, and construction and development works started in parallel with the completion (Figure 3). It was founded on March 17, 2006, and as of present, 21.462 students are enrolled in its ten faculties and three institutes [26]. There are some other faculties and schools of the university in diverse villages of Kırşehir, including Cacabey, Kaman, Mucur, and Çiçekdağı. Bağbaşı Campus has a total area of around 2.900.000 m2, of which the proposed campus occupies less space. The campus area is at the slope area next to the city center.

There are different slopes and terrain shapes within the university campus area. Generally, the slope increases from northeast to southwest and is not homogeneous. While a slope of 5% is observed in some places, it reaches up to 25% in others. When the university was founded, an unfinished educational building was located at the northeast end of the land, but its construction had largely been completed. The general planning principles mention that installation and infrastructure costs should be minimized, phased development should be enabled, and pedestrian and service transportation should be organized. Therefore, the planned settlement areas have been separated according to different uses.

The approximately 500,000 square meter area designated as the main settlement area starts from the northeast end of the land and ends with the sloped area in the southwest and the flat area behind it. The road surrounding this area provides service transportation to all building areas. A main pedestrian road has been planned along this area's terrain and geometric analysis. This pedestrian road reaches the hill settlement where administrative and cultural buildings are located by providing service to the educational buildings in both directions. Thus, building areas and activities have been associated and provided access with different levels.

[1] All images given due to North up direction.

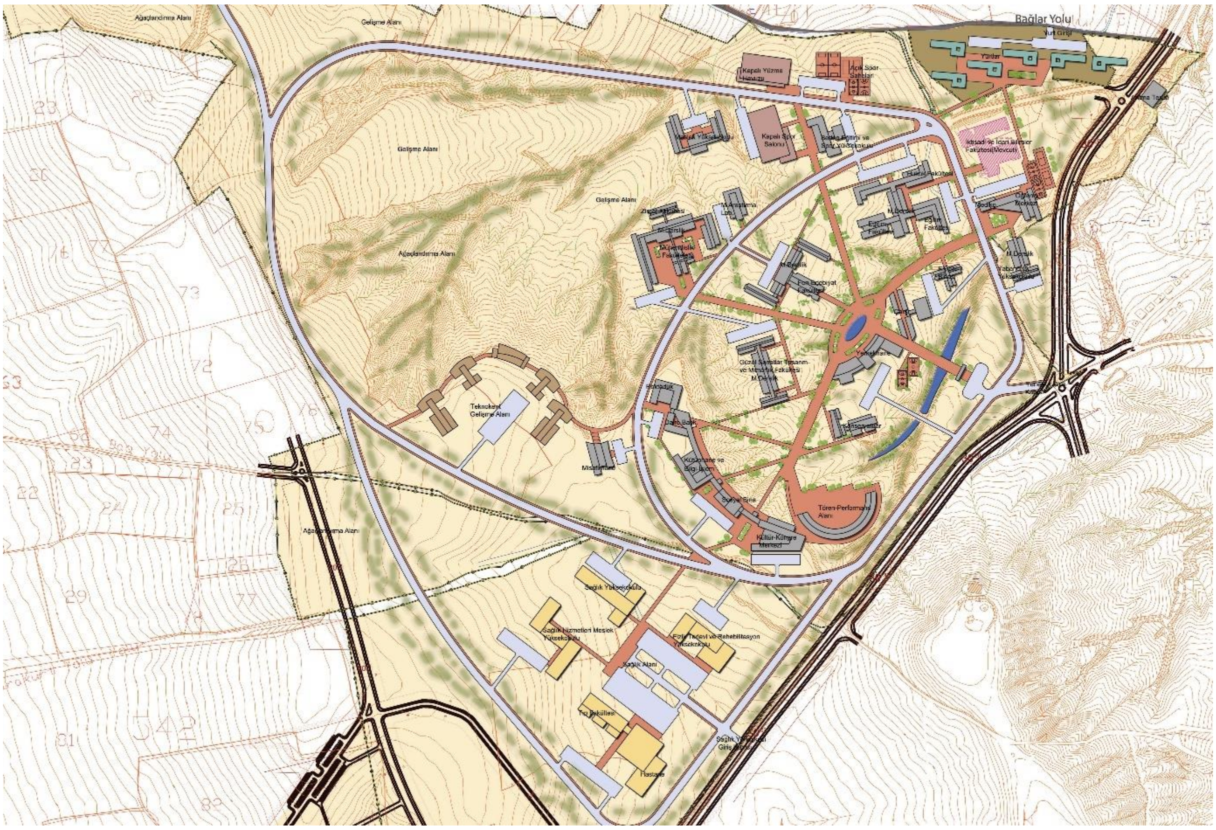

Figure 3. *Kırşehir Avi Evran University Campus Plan*

While sports, cultural, and educational areas are planned within the main settlement and neighboring areas, areas for future development are designated for transportation. The dormitory area, technopark area, healthcare facilities area, and accommodation areas are located where they can be integrated into the campus but can also be accessed independently. Most of the planned structures within the campus have a proper view towards the north and northeast directions and are supported by the slope direction. Therefore, attention has been paid to this situation in all service and pedestrian transportation of building areas.

4. LAND USE AND LAND COVER ANALYSIS

Land use and land cover analysis are implemented for diverse tools and methods with conducting capabilities of remote sensing. In this study, the original project of the campuses, satellite photos [27], and produced and verified analysis from the Copernicus project [19] were implemented. The time interval of the campuses is effective with the establishment of universities (2006,2007). The data available at the Copernicus project is from between 2000-2018. Thus, the materials were taken for the establishment dates until 2018. Figure 4 shows the legend of the materials used for analysis and evaluation.

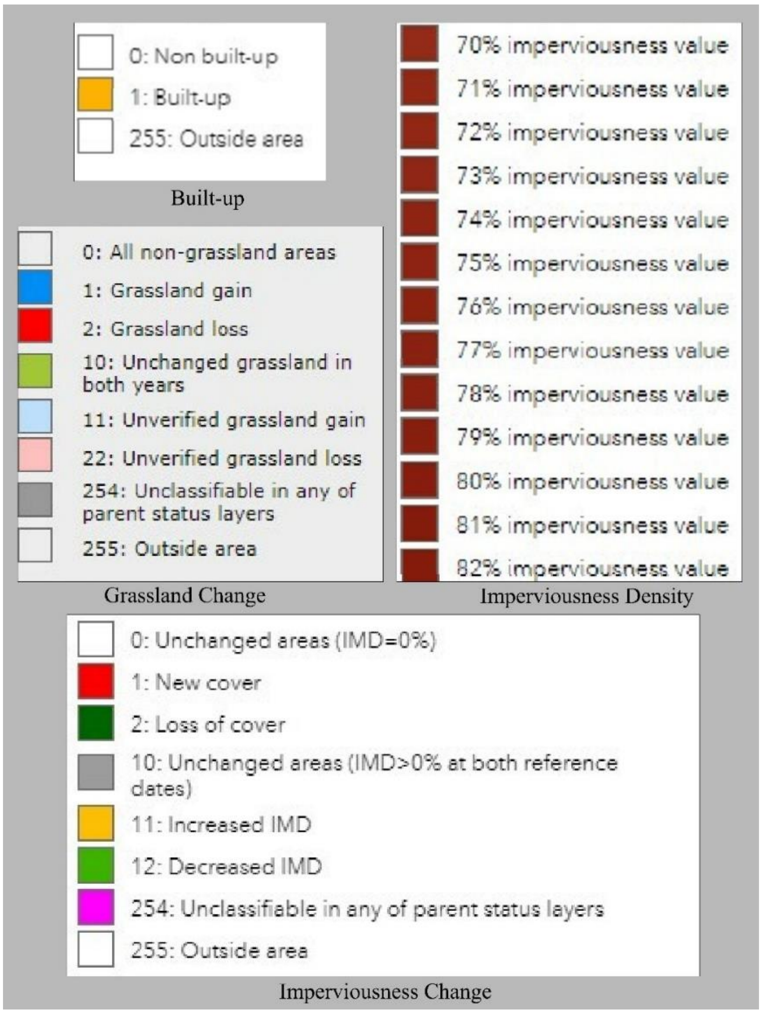

Figure 4. *Legend for Analysis*

For the analysis, the built-up land, grassland, and imperviousness were used for classification. Built-up data shows the constructed areas, including any pavement and roof of the buildings [28]. Grassland illustrates the areas' gains, losses, and changes [29]. The verification and classification situation can be seen in the distribution subsection. The grassland changes from 2015 to 2018 are captured for evaluation. Imperviousness refers to the ability of a surface to prevent or resist the infiltration or penetration of water. An impervious surface does not allow water to pass through it. Instead, it causes water to run off and accumulate in other areas, leading to flooding, erosion, and pollution [30]. Impervious surfaces include paved roads, parking lots, sidewalks, and rooftops. The degree of imperviousness of a surface is measured as a percentage of the surface area covered by impermeable materials. It is an important factor in the hydrology and management of urban areas. High levels of imperviousness can have negative impacts on the environment and public health, and therefore, efforts are made to reduce the imperviousness of surfaces through the use of permeable pavements, green roofs, and other techniques that allow water to infiltrate into the ground. The imperviousness density shows the ratio from 0% to 100% which is parallel to light to darker color. Darker color means that the area blocks the penetration of water which could refer to conversion from soil to harder textures. Imperviousness change legend illustrates the situation whether it is new cover, loss of cover, increase/decrease or unchanged area within the time interval. It is significant to observe the construction sequence within in time by remote sensing. The framework of two university campuses is shown in the sub sections within the integrity and evaluations are conducted by referring to the assigned figures. The evaluations are made through observations among images, and the same sequence is followed.

4.1. Kırklareli University Campus

The analysis material of Kırıkkale University campus is shown in Figure 5. The comparison of the master plan and satellite images shows the overall consistency of the campus development after nine years. The service and pedestrian roads that form the main framework of the campus plan and the construction of building areas have been made with the master plan. The second square and the buildings that define it have been built within their zones and descriptions. The first square, located on the east border of the campus, has not been completed, and the buildings that define this square have not been constructed. However, a larger building construction is observed east of this square according to the building area. The religious facility at the western end of the main pedestrian road is not included in the master plan. In addition, two of the building project construction areas have been constructed to include the area east of this building. The structures and open space arrangements seen in the sports area are compatible with the project. Some of the structures have been completed.

When examining the built-up area in 2018, a remote sensing result is obtained parallel to the 2018 satellite image. Significant differences belong to the roads, green areas, and the building north of the second square. There are differences in the surface coverings of the roads and interruptions on the main pedestrian road and campus entrance road due to surface reflections. The large green area in the middle of the stadium, recorded as construction, has not been perceived as construction in parallel with its surface features. An important detail is that the building to the north of the square has not been perceived as a general structure, but the parking lot of this building has been perceived. The reason for this can be revealed by examining the roof surface features of the building.

When examining the imperviousness density in 2018, a much more detailed and consistent comparison can be made compared to the previous analysis. The presence of roads and the differences in surfaces near the roads are present in the analysis. In addition, the density differences between building roofs and road coverings reveal surface impermeability. The constructions near the building environments have affected the surface structure in parallel in certain proportions and resulted in surface impermeability.

The Grassland Change analysis between 2015-2018 shows important observations. Protected green areas are parallel with constructions. The green loss shown in red and unconfirmed green losses in the area around it indicates the construction period of the starting construction in the region. Other green losses shown in pink are consistent and related to road construction. In addition, the unconfirmed green areas shown in blue illustrate an increase in green areas within the campus due to human or natural paths. A detailed area comparison can be made with this analysis, which construction affects green areas and how it can be listed.

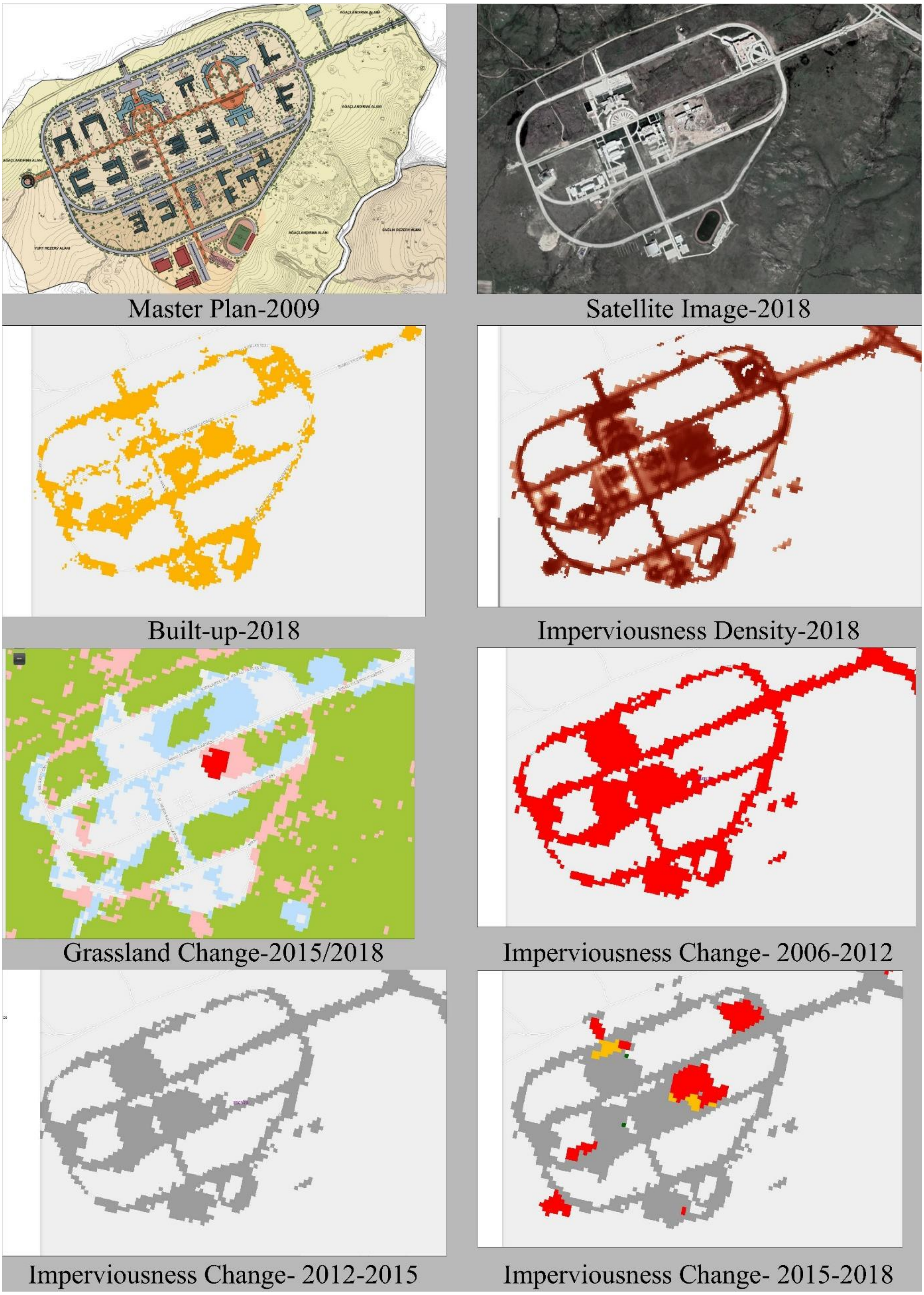

Figure 5. *Kırklareli University Land-Use and Cover Analysis*

An analysis of imperviousness change has been presented for three time periods. These periods include the establishment of the university and the obtained data for the end of 2018, which are 2006-2012, 2012-2015, and 2015-2018, respectively. By examining these periods, it is possible to investigate the land use and development ratios over time through area analysis if desired. Based on observations, it can be said that the greatest amount of development took place between 2006 and 2012. The development was completed during this period, except for the buildings in the neighboring areas of the symmetric buildings defining the second square on the eastern border. There was no development reflected in the outdoor areas between 2012 and 2015. From 2015 to 2018, the final state of 2018 was reached. This analysis shows that three buildings that did not exist in 2015, the parking area north of the student square and the surface production in the southwest of the main settlement area, are visible.

4.2. Kırşehir Ahi Evran University Campus

The analysis material of Kırşehir Ahi Evran University campus is shown in Figure 6. Compared to the master plan and satellite photographs, the project has significant differences despite some key decisions aligning with the master plan. Firstly, there are unfinished or differently constructed pedestrian and service roads compared to the master plan. The main pedestrian road construction has not been completed, and the service road construction in the north on the southeast line has not been done. Looking at the road traces in the north, it can be seen that the road route will shift northward. In addition, a new service road line has been added to the northeast of the building areas in the southwest line in a pedestrian shape, and its construction has been completed. It can be observed that the stadium construction and square planned structure in the southeast has been added to the project. Furthermore, a building with a rectangular plan has been constructed on the main pedestrian road route. By comparing buildings and road lines in detail, the master plan can be revised accordingly, and the activity and structure relationships can be updated accordingly.

When examined with Built-up 2018, there is a result of remote sensing parallel to the 2018 satellite photograph. Road traces cannot be identified. The main pedestrian and service roads may not have been analyzed due to differences in surface coverings and reflections. The boundaries and areas of buildings cannot be revealed. However, there is generally parallelism with the traces of construction. The reason for this can be revealed by examining the roof surface characteristics of the building.

Observing the Imperviousness Density 2018, a more detailed and compatible comparison can be made compared to the previous analysis. The presence of roads and differences in surfaces around the roads are present in the analysis to a certain extent. In addition, the density differences between building roofs and road coverings reveal surface water impermeability. Due to buildings, road coverings, and ongoing construction, surface impermeability has been combined, and different surfaces have not been defined.

When the Grassland Change 2015-2018 analysis is examined, no significant loss or gain of green areas is observed between these dates. Only unconfirmed green area gains have been identified. This situation may be green area gains around the construction works within the campus. The analysis of imperviousness change is presented at three-time intervals. Specifically, for the period between the establishment of the university and the end of 2018, the time intervals of 2006-2012, 2012-2015, and 2015-2018 are provided. Based on these, area analyses and building ratios can be examined for the time intervals if desired. Observation reveals that the greatest construction occurred between 2012-2015, as indicated by the orange coloration that shows an increase in imperviousness. The lack of new surface definition, i.e., red definition, is due to the unclear boundaries of surface areas, which parallel the built-up and density analyses. No external construction occurred between 2016 and 2012, while no significant new construction occurred between 2015 and 2018. However, during this period, there was a gain in impervious surface area or a loss of surface cover. In this example study, surface cover and usage analyses provide a general idea about construction but do not provide detailed information about building boundaries and surface types.

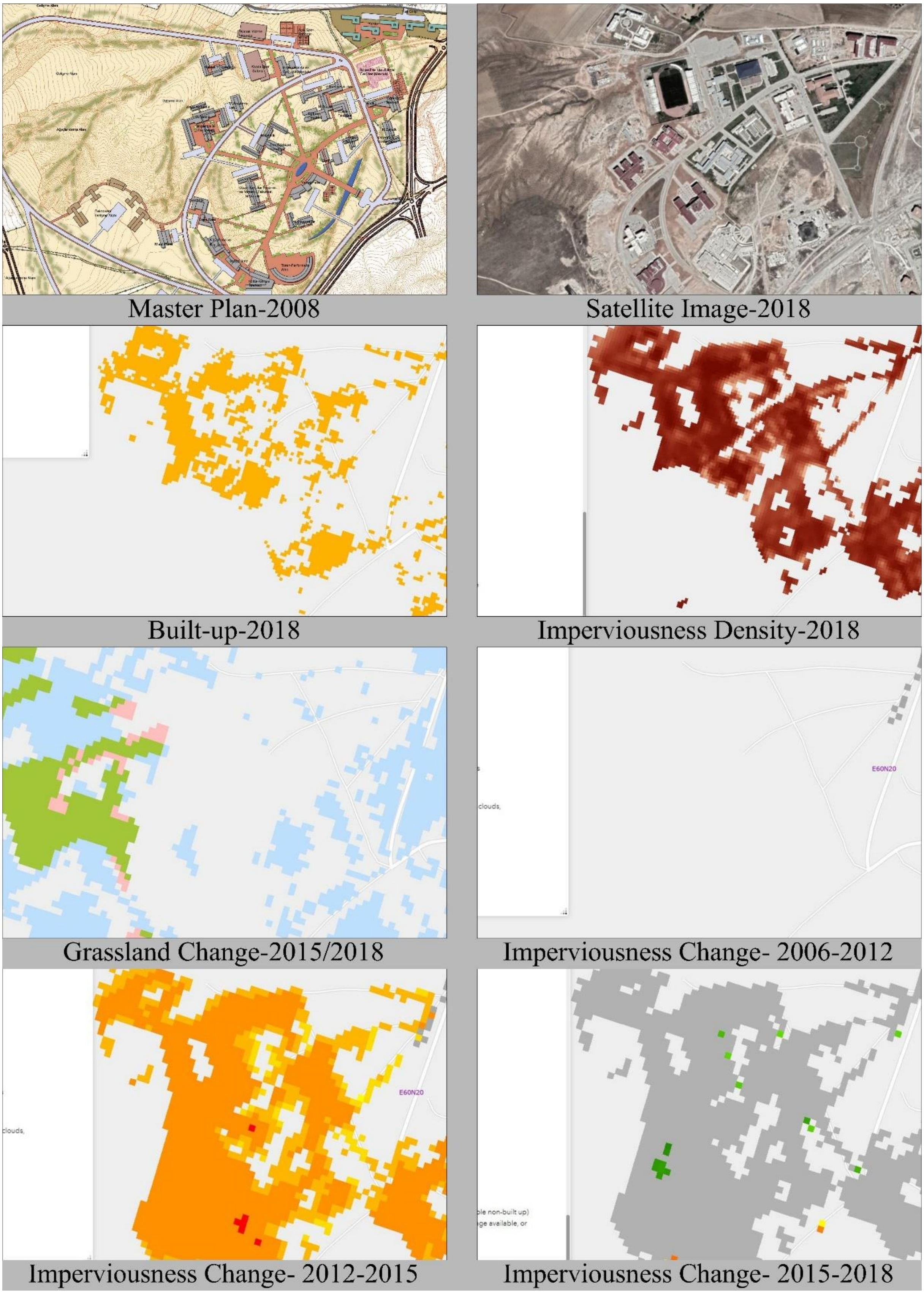

Figure 6. *Kırşehir Avi Evran University Land-Use and Cover Analysis*

5. DISCUSSIONS

The analysis presented in the material provides valuable information on the development and changes in the Kırıkkale and Kırşehir Ahi Evran University campuses over time. The remote sensing techniques used in the analysis have enabled a comprehensive understanding of the campus area's land use and development patterns, providing insights into the effectiveness of master plans in guiding the development process.

In the case of Kırıkkale University, the analysis shows that the development process has been consistent with the master plan, with the service and pedestrian roads and building areas being constructed following the plan. The lack of completion of the first square and the buildings that define it suggests there may have been challenges in implementing the plan fully. However, the analysis shows that a larger building construction was observed east of this square, indicating the possibility of new development in the area. Furthermore, the analysis of imperviousness density shows that the surface impermeability caused by building constructions has affected the surface structure in certain proportions, which could affect the campus's water management and environmental sustainability. The Grassland Change analysis also highlights the loss of green areas due to construction activities and road constructions, suggesting better management practices to minimize the environmental impact.

In the case of Kırşehir Ahi Evran University, the analysis reveals significant differences between the project and the master plan, with unfinished or differently constructed pedestrian and service roads. Adding new service road lines and construction of buildings on the main pedestrian road route suggests that the master plan may need to be revised to update activity and structure relationships accordingly. Overall, analyzing the two university campuses using remote sensing techniques provides valuable insights into the effectiveness of master plans in guiding development processes and the potential environmental impact of construction activities. The information obtained from these analyses can be used to inform better management practices and future planning decisions for sustainable development.

The analysis material presented in Figures 5 and 6 shows the consistency and changes in the development of Kırıkkale University and Kırşehir Ahi Evran University campuses over time. The overall consistency of Kırıkkale University campus development after nine years is observed in the service and pedestrian roads and building areas constructed following the master plan. However, differences in surface coverings, road interruptions, and green losses affect the surface structure in parallel in certain proportions. The analysis of imperviousness change shows that the greatest development occurred between 2006 and 2012, with no development in outdoor areas between 2012 and 2015, and the final state of 2018 reached by 2018. In contrast, Kırşehir Ahi Evran University campus shows significant differences in the project compared to the master plan, with unfinished or differently constructed pedestrian and service roads. However, the stadium construction and square planned structure have been added to the project. The analysis of imperviousness density shows that a much more detailed and compatible comparison can be made compared to the previous analysis, with the presence of roads and differences in surfaces around the roads present in the analysis to a certain extent. These analyses provide valuable insights into land use and development ratios over time, allowing for the revision of the master plan and updating of activity and structure relationships accordingly.

6. CONCLUSION

This study provides an overview of land cover and land use changes that have taken place at Kırklareli University and Kırşehir Ahi Evran University between 2006-2018. The remote sensing and satellite image analysis gave comprehensive information of land use and land cover changes and their effects on the surroundings. The findings of this have a look at highlighting the significance of monitoring land use changes over the years and the want for sustainable land control practices in those regions. The consequences of this examination can be a valuable aid for decision-makers and planners in growth strategies for improving those regions. The results of this study present the changes in land use and land cover that have occurred at Kırklareli University and Kırşehir Ahi Evran University between 2006-2018. The analysis of remote sensing and satellite images clearly understood the patterns and temporary situations in land cover and land use changes.

The study also found that the rate of urbanization had increased significantly in both regions. The conversion of lands to built-up areas may additionally lead to the loss of valuable natural resources, such as soil and water, and has resulted in environmental influences. Additionally, this study can be a valuable resource for urban planners and other stakeholders interested in designing and implementing effective land-use control strategies to mitigate the negative impacts of land-use adjustments and promote sustainable and tracked development. Two potential directions for future research on analyzing university campus development using remote sensing include long-term tracking and conducting a comparative evaluation. The long-term analysis ought to provide an extra comprehensive knowledge of campus development and extra periods in the examination. Remote sensing could identify changes in cover and use, which could be valuable for campus planning and management. Finally, conducting a comparative analysis of multiple university campuses could identify common trends and best practices in campus development, informing policy and planning decisions for universities in Turkey.

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