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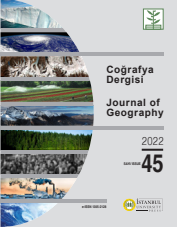
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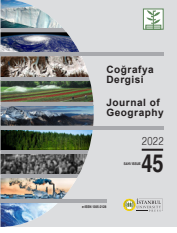https://dergipark.org.tr/en/pub/iucografya

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P R E S S

Noise in the City: A Socio-Spatial Analysis of the Actual and Perceived Noise Levels in a Medium-Sized Urban Center

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ABSTRACT
Despite substantial systematic studies on noise pollution, studies relating actual noise levels to perceived noise pollution in the context of rapidly urbanizing medium-sized cities of the Global South are scarce. This study examined the perceived impact of noise pollution on the health of residents of Osogbo, Southwest Nigeria. It used a cross-sectional research design that included direct field observation to obtain noise levels and a questionnaire survey to assess residents' perceptions of acoustic disturbance in the study area's residential, commercial, and mixed land uses. Ambient noise levels were significantly higher during the day and night in residential, commercial, and mixed land uses than the WHO-prescribed maximums. Significant variations between different land uses were observed. More than 80% of the respondents perceived their neighborhoods as noisy, indicating a convergence between actual and perceived noise levels. Respondents scored power generators (22.1%), transportation (21.7%), worship places (20.3%), and markets and clubs (14.7%) as important sources of ambient noise pollution. Sleep loss (72.3%), hearing impairment (64.3%), and aggravation of hypertensive ailments (54%) were the acute effects of noise pollution. Few respondents claimed to be aware of the efforts of the government (34%) and neighborhood associations (28%) to stem the escalating rate of noise pollution. Enforcing environmental laws on noise reduction and advocacy that provokes noise-abating behavioral changes among residents could help curb noise pollution in the city.
Keywords: Medium-sized urban centers, noisescape, noise abatement, city's livability, ambient noise levels

INTRODUCTION

Noise pollution is aptly defined as the intrusion of unwanted, uncontrollable, and unpredictable sounds, not necessarily loud (Jariwala et al., 2017), into the lives of individuals with reasonable sensitivities. It remains an environmental problem of no mean significance in both developing and developed countries' urban centers (Fiedler & Zannin, 2015; Mehdi et al., 2011; Oyedepo & Saadu, 2010). The increased population, attendant urbanization, and industrialization are primarily responsible for the rising incidence and ubiquity of noise pollution worldwide (Ma, Li, and Kwan, 2018; Reed, Boggs, and Mann, 2012; Yuan et al., 2019). Despite empirical studies demonstrating a rapid increase in urban noise levels in developing countries, relevant urban stakeholders have yet to give the problem the attention it deserves (Jariwala et al., 2017).

Noise pollution and its impact on health and well-being have long been ignored. However, this is changing, with several health institutions now viewing the increase in community noise as undesirable and unsustainable. The effects of noise on human health and comfort can be devastating depending on its duration and volume. According to Ackah, Amankwa-Danquah, and Atianashie (2021), these effects are divided into four categories: physical effects (e.g., hearing defects), physiological effects (e.g., increased blood pressure, irregular heart rhythms, and peptic ulcers), psychological effects (e.g., disorders, sleeplessness and late sleeping, irritability, and stress), and effects on work performance (e.g., decreased productivity and misinterpretation of what is heard (Oyedepo 2013). Noise pollution is an important environmental pollutant that affects human performance (Pal and Bhattacharya, 2012). The individuals' survival and healthy existence depend basically on the enabling environment where they reside since disruption of the conducive environment can lead to dysfunction of their health status (Otukong 2002).

In developing countries, particularly Nigeria, the framework for enforcing legislation and noise pollution abatement codes is weak and rarely enforced. The Nigerian federal environmental regulator, the National Environmental Standard and Regulation Agency (NESREA), only provides daily noise exposure limits for different environments. Given the present and future impacts of noise-induced health hazards on urban dwellers, stakeholders must control the noise level. Noise generation in a metropolitan setting can be viewed in relation to city planning disorderliness and increasing vehicular traffic caused by urban growth and development. Several studies have identified weak governance structure and financial foundation as significant factors that hinder the implementation of environmental and other policies and programs in small- and medium-sized cities (Samuel, Agbola, and Olojede 2021; Samuel and Atobatele 2019a, 2019b).

Planning, developing, and establishing a noise control capacity are crucial in noise control efforts. Moreover, abatement plans for noise-generating areas and land-use categories are required. Such policies and programs would be successful and sustainable only if residents, both generators and victims of noise pollution, were involved in the conceptualization, implementation, and postimplementation oversight. It is instructive that the ability of residents to participate in noise abatement programs will be a function of their perception of noise pollution's menace. This highlights the importance of understanding the objective and subjective assessment of noise pollution as indicated by the noise levels with the subjective evaluation of the residents based on their perceptions. Many systematic studies on noise pollution are conducted in large urban centers (Ali and Tamura 2003; Raimbault and Dubois 2005; Tonne et al. 2018), except for a few that focused on small- and medium-sized cities (Oyedepo and Saadu, 2009, 2010; Popescu and Moholea, 2010). Again, a disproportionate number of these studies have focused on single-source pollution from road traffic (Ali and Tamura 2003; Arokoyu, Emenike, and Atasi 2016; Botteldooren, De Coensel, and De Muer 2006; Frei, Mohler, and Röösli 2014; Khan et al. 2018; Oyeleye 2013) to the exclusion of other sources of environmental noise pollution. A comprehensive noise pollution analysis that observes both actual noise levels and perceived noise pollution can reveal the actual situation of the problem and assess how the residents feel about it. Understanding the residents' perceptions can inform people-oriented, community-based policies and other interventions to reduce the threat. To our knowledge, studies that combine objective noise pollution measures with subjective assessment by residents are very rare.

Few large cities in Nigeria, like Lagos, have taken policy and advocacy measures to reduce the elevated noise levels within their domains. However, most medium-sized cities lack the human and material resources and a robust institutional framework to combat noise pollution. Knowledge of actual and perceived noise levels is critical for policies and advocacy encouraging behavioral changes to reduce noise pollution. Effective noise pollution control measures would necessitate the active participation and cooperation of affected individuals and communities, a situation dictated by people's perceptions of the problem's reality and the risk exposure. Against this backdrop, this study seeks to identify the areas prone to noise pollution in

the city, assess the perception of noise pollution by residents, and compare the objective measures of noise pollution with the subjective assessment by residents of the medium-sized town of Osogbo, Osun State, Nigeria.

Extant empirical and theoretical works on noise pollution have linked the escalating noise pollution to several factors, among which the main are population growth, urbanization, poor urban planning, and certain behavioral traits that encourage noise generation (Abankwa, Agyei-Agyemang, and Tawiah 2017; Ma et al. 2018; Mehdi et al. 2011; Morillas et al. 2018; Paunović, Belojević, and Jakovljević 2014).

In attempts to depict the acoustic landscape of cities, scholars have generated noise maps, some of which relate the observed pattern to some city characteristics. For instance, Barrigón (2010) established a relationship between urban noise and inhabited areas on the one hand and population on the other in their study of the noisescape of small and medium-sized cities in Spain. Similarly, Oguntoke et al. (2019) created a risk map for a medium-sized Nigerian city. They found the noise levels higher than the prescribed World Health Organization (WHO) minima across spatial and temporal scales. However, they did not explicitly account for variations attributable to different land uses. Meanwhile, Barrigón et al. (2010) found a relationship between urban noise and inhabitants and between urban noise and inhabited areas in their research of 20 cities in Spain, reflecting the urban structure defined in the strata of the categorization method. In Karachi City, Mehdi et al. (2011) found that noise levels were generally higher in the mornings and evenings because of the commuting pattern of Karachi residents. The average value of noise levels was over 66 dB, which could cause serious nuisance, according to the outdoor noise guidelines of the WHO. The maximum peak noise was over 101 dB, which is close to 110 dB, a level that can cause possible hearing impairment (Berglund, Lindvall, and Schwela, 1999).

Gregory (1998) identified three types of noise sources: (i) those associated with the operation of building services, (ii) those associated with activities and office equipment, and (iii) those associated with environmental sound from outside the building. The first two are internal sources, whereas the third is from external sources. In line with this, Shabi (2016) summarized the sources of urban environmental noise pollution into industrialization (compressors, generators, exhaust fans, and grinding mills participate in producing big noise), construction activities (mining, construction, and welding), social events

(partying, clubbing, and religious activities), transportation (vehicles, airplanes, trains, and other transport modes), household chores, and equipment (household gadgets like TV, mobile, lawnmowers, etc.).

Anomohanran and Osemeikhian (2006) identified automobiles, commercial motorcycles, recording houses, and electricity generators as responsible for most noise in Nigeria in their study conducted in Delta State, Nigeria. Similarly, Samuel (2008) attributed urban noise and other atmospheric pollution to the persistence of traffic congestion caused by temporal periodicity in intraurban movements. However, in a study conducted in Ilorin, Nigeria, Oyedepo and Abdulahi (2010) observed that the city's population growth, which increased by more than 50% between 1980 and 2006, was partly responsible for the increase in noise pollution. They also asserted that road traffic is Nigeria's predominant and most generalized noise source. Meanwhile, Essandoh and Armah (2011) stated that the Cape Coast in Ghana is exposed to environmental pollution from increased commercial activities and road traffic. Therefore, this claim associates environmental noise pollution with economic growth. Onuu and Menkiti (1993) also found that the peak noise level in Aba and Uyo, Nigeria, ranges between 86 and 106 dB(A). This noise level exceeds the recommended the 60 dB(A) level for commercial and residential areas.

Other studies have shown that noise pollution harms the health of those exposed to it. In a study of the relationship between ambient noise pollution and sleep in the northern municipality of Belgrade, Serbia, Jakovljević et al. (2006) found that respondents from the noisy area reported having significantly more difficulties falling asleep, being awakened by noise at night more often, and having more problems falling back to sleep. Using a sample of 310 respondents, 192 from noisy neighborhoods and 118 from quiet areas, the study further revealed that noise annoyance, subjective noise sensitivity, and neuroticism were significantly correlated with difficulties falling asleep, time needed to fall asleep, poorer sleep quality, tiredness after sleep, and use of sleeping pills. A meta-analysis of 27 empirical studies published between 1970 and 2010 showed that road traffic noise was positively and significantly associated with hypertension (Van Kempen and Babisch, 2012). In a similar but recent study of 139 low- and middle-income countries, Schwela (2021) discovered an increase in motor vehicle fleets, airport operations, and industries, among other things, as factors responsible for escalating noise levels, with population growth, urbanization, motorization, and, to a large extent, technological development acting as catalysts.

Table 1: World Health Organization (WHO) guideline for community noise (2005)

Environment	Critical Health Effect	Sound Level Db (A)	Time (hours)
Outdoor Living Areas	Annoyance	50 - 55	16
Indoor Dwellings	Speech intelligibility	35	16
Bedrooms	Sleep disturbance	30	8
Schools Classrooms	Disturbance of communication	35	During class
Industrial, commercial and traffic areas	Hearing Impairment	70	24
Music through earphones	Hearing Impairment	85	1
Ceremonies and entertainment	Hearing Impairment	100	

Source://www.consultnet.ie

Table 2: National Environmental Noise Standards for Nigeria

s/no	Land use	Maximum permissible Noise Limits (dB)	
		Day (6 am–10 pm)	Night (10 pm – 6 am)
1	Any building used as a hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
2	Residential Buildings	50	35
3	Mixed Residential (with some commercial and entertainment)	55	45
4	Residential + industry or small-scale production + commerce	60	50

Source: NESREA (2009)

Omubo-Pepple et al. (2010) investigated the effect of noise-induced hearing loss in two locations within the Port-Harcourt metropolis, Nigeria. They concluded that the noise pollution at Port-Harcourt International Airport was harmful to the environment and advised that if specific protective measures were not implemented, it would result in hearing loss and other psychological and pathological effects. Environmental noise can cause tinnitus, hearing loss, sleep disturbance, and other harmful effects on people's health.

The literature on noise pollution inextricably links noise generation with different activities, and its impact on residents' health has been significant. However, it is unclear whether urban residents perceived their activities as the main contributors.

RESEARCH METHODOLOGY

The Study Context

Osogbo, the capital of Osun State in southwest Nigeria, provides the geographical context for this study. Located at longitude 4°34′ East and latitude 7°46′ North with an area of 47 km², Osogbo is a fast-growing medium-sized city with a population of 730,529 in 2021 (UNDESA, 2021). Residential land use dominates the city's landscape, but commercial and mixed land use, an amalgam of residential, industrial, commercial, educational, and other land uses, is also important. The industrial land use is not distinct as it is mainly integrated into different land uses, except for the Osogbo Steel Rolling Mill, Osogbo Machine Tools, and Tuns Industries. These uses of land generate varying levels of noise pollution. Meanwhile, the

transportation system consists of a rail line and a network of roads comprising motorways, major roads, and streets. These roads are used by various modes of transportation, including private cars, minibuses (known locally as *Korope*), articulated trucks, and motorbikes known as *Okada*. Because these modes are mostly old and rickety, they produce abnormally high noise levels, contributing to ambient noise pollution. The city is home to numerous religious institutions, as evidenced by the many mosques and churches, the majority of which have external loudspeaker systems that emit high-pitched noise that pollutes the environment. Noise pollution in the city heightens during festivities and ceremonies, such as burial, naming, wedding, and other traditional and religious festivals that attract open-air drumming and music. Due to the city's epileptic power supply, households, businesses, and organizations resort to an alternative power supply in the form of electric generators, most of which produce high-pitched noise, thereby raising environmental noise levels. This is particularly noticeable in residential areas at night when there is a power outage. Residents usually switch to their generators, not considering the quantum of noise in the environment.

Data Collection and Analysis

The data for this study were obtained through a field survey, questionnaire administration, and group discussion/interview. The field survey measured noise levels using a sound-level meter in 22 sample sites, including industrial, commercial, residential, transport corridors, and mixed land-use areas (Olojede et al. 2019). The questionnaire was administered to people living,
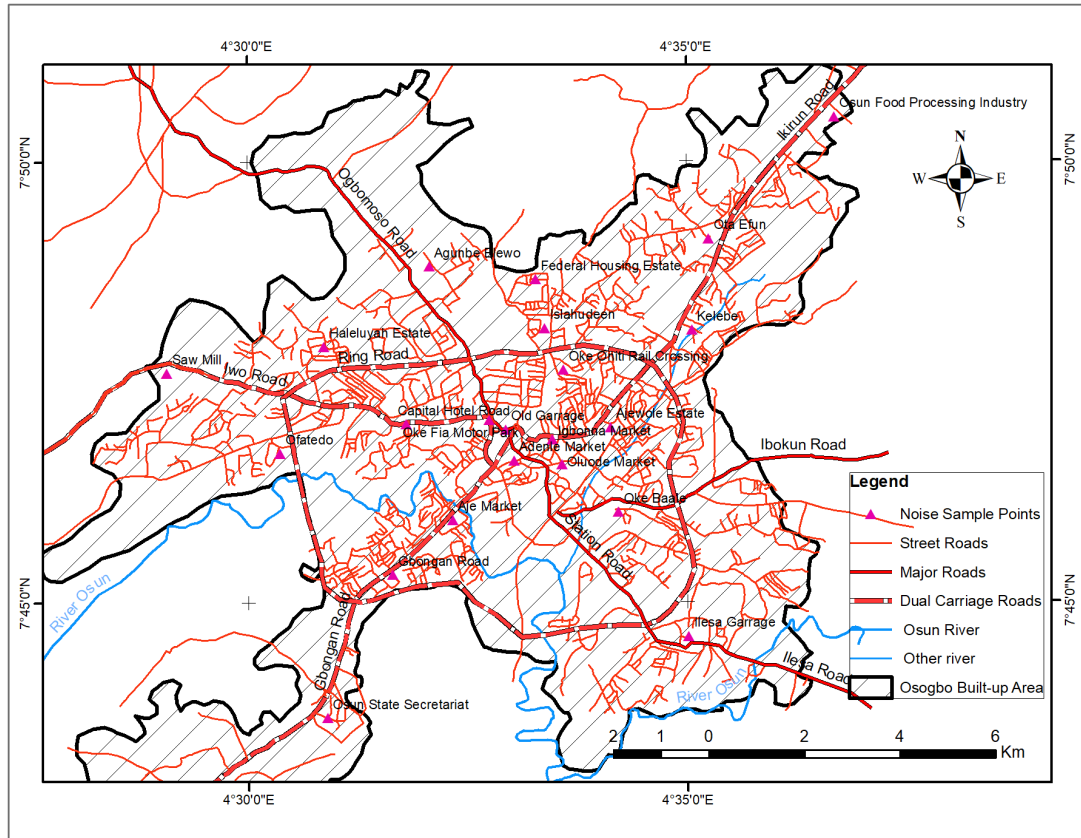
Figure 1: The Built-up Areas of Osogbo (2019)

working, or visiting the study's designated sample area. It elicited information on noise sources and causes, variation in noise levels, the effects of noise pollution, and potential steps to mitigate noise pollution in the study area. Secondary data were derived from journals, published online articles, textbooks, maps, the permissive noise level standards prescribed by NESREA (2009) and WHO's Guideline for Community Noise (2005).

Field Observation

Field observation was conducted to obtain observed noise levels for different land uses, including industrial, commercial, residential, transport corridors, and mixed land-use areas. The digital sound-level meter (or decibel meter) was used to measure the level of noise pollution in different areas of the city. It was used to measure the sound level during the day and night. The obtained values were compared with the acceptable WHO standards. In each of these zones, five and three sample points were chosen randomly (in proportion to the size of the land use) to collect sound-level data, for a total of 22 sample areas. Industrial land-use samples were collected in areas with critical industrial activities. In contrast, samples for commercial,

residential, and transportation land services were collected irrespectively at markets, streets, and roads. The noise levels were observed for these land-use types from 06:00 am to 10:00 pm and from 10:00 pm to 06:00 am over eight days. The average for day and night observations was calculated for each of the land-use types to determine the average noise levels for each land-use type.

Questionnaire Administration

A total of 195 copies of the questionnaire were administered at 22 locations in the 5 land-use types identified in the study area. The questionnaires were assigned to each type of land use in proportion to each land-use size (Table 3). The questionnaire was designed to collect information on people's perceptions of sources, causes, effects, and other salient issues related to noise pollution in the study area. The questionnaire also asked for demographic and socioeconomic information, such as gender, age, occupation, education status, perception of noise level and sources of noise, health and other effects, and awareness of noise abatement measures. Relevant ethical committees approved the design and instruments for data collection. The authors informed the respondents that their participation was entirely voluntary

and that they could opt out participating during the questionnaire administration. Respondents were also informed that all information provided during the data collection would be kept strictly confidential.

The data collected for this study were analyzed using both descriptive and inferential statistical techniques. In particular, data on the sources, causes, and effects were analyzed using descriptive statistics like means and percentages. Simple percentages and frequencies were also used to analyze the distributions, in line with Adejobi's (2012) study of the spatio-temporal analysis of noise pollution levels in Lagos, Nigeria. The analytical techniques are used to ensure that the results of the analysis speak to the research objectives and questions. Additionally, the one-way analysis of variance (ANOVA) was used to analyze the differences in noise levels among the land-use types for day and night observations. This study hypothesized that there is no significant variation in noise levels (day and night) among land uses.

Table 3: Sample Points by Land Use Types

Land use Type	Sample sites for Noise Meter Observations		Questionnaire Samples	
	Frequency	Per cent	Frequency	Per cent
Residential	7	30.4	59	30.4
Commercial	4	17.4	34	17.4
Industrial	3	13.0	25	13.0
Transportation	4	17.4	34	17.4
Mixed land use	5	21.7	42	21.7
Total	**22**	**100.0**	**195**	**100.0**

RESULTS AND DISCUSSION

This study aims to analyze actual and perceived noise pollution to determine if the two converge and assess the impact of noise on the well-being of small- and medium-sized urban center residents. This is important, as any noise abatement measure would require residents' knowledge, awareness, and cooperation to succeed. When and where the residents' perception conflicts with the noise level observed and efforts to reduce noise may not record the desired effect. This study discussed the analysis results of the objective measure of noise and perceived subjective measure of the residents, and compared both to determine whether any convergence exists between them.

Actual Noise Levels across Land-Use Types in the Study Area

The summary of environmental noise levels reveals that the mean daylight sound levels of industrial land use (72.85 dB),

residential land use (55.42 dB), commercial land use (76.61 dB), and transportation use (80.67 dB) are higher than the WHO maximum standards sound levels of 50, 60, and 55 dB for various land uses. Similarly, the nocturnal sound levels for the three land uses were 48, 72, and 61.7 dB for residential, commercial, and mixed land uses, respectively. These figures also exceeded the WHO standards of 35, 50, and 45 dB for residential, commercial, and mixed land uses, respectively. Thus, this scenario suggests that noise has become a significant pollutant in Osogbo city. The study also documented the effect of land-use types on levels of urban noise pollution. Elevated noise levels have been linked to various land uses and the rapid rate of urbanization. Living in a medium-sized urban environment with high levels of noise pollution daily could have detrimental physical, health, and psychological effects that are not always immediately visible but, in the long run, affect the well-being of people.

Variation in Noise Levels Among Dominant Land Uses

Table 4: Actual Noise Levels in the Study Area

Land Use	Actual Noise Level (dB) (Day)	Permissible Noise Level (dB) (Day)*	Actual Noise Level (dB) (Night)	Permissible Noise Level (dB) (Night)*
Industrial Area	72.85	45	53.58	35
Residential Area	55.42	50	43.93	60
Commercial Area	76.61	55	55.86	45
Transport Area	80.67	60	62.01	50
Mixed Area	78.44	55	55.43	50
Average	72.80	56	54.20	45

*Derived from NESREA, 2009.
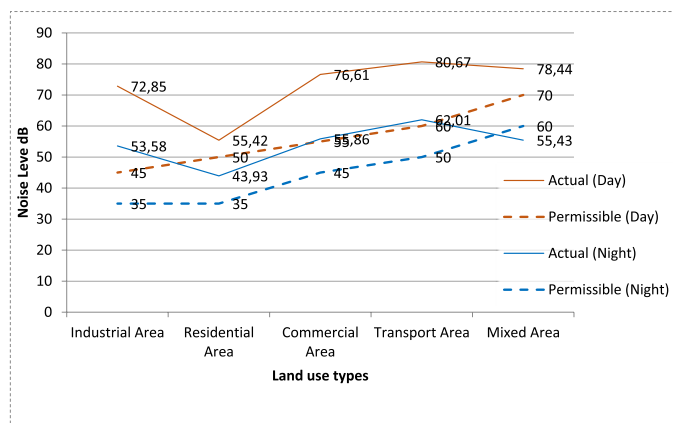
Figure 2: Actual and Permissive Noise Levels in the Study Area

This study was set out to test the null hypothesis (H_o) that land-use type has no significant effect on noise pollution in Osogbo against the alternative hypothesis (H_I) that land-use type significantly affects noise pollution in the city. An ANOVA test

Table 5: Analysis of Variance of Noise Pollution across Land Use Types

		Sum of Squares	df	Mean Square	F	Sig.
Day_Average * Landuse_Type	Between Groups	1010.16	5	202.03	12.94	0.000*
	Within Groups	249.90	16	15.62		
	Total	1260.05	21			
Night_Average * Landuse_Type	Between Groups	371.32	5	74.26	3.15	0.036*
	Within Groups	376.95	16	23.56		
	Total	748.27	21			

Significant at 0.05 (p < 0.05) alpha level

was performed at a 95% confidence level to evaluate the effect of land-use types on noise pollution in the city. The fixed factor (or independent variable) is the land-use type, with three categories: residential, mixed uses, and commercial. The noise level was the dependent variable in the analysis. The assumption of homogeneity of variance was first tested, and the result was found to be tenable using Levene's test. Table 5 presents the results of the ANOVA test. It reveals a statistically significant relationship between land-use type and noise levels observed across the land-use types in the study area. The results indicate that the F-ratio of 12.94 (p-value = 0.036) for the daylight noise level and 3.15 (p-value = 0.000) for the night noise level are significant at the 95% confidence level.

This result implies that the observed differences in environmental noise level in the study area did not occur by chance but varied significantly across all land-use types. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted. From these results, we can infer that land-use types significantly affect the observed noise levels. The reason for this could not be isolated from the fact that different activities associated with different land-use types generate different noise levels. For example, transportation land-use type generates high traffic noise, which is more endemic than commercial activities in commercial land-use areas. These also differ from noise generated in residential areas, as residential land use involves fewer noise-generating activities. This finding is consistent with the findings of Olayinka and Abdullahi (2010), who ranked noise from transportation activities as the highest in Ilorin, followed by noise from commercial areas, then from industrial and public land use, and noise from residential areas as the lowest.

The ANOVA result is emphasized further by the noise heat maps shown in Figures 3 and 4, which depict the spatial variations in noise pollution during the day and night across different land uses. Figure 3 shows the noisescape of the city during the day. The noise levels in most central areas are high, generally exceeding 65 dB. However, there are pockets of very high noise levels (≥70 dB) that coincide with noise-generating land uses, such as the Ilesa Motor Park (extreme southeastern part of the city), intense commercial activities like the Oluode and Adenle Markets (in the central area, and the industrial land use in the

extreme northeast. The low noisescapes are located in the western and southwestern peripheries of the city, the areas with limited daylight activities.
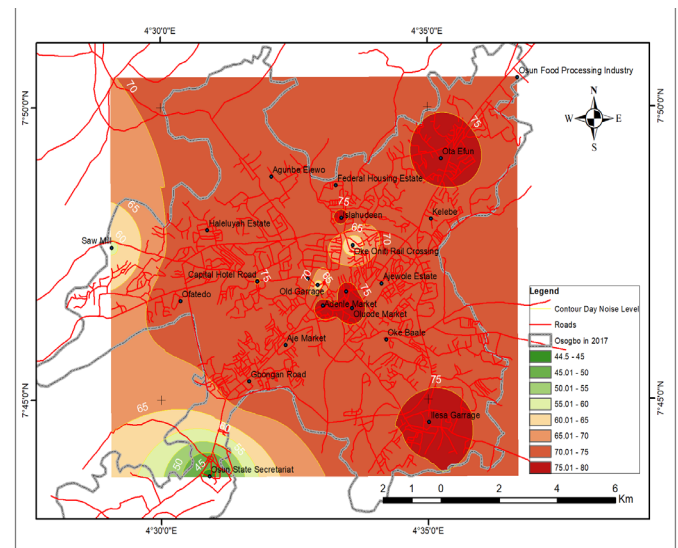
Figure 3: Spatial Variations in Observed Noise Levels during the Day in the Study Area
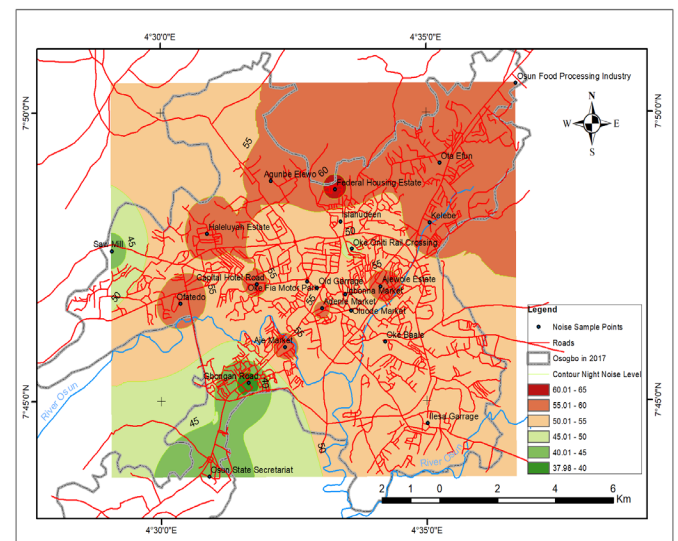
Figure 4: Spatial Variations in Observed at Night Noise Levels in the Study Area

Table 6: Socio-economic Characteristics Respondents

Characteristic	Category	No. of Respondents	Per cent (%)	Mean
Age	· 0 – 20 years	25	12.5	44.5years
	· 21 – 40 years	73	37.5	
	· 41 – 60 years	53	27.3	
	· 61 years and above	44	22.7	
	Total	195	100.0	
Gender	· Male	87	44.9	
	· Female	108	55.1	
	· Total	195	100.0	
Marital Status	· Single	12	6	
	· Married	128	65.8	
	· Divorced	16	8.3	
	· Widow and Widower	32	16.7	
	· Separated Parent	7	3.2	
	Total	195	100.0	
Household Size	· 1 – 4 People	21	10.6	6.4 people
	· 5 – 8 People	87	45	
	· 9 – 12 People	62	31.9	
	· 13 and above	25	12.5	
	Total	195	100.0	
Highest level of Education	· No Formal Education	8	4.2	
	· Primary	39	19.9	
	· Secondary	29	14.8	
	· Tertiary	119	61.1	
	Total	195	100	
Occupation	· Civil Service	53	27.3	
	· Trading	32	19	
	· Farming	27	16.3	
	· Artisan	33	13.7	
	· Others	13	6.7	
	Total	195	100	
Monthly Income	· Less than N20,000	25	12.5	N53,000
	· N20,000 – N40,000	57	29.2	
	· N40,000 – N60,000	39	19.4	
	· N60,000 – N80,000	35	18.1	
	· N80,000 – N100,000	23	12	
	· Above N100,000	15	8.8	
	Total	195	100	
Ethnicity	· Yoruba	125	64.3	
	· Hausa	37	18.7	
	· Igbo	27	14	
	· Others	6	3	
	Total	195	100	
Religion	· Christianity	100	51	
	· Islam	88	45.3	
	· Traditionalist	7	3.7	
	Total	195	100	

Source: Author's Fieldwork, 2018

The night noisescape presents a different picture as the vast area of the city is calmer at night with an observed noise level of 55 dB or less. Only the industrial areas in the extreme northeast of the town recorded a higher noise level exceeding 65 dB. Around the city center, pockets of heightened noisescapes coincide with the location of nightclubs and worship centers. Nightclubs in the city are known for playing high-pitched music and featuring live bands to entertain patrons, contributing to noise pollution. It is also worth noting that adherents of the city's two dominant religions engage in noise-generating nocturnal religious activities such as vigils and open-air crusades, among other activities. Conversely, the area in the western and southwestern parts of the city experiences calmer nights because the noise-generating activities are very low.

Socioeconomic Characteristics of the Respondents

The generation and management of urban noise are highly dependent on land use, household characteristics, and individual behavior. Therefore, Table 6 shows the distribution of the 292 respondents selected by household and demographic characteristics. As shown in Table 6, 55.1% of the respondents are women, whereas 44.9% are men. The implication is that there is a likelihood of high indoor noise and noise from domestic activities, such as blending, grinding, and other kitchen activities performed primarily by women. This is because it is widely assumed that women talk more than men and engage in more domestic activities (Boateng and Amedofu, 2004).

Regarding land uses, 32.7% of those interviewed lived in residential areas, 23.7% in commercial areas, and 24.7% in mixed land uses. Industrial land uses accounted for approximately 13.6%, whereas other land uses accounted for 5.3%. This result indicates that most respondents were drawn from the city's commercial and mixed land uses. The two land uses contributed an appreciable size (48.7%) of the study area compared to the 32.7% drawn from residential land use. The preceding section illustrates that commercial and mixed land uses have higher levels of diurnal and nocturnal noise than residential land uses.

Individuals' ages are a good predictor of how active and chatty they are (Mougeot, 1999). As shown in Table 6, the majority of the sampled respondents are between the ages of 21 and 40, with a percentage value of 37.5%. The average age of urban residents in Osogbo is 44.5 years. This implies that most people are young and productive, which might allow them to engage in activities that generate urban noise (e.g., engaging in industrial production, playing loud music, partying, and engaging in street protests). Moreover, many of these respondents are of childbearing age; hence, constant crying and screaming from their infants and toddlers will likely contribute to ambient noise levels in their neighborhoods. Regarding the marital status of the respondents, Table 6 reveals that 45.8% of the respondents are married, 16.7% are widowed, 8.3% are divorced, and 29.2% are single. The implication is that married respondents are likely to have children that can be considered noise sources in residential areas. Furthermore, a family's size influences the noise emitted by dwelling units. The survey revealed that the average household size in Osogbo is eight people. Meanwhile, the mean household size was 6.4 people, with approximately 80% having 5 to 12 people, indicating a predominance of large households.

Table 7: Residents' Perception of Noise Pollution in Osogbo

Question Asked	Response	No. of respondents	Percentage (%)
Noise as pollution	Yes	194	99.0
	No	1	1.0
	Total	195	100.0
Sources of noise pollution in your area	Transport	182	92.7*
	Markets & Clubs	123	63.0*
	Religious area	170	87.0*
	Generator	185	94.7*
	Music from Neighbour	106	54.0*
	Industrial activities	72	37.3*
Perceived Neighbourhood Noise Levels	Extremely noisy	22	11.3
	Very noisy	67	34.3
	Noisy	83	42.7
	Quiet	21	11
	Very quiet	1	0.7
	Total	195	100
Awareness of any government intervention to reduce noise pollution	Yes	22	11.3
	No	173	88.7
	Total	195	100
Perceived neighbourhood associations' action in curbing noise pollution	Yes	18	9.2
	No	176	90.4
	Total	195	100

* Multiple-choice responses; hence, it wouldn't add up to 195
Source: Author's Fieldwork

Perception of Noise Pollution Among Residents

Noise pollution poses a significant threat to urban sustainability worldwide (Fiedler and Zannin, 2015; WHO, 2005). According to the WHO, noise is a hazardous agent that affects both human health and the environment. In the past, most Nigerians have not paid significant attention to the seriousness of noise pollution and its dangerous consequences.

Almost all of the 295 respondents (99.3%) in the study area agreed that noise was a major source of pollution in the study area. Among these respondents, 99 (34%) stated that they perceived the most noise in the morning hours, whereas 86

(29.3%) agreed that noise pollution is always at its peak in their areas during the evening hours. Moreover, 17.3% said that they perceived the noise most at night, whereas 16.1% perceived the noise the most in the afternoon. In general, 79.4% of urban residents agreed they perceived diurnal environmental noise pollution more than nocturnal noise level. In comparison, 20.6% were more exposed to it at night than during the day. Therefore, this implies that, irrespective of land use, urban residents experience more environmental noise pollution during the day than at night. This result agrees with the findings of Olayinka and Abdullahi (2010) and Abel (2015). They affirmed that in most cities in developing countries, the diurnal noise level is commonly higher than the nocturnal noise.

Perceived Effects of Noise Pollution on Residents' Health

A central objective of this study is to analyze the health effects of noise pollution in the study area. To achieve this objective, the authors asked relevant questions. Table 8 presents the responses obtained. Almost all respondents know that environmental noise pollution causes significant health problems for the well-being of residents, as 94% of respondents in the city responded affirmatively. In addition, more than 32% of the respondents reported feeling highly annoyed with noise pollution in their neighborhoods. In terms of the health effects of noise pollution in the study area, the survey found that nearly three-quarters (72.3%) of Osogbo residents frequently experience loss of sleep (insomnia) during the night due to high levels of nocturnal noise pollution from sources, such as nightclubs, generating sets, parties, traffic, and noise from religious activities.

Similarly, approximately two-thirds (64.3%) of the respondents also reported that they had, at one time or another, experienced hearing impairment caused by the level of noise pollution in the atmosphere. Furthermore, 42.7% stated that they had previously experienced a sudden loss of hearing (some lasted for a short period, whereas others led to a permanent loss of hearing). The psychological effect of noise pollution in the study area is also significant, with 49.7% of the study population reporting that they occasionally experience psychological problems, such as stress (46.7%), anxiety (43.8%), and psychosis and emotional instability (33.6%) due to the high noise pollution in their environment.

Environmental noise pollution also produces other effects for the residents of the study area, including loss of concentration (71.7%), speech interference (54%), and worsening of hypertensive symptoms (64.3%). Table 8 further shows that 28% of urban residents in the study area suffer from mild or chronic hypertension, which may be worsened by increased exposure to loud noise. Importantly, 37% of the urban residents had visited the hospital at least once for noise-related ailments. Therefore, we can infer that noise pollution significantly impacts the health and well-being of city dwellers.

Table 8: Effects of Noise Pollution on People's Health

Question Asked	Response	Frequency	Percentage (%)
Awareness of adverse health effects of noise?	Yes	184	94
	No	11	6
	Total	195	100
Level of annoyance experienced from noise pollution	Too much	*63*	32.7
	Much	73	37.7
	Little	53	27
	Nothing	5	2.6
	Total	195	100
Noticeable health effects of noise	Insomnia	141	72.3*
	Hearing Impairment	126	64.3*
	Hypertension	55	28.0*
	Loss of Concentration	140	71.7*
	Psychological effects	97	49.7*
	Speech Interference	106	54.0*
	Sudden loss of hearing	83	42.7*
	Shock due to loud noise	82	42.0*
Any experience with these psychological feelings?	Stress	91	46.7*
	Anxiety	85	43.8*
	Psychosis and emotional instability	65	33.6*
Have you ever visited a hospital as a result of a noise-related ailment?	Yes	37	72
	No	63	123
	Total	100	195

Multiple-choice responses, hence it wouldn't add up to 195
Source: Author, 2021

Conclusion

The noise levels in the sampled areas were above the NESREA and WHO recommended limits. The current level of noise pollution in the city poses a serious health risk to all urban dwellers in the area. Furthermore, the discomfort and irritability caused by noise pollution can significantly reduce productivity in both the public and private sectors. Since the transport infrastructure constitutes a key noise source, technical actions on transport systems can produce exciting results. In addition,

effective land-use planning in Nigeria's urban areas could help prevent unnecessary noise pollution at odd hours of the day (i.e., noise from religious worship at midnight). Most cities in Nigeria should take the prevention and mitigation of noise pollution seriously and explore all possible means to combat the threat of noise pollution.

Noise is also a byproduct of people's behavior (e.g., reckless driving, playing music at loud volume, product marketing and street hawking, and religious activities). Therefore, information and enlightenment campaigns, usually produced on radio, television stations, and print media, can be used to invoke behavioral and altitudinal changes that promote noise abatement. A positive behavioral change would help reduce noise pollution in the study area significantly. In addition, environmental noise impact criteria levels for various land uses must be established before any intending developer can be granted planning and development permits. These criteria would allow the noise impacts of any proposed development to be predicted and management strategies proposed. Similarly, the government should enact and enforce laws to limit the number of religious activities and nightclubs in the city to reduce noise pollution from these sources.

Sound urban planning and enforcing planning codes are ultimately required to mitigate the escalating noise pollution in medium-sized urban centers. Due to resource constraints and weak governance structures, many small- and medium-sized African cities find it difficult to create and enforce environmental laws in areas with strong religious and cultural beliefs. This most likely explains the persistence and aggravation of noise pollution in these cities. This study demonstrates that noise pollution contributes to public health problems and affects productivity. Consequently, this study recommends a constructive partnership between the government and residents as a panacea for the debilitating noise pollution in Africa's small and medium-sized cities. This collaboration will make residents active participants in the government's noise mitigation strategies.

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Rüzgâr Enerji Santrali (RES) Yer Seçimi için BWM-CBS Tabanlı Bir Yaklaşım: Tunceli Örneği

A BWM-GIS Based Approach for Wind Power Plant (WPP) Site Selection: Sample of Tunceli

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ÖZ

Günümüz dünyasında fosil yakıtların yerine alternatif bir enerji kaynak arayışı oldukça popüler bir yaklaşımdır. Güneş panelleri ve rüzgâr enerjisi santralleri gibi yenilenebilir enerji kaynakları fosil yakıtların alternatifleri arasındadır. Rüzgâr enerjisi santralleri hem denizde hem de karada olmak üzere dünyanın birçok bölgesinde aktif olarak kullanılmaktadır. Türkiye'de de RES'ler özellikle 2000'lerin başından itibaren kullanılmaya başlamıştır. Türkiye'deki RES'ler daha çok Ege ve Marmara Bölgesinde yer almaktadır. Çalışma alanı olan Tunceli'de ise herhangi bir RES bulunmamaktadır. Bu çalışmanın temel amacı Tunceli için uygun RES alanlarını önermektir. Bu kapsamda Best-Worst yöntemi (BWM) CBS'ye entegre edilerek kullanılmıştır. BWM yöntemi ikili karşılaştırmaya dayanan Çok Kriterli Karar Verme (ÇKKV) yöntemidir. Çalışmada BWM modeli kullanılarak "topografya", "sosyo-ekonomik", "teknik" ve "lokasyon" olmak üzere dört ana kriter altında 16 kriter belirlenmiştir. Her bir kriter farklı disiplinlerden uzmanlar tarafından anket olarak değerlendirilmiş ve uygun yer seçimi için kullanılmıştır. 16 kriter için ayrı ayrı haritalar oluşturulmuş, kriterlerin açıklamaları yapılmış ve bu haritalar sonuç haritasında kullanılmıştır. BWM modeli kullanılarak tespit edilen kriter ağırlıkları CBS'ye entegre edilerek Tunceli için uygun RES kurulum alanları belirlenmiştir. Buna göre, Tunceli'nin güneydoğusunda yer alan Pertek ve Mazgirt çevresi ile Pülümür'ün kuzeyi ve Çemişgezek'in çevresinde fiziki coğrafya açısından uygun şartları sağlayan bazı alanlar RES kurulumuna elverişlidir.

Anahtar kelimeler: RES, Best-Worst Metot, CBS ile Uygun Yer Seçimi, Tunceli

ABSTRACT

In today's world, searching for an alternative energy source instead of fossil fuels has become highly popular. Renewable energy sources such as solar panels and wind power plants are the alternatives to fossil fuels. Wind power plants (WPPs) are actively used in several regions of the world, both at sea and on land. In Turkey, WPPs have been used, especially since the early 2000s, with the Aegean and Marmara regions being their prime locations. However, there is no WPP in Tunceli. Thus, the main objective of this study is to recommend suitable WPP areas for Tunceli. In this context, the best-worst method (BWM) was integrated into the geographical information system (GIS) and used in the study. The BWM method is a multi-criteria decision making (MCDM) method based on pairwise comparison. In the study, 16 criteria were determined under four main criteria "topography", "socio-economic", "technical," and "location" by using the BWM model. Experts from different disciplines evaluated each criterion as a questionnaire and used it for appropriate site selection. For the 16 criteria, separate maps were created, explanations of the criteria were established, and these maps were cumulatively used in the resulting map. The criteria weights determined using the BWM model were integrated into the GIS, and suitable WPP installation areas for Tunceli were determined. Accordingly, some areas around Pertek and Mazgirt in the southeast of Tunceli, north of Pülümür, and around Çemişgezek, which provide suitable conditions in terms of physical geography, are suitable for WPP installation.

Keywords: WPP, Best-Worst Method, Appropriate Site Selection with GIS, Tunceli

EXTENDED ABSTRACT

The increasing energy demand in the world pushes countries to meet this demand each year from renewable resources in addition to fossil fuels. Based on sustainability and environmental impact factors, renewable energy sources have become extremely important. Wind energy is a renewable energy source, whose capacity is increasing both at home and abroad.

In this study, the most suitable WPP installation site for Tunceli was determined by using Best-Worst Metot (BWM)-GIS in an integrated manner. In this context, a total of 16 criteria were determined based on the literature and the characteristics of the study area, which were then evaluated by experts and used in the study. Since wind power plant location selection is an interdisciplinary problem, experts from different fields were consulted in the criteria evaluation. The expert team consisted of experts in the fields including geography, industrial engineers, surveyors, geology, energy systems engineering, disaster management, and renewable energy resources. These experts filled out the questionnaires (Table 3), and the criteria weights were calculated using the LINGO 19.0 software according to the formula suggested by the best-worst method (BWM). BWM is an MCDM method based on pairwise comparison. BWM outputs were transferred to the GIS, an overlapping analysis was applied using the "Weight Sum" tool from ArcGIS tools, and suitable areas for RES installation were determined.

For Tunceli, the most suitable WPP areas proposed within the scope of the study constitute a limited area. These areas are partly the northern periphery of Pülümür and the environs of Pertek and Mazgirt. According to the study outputs, the "less suitable" and "not suitable" fields correspond to a fairly wide area owing to the wind speed in the Tunceli province and the difficult physical geographical conditions of the region. Especially in Munzur and Mercan Mountains located in the northern part of the study area, the altitude reaches 3,000 m and has considerably high slope values. Likewise, in most parts of the study area, the elevation and slope values are quite high. In addition, except for certain regions of the study area (partially north of Pülümür and around Pertek and Mazgirt), the wind speed is substantially low. Therefore, based on the effect of these conditions, suitable areas in the WPP installation coincided with a limited area.

Within the scope of the study, field studies were conducted in the areas most suitable for the WPP installation. Fieldwork is critical for the comparison of the analysis results with the real area. In this direction, necessary comparisons were drawn and locations possibly suitable for the WPP installation were shown. Despite the integrated use of BWM-GIS in this study, certain limitations exist. Within the scope of the study, a total of 16 criteria were used among only four main criteria. The output of the study agrees with these criteria. In addition, technical details such as wind turbine type and shape have not been considered and were evaluated in general, which was another limitation of the study. More precise results can be achieved if the number of criteria and turbine type are considered in detail in future studies.

Based on the results of this study, places with high elevation, very high slope, very dense forests, and those far from main roads and power lines correspond to "less suitable" and "unsuitable" areas. These areas are mostly located around the Munzur and Mercan mountain ranges, around the Munzur and Pülümür valleys, and high areas in the north of Hozat and Çemişgezek. These areas have limited settlement with difficult physical and climatic conditions. Therefore, such areas are not only suitable for WPP installation but also for various human activities.

1. GİRİŞ

Küresel enerji talebinin gelecek yıllarda artmaya devam edeceği öngörülmekle birlikte, sanayileşmiş ülkelerdeki artışın, sanayileşmiş dünyayı takip etmeye devam eden gelişmekte olan ülkelere göre daha düşük olacağı tahmin edilmektedir. Dünya nüfusu önümüzdeki birkaç on yılda artmaya devam edeceği için 2050 yılına kadar enerji talebinin de 1990'a kıyasla 2.3 ila 4 kat artacağı düşünülmektedir (Quaschning, 2005). Enerji talebinin kullanım çeşitliliğindeki çok yönlü büyümeyle paralel olarak gün geçtikçe arttığı günümüz dünyasında, enerjinin yenilenebilir ve çevre dostu teknolojiler vasıtasıyla elde edilmesi giderek önem kazanan bir olgudur. Her geçen gün artan talep, mevcut enerji altyapısı üzerinde önemli bir baskı oluşturmakta, sera gazı emisyonları ve küresel ısınma nedeniyle çevre sağlığı önemli ölçüde etkilenmektedir. Bugün karşı karşıya olduğumuz çevre sorunlarına çözüm bulmak, aynı zamanda sürdürülebilir kalkınma için de uzun vadeli eylemler gerektirmektedir. Bu bağlamda, yenilenebilir enerji ve sürdürülebilir kalkınma arasındaki yakın ilişkiden dolayı yenilenebilir enerji kaynakları en verimli ve etkili çözümlerden biri olarak görünmektedir (Omer, 2008). Çevre sağlığının olumsuz etkilenmesi de yenilenebilir enerji kaynaklarının gündeme gelme sıklığını artırmaktadır.

Günümüzde küresel ısınma ve iklim değişikliğinin çevreye ve insanlığa verdiği zararlar herkesçe bilinmektedir. Enerji sektörü ise, tıpkı sera gazı emisyonları gibi küresel ısınmayı ve dünyadaki toplam karbondioksit (CO_2) salınımını %75'e varan oranlarda artırıcı bir etkiye sahiptir (Manish vd. 2006). Enerji üretiminde yenilebilir kaynaklara yönelmesinin ulaştığı düzey, gelişmiş ve gelişmekte olan birçok ülkeden verilebilecek örneklerle daha iyi anlaşılabilir. Almanya'da Energiewende programıyla, nükleer enerjinin terk edip yenilenebilir kaynakların kullanımının hızlandırılması yoluyla 2050 yılına kadar sera gazı emisyonlarının %80 oranında azaltılması hedeflenmektedir (Renn ve Marshall, 2016; Morris ve Jungjohann, 2017). Yenilenebilir enerji kullanımına yönelik hedefler, birçok ülke ve bölgede büyümeye devam etmektedir. Örneğin, Avrupa Birliği 2014 yılında %27 olarak belirlediği 2030 yenilenebilir enerji üretim payı hedefini 2018'de %32'ye yükseltmiş bulunmaktadır (**Şekil 1**) (Gielen vd. 2019).

Enerji sektörünün heterojenliğine ve 50 eyaletinin her birinde tedarik kaynaklarının belirgin farklılıklarına rağmen, Amerika Birleşik Devletleri de yenilenebilir enerjiye başarılı bir geçiş süreci yaşamaktadır. Yenilenebilir enerji kaynaklarına yönelik vergi teşviği gibi uygulamalar gerek federal hükümetler gerek ise
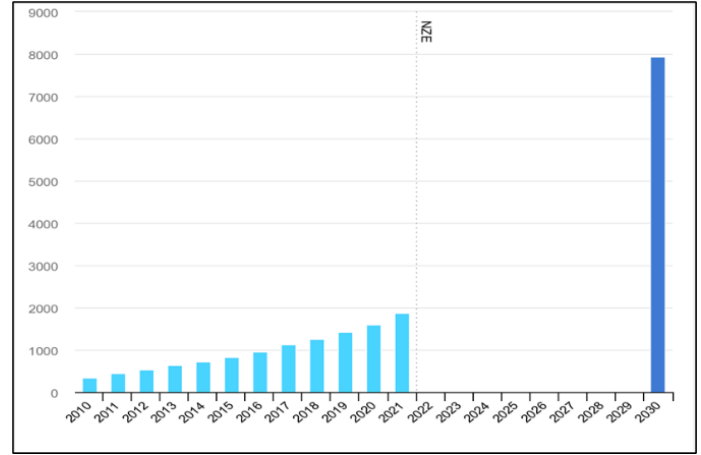
Şekil 1: Dünyada Rüzgâr Enerjisi Üretiminin TWH Olarak Mevcut Durumu ve 2030 Tahmini (IEA, 2022)
Figure 1: Status of Wind Power Production in TWH and Forecast for 2030 (IEA, 2022).

eyaletler düzeyinde ülkenin enerji sektörünü dönüştürmektedir. Dünyanın en büyük enerji üreticisi ve tüketicisi olarak Çin ise, enerji tedarik dönüşümünde kritik bir role sahiptir. Çin, artan enerji talebini karşılamak ve hava kirliliğini azaltmak için yenilenebilir kaynaklara yönelmiş, ülke ayrıca 2030'a kadar gayri safi yurtiçi hasılasındaki birim başına düşen karbon emisyonlarını %60-65 oranında azaltmak için hedefler belirlemiş bulunmaktadır (URL-1). Küresel enerji kullanımında önde gelen başka birçok ülke yenilenebilir kaynaklardan tedariğe yönelik ciddi adımlar atmayı sürdürmektedir. Nitekim, Rusya'nın 2024 yılı için güneş, rüzgâr ve jeotermal başta olmak üzere yenilenebilir kaynak kullanımı açısından belirlediği 5 GW hedefini aşacağı öngörülmektedir (Gielen vd., 2019). Türkiye'de cari açığındaki en önemli kalem olan enerji ithalatını azaltmak için arz noktasında güneş ve rüzgâr enerjisi gibi yenilenebilir kaynakların kullanımını arttırması gerekmektedir (Yılmaz, 2012).

Enerji talebinin karşılanması noktasında kaynakları yeterli olmayan ülkemiz, enerji ithalatını sürekli arttırır hale gelmiştir. Özellikle petrol ve doğalgaz gibi kaynaklar açısından enerji ithalatına olan bağımlılık giderek artmaktadır (Yılmaz, 2012). Fosil yakıtlar açısından fakir olan Türkiye'nin bu sürekli artan enerji talebini karşılamakta kaynakları yetersiz kalmakta olup, toplam enerji talebinin ancak %26'sı kendi kaynaklarımızdan karşılanabilmektedir. Bu durum şüphesiz ülkemizi enerji ithalatçısı bir konuma getirmektedir. Türkiye'nin enerji talebi noktasında petrolün %92'sini ve doğalgazın %99'unu ithal etmesine bağlı olarak dış kaynaklara olan bağımlılığı %74 oranındadır (Arslan ve Solak, 2019). Türkiye'nin resmi enerji politikası, 2023'e kadar ülkenin dış kaynaklara olan bağımlılığını azaltmak ve doğal kaynaklara harcanan maliyeti kısarak iç

kaynaklardan maksimum ölçüde yararlanmaktır. Bu çerçevede 2023 yılında toplam elektrik üretiminin yüzde 30'unun yenilenebilir kaynaklardan temin edilmesi hedeflenmiştir (Yılmaz ve Öziç, 2018, s. 526).

Yenilenebilir enerji kaynakları doğadaki tükenmeyen ve kendi kendini yenileyebilen enerji türleridir. Bunlar rüzgâr, güneş, jeotermal, hidroelektrik, dalga ve biyokütle gibi enerjilerdir (Akova, 2003). Türkiye yenilenebilir enerji kaynaklarından biri olan rüzgâr enerjisi bakımından çok büyük bir potansiyel barındırmaktadır. Nitekim Türkiye OECD ülkeleri arasında da en yüksek rüzgâr enerjisi potansiyeline sahip ülke konumundadır. Teknik potansiyel bakımından ülkemiz, Almanya'nın yaklaşık 7 ve İspanya'nın ise 2 katı daha fazla potansiyele sahiptir. Potansiyelin yanında bir ülkede rüzgâr hızının fazla olması da rüzgâr enerjisinden faydalanma noktasında önemli bir bileşendir (SETA, 2017), 2023 hedefleri doğrultusunda Rüzgâr Enerji Santrali (RES) kurulu gücünün, toplam gücün %20'sine karşılık gelecek şekilde 20 bin MW değerine ulaşması beklenmektedir. Potansiyel hesaba katıldığında güncel RES kurulu gücü az olmakla beraber, son 10 yıl arzında önemli gelişmeler sağlanmıştır. 2014 sonunda 3.762 MW olan RES kurulu gücü, 2015'in ilk yarısında 430 MW'lik artışla 4.192 MW seviyesine, 2022 yılı itibariyle ise yaklaşık 11.000 MW'ye yükselmiştir. Dolayısıyla elektriğin %6'lık bölümü rüzgâr enerjisinden üretilmekte olup, bu değerin 2023'te %20 düzeyine yükseltilmesi hedeflenmektedir (**Şekil 2**) (Gültekin, 2019).
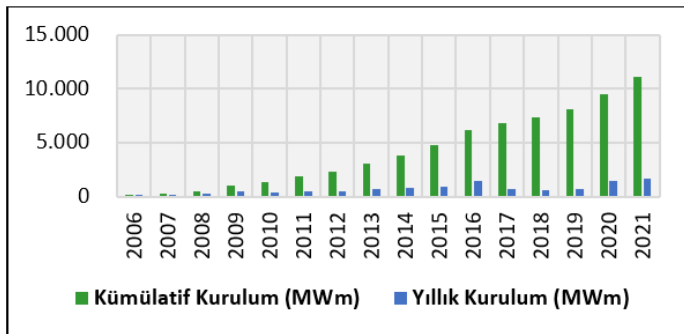
Şekil 2: 2006-2021 Dönemi RES Kurulum Miktarları (TUREB, 2022)
Figure 2: 2006-2021 WPP Installation Amounts (TUREB, 2022)

Doğu Anadolu bölgesi, kurulu RES gücü bakımından 2019 yılı verilerine göre %1,22 ile 7 bölge içerisinde sondan ikinci sırada gelmektedir. 43 adet rüzgâr türbininin bulunduğu bölgede özellikle diğer bölgelerden geçiş alanlarına kurulu olan santraller vasıtasıyla 1.500 metre seviyesinin üzerine çıkılarak bu yükselti basamağındaki üretim artmış ve 1.500-1.750 metre yükselti basamağında 945,15 MW enerji üretimi sağlanmış bulunmaktadır

(Pınar vd. 2020). Tunceli çevresi her ne kadar rüzgâr hızları belirli seviyede (3 ile 6 m/s) olsa da belirli bölgeler RES kurulumları için bir potansiyele sahiptir. Bölgeye kurulacak RES'ler ekonomik olarak çok uygun görülmese de bölgede yer alan tarıma yönelik küçük yerel işletmeler ile köylerin enerji ihtiyacını karşılamak için inşa edilebilir. Söz konusu RES'ler küçük ölçekli olacaktır.

2. ARAŞTIRMADA AMAÇ VE YÖNTEM

Bu araştırmada, Tunceli ilinde RES kurulumu için en uygun lokasyonların belirlenmesi amaçlanmıştır. Dünya genelinde kullanımı giderek artan rüzgâr enerjisinin Tunceli özelinde sunduğu fırsatlar, RES kurulumu için uygun alanların belirli kriterlerle seçimi temelinde ele alınmıştır.

Araştırma kapsamında uygun yerlerin belirlenebilmesi için Çok Kriterli Karar Verme (ÇKKV) yöntemlerinden biri olan Best-Worst Metodu (BWM) Coğrafi Bilgi Sistem CBS) araçları entegre bir şekilde kullanılmıştır. Rüzgâr enerji santrali yer seçimi disiplinler arası bir problem olduğu için kriterlerin değerlendirilmesinde farklı alanlardaki uzmanlara başvurulmuştur. Uzman ekip coğrafya, endüstri mühendisi, harita mühendisi, jeoloji, enerji sistemleri mühendisliği, afet yönetimi, yenilebilir enerji kaynakları gibi alanlarda uzman kişilerden oluşmaktadır. Söz konusu uzmanlar gerek çalışma alanı özelinde yeterliliğe sahip olup çalışmada kullanılacak yöntemi ve metot hakkında yeterli bilgiye sahiptirler. Bu uzmanlar anketleri doldurmuş ve kriter ağırlıkları BWM'nin önermiş olduğu formüle göre LİNGO 19.0 yazılımı kullanılarak hesaplanmıştır.

3. MATERYAL VE VERİ

Çalışmanın bu bölümünde çalışma alanı ve RES kurulumu için kullanılan ÇKKV yöntemi ile çalışma kapsamında kullanılan kriterler detaylı bir şekilde açıklanmıştır.

3.1. Çalışma Alanı

Çalışma alanını oluşturan Tunceli ili, Doğu Anadolu Bölgesi'nin Fırat Bölümü'nde 9° 19' ve 40° 26' doğu boylamı ile 39° 36' ve 38° 46' kuzey enlemleri arasında yer almaktadır. Tunceli'nin ili kuzeyden Munzur Dağları, doğudan Şeytan Dağları, güney ve batıdan da Keban Baraj Gölü çevrilidir. Aynı zamanda Bingöl, Elâzığ ve Erzincan illeriyle komşudur. Yaklaşık 7600 km² ile Türkiye topraklarının %1'ini kaplamaktadır (**Şekil 3**).

Ortalama yükseltisi 1264 m ile dağlık bir bölgede yer alan Tunceli'nin yükseltisi güneyden kuzeye ve batıdan doğuya

doğru gidildikçe artmaktadır. Özellikle kuzeyde yer alan ve doğu Torosların devamı niteliğindeki Munzur, Mercan ve Bağırpaşa dağları ilin en yüksek noktalarını oluşturmaktadır. Bu dağlık bölgede yükselti yer yer 3000 m'leri (Akbaba zirvesi 3463 m) aşmaktadır. Bölgede kuzeyden güneye doğru yükselti azalmakta olup, ilin güney sınırını oluşturan Keban Baraj Gölü çevresinde 750 m'lere kadar düşmektedir.

Tunceli topraklarının %70'ini dağlar, %25'ini platolar ve %5'ini ovalık, düz alanlar oluşturmaktadır. Bölgedeki plato sahalarını kuzeydeki dağlık alanların üzerinde, yüksek sırtlarlar çevrilmiş ve yaklaşık 2500 m yüksekliklerdeki yüksek platolar ile güneyde, yaklaşık 850-1250 m civarındaki alçak platolar oluşturmaktadır (Erinç, 1953). Çalışma alanının kuzeyi yerleşme açısından uygun olmayan, dağlık ve engebeli bir durumdayken, güney bölgesinin yükseltisi az, daha düz ve kuzeye göre yerleşilebilir alanlardan oluşmaktadır (Saraçoğlu, 1956).

Tunceli ilinin kuzey-güney arasındaki yükselti farkı iklimin şekillenmesinde de etkili olmuştur. Bölgenin kuzeyindeki yüksek kesimlerde kışlar çok sert, yazlar serinken; güney bölgesinde kışları daha yumuşak, yazları ise daha serin ve kurak geçmektedir. Bölgede yıllık ortalama sıcaklık 12,8 °C, yıllık ortalama yağış 862, 6 mm'dir (MGM, 2022).

Tunceli'de topografya koşullarının farklılık göstermesi nüfusun dağılışı üzerinde de etkili olmuştur. İl genelinde yaklaşık 1700 m üzerinde yükseltinin etkisiyle iklim koşulları sertleşmekte ve arazi parçalı görünüm kazanmaktadır. Buralarda yaşam koşullarının zorlaşması hem yerleşmelerin karakterlerini hem de nüfusun ekonomik aktivitelerinin sınırlandırarak nüfus ve

yerleşmelerin azalmasına neden olmaktadır (Esen ve Avcı, 2017). Bu anlamda yöredeki nüfus yüksek ve engebeli kuzey kesimlerde seyrek iken, kısmen düz alanların geniş olduğu güney bölgelerinde daha sık bir görünümdedir.

Çalışma alanında ortalama rüzgâr hızı 3-6 m/s arasında değişmektedir. Rüzgâr hızı vadi içlerinde, etrafı dağlarla kapalı alanlarda da azken, kısmen etrafı açık sahalarda, platoluk alanlarda daha yüksektir. Tunceli şehir merkezinin de içerisinde yer aldığı Munzur ve Pülümür vadileri, etrafı dağlarla çevrili Ovacık Ovası ve çevresinde rüzgâr hızları en düşük değerlere (2-3 m/s) inmektedir. Diğer taraftan dağlık ve engebeli alanların daha az olduğu ve etrafının kısmen açık olduğu doğu-güneydoğu kesimlerinde nispeten daha yüksek rüzgâr hızlarına (5-6 m/s) hakimdir.
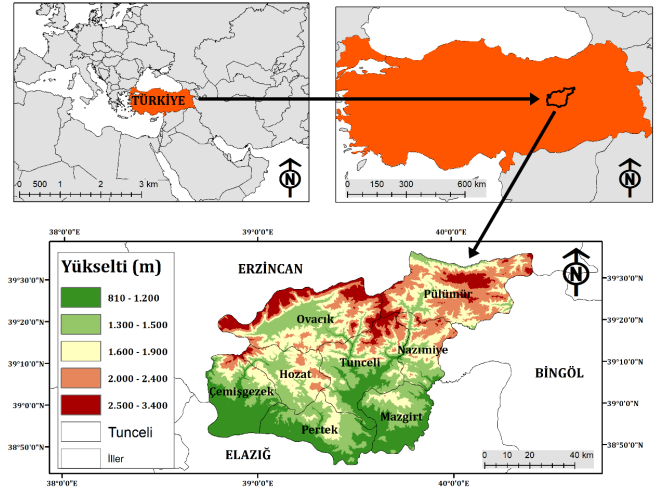
Şekil 3: Tunceli İlinin Lokasyon Haritası
Figure 3: Location Map of Tunceli Province

Tablo 1: Çalışmada Kullanılan Kriterlerin Veri Kaynağı ve Çözünürlükleri.
Table 1: Data Source and Resolutions of The Criteria Used in The Study.

Ana Sınıflandırma	Kriter	Veri Kaynağı	Veri Tipi	Çözünürlük (Ölçek)
	Yükselti	USGS, 2022	Grid	30 m
	Eğim	USGS, 2022	Grid	30
Topografya	Arazi Kullanımı	CORİNE (2018)	Shapefile	1:100,000
	Bitki Örtüsü	USGS, 2022	Grid	100 m
	Litoloji	MTA, 2022	Shapefile	1:100,000
Sosyo-Ekonomik Koşullar	Nüfus Yoğunluğu	TUİK,2022	Shapefile- Alan	1:100,000
	Maliyet	Yazarlar tarafından hesaplandı.	Grid	30 m
	Kuş Göç Rotaları	Kiziroğlu ve Erdoğan, 2015	Shapefile-Çizgi	1:100,000
Teknik	Rüzgâr Hızı	Global Wind Atlas, 2022	Grid	100 m
	Kapasite Faktör Dağılımı	Global Wind Atlas, 2022	Grid	100 m
	Rüzgâr Güç Yoğunluğu	Global Wind Atlas, 2022.	Grid	100 m
	Elektrik Hatlarına Uzaklık	OpenStreetMap, 2022	Shapefile-Çizgi	1:50,000
Lokasyon	Yollara Uzaklık	OpenStreetMap, 2022	Shapefile- Çizgi	1:25,000
	Yerleşim Alanlarına	OpenStreetMap, 2022	Shapefile-Çizgi	1:100,000
	Faylara Uzaklık	OpenStreetMap, 2022	Shapefile-Çizgi	1:100,000
	Akarsu-Göllere Uzaklık	OpenStreetMap, 2022	Shapefile- Çizgi	1:25,000

Çalışma kapsamında her bir kriter için uygun veri kaynakları belirlenmiş ve kullanılmıştır. İlgili veri kaynakları ve tipleri tablo 1'de detaylı olarak gösterilmektedir. Bu veriler öncelikle uygun veri tipine dönüştürülmüş ve çalışma alanı sınırlarına göre kırpma işlemi yapılarak kullanılmıştır.

3.2. Best-Worst Metot

BWM Rezaei (2015) tarafından önerilen bir Çok Kriterli Karar Verme (ÇÇKV) yöntemidir. BWM temelde ikili karşılaştırmaya dayalı bir ağırlıklandırma aracıdır. Tüm kriterleri tek tek birbirleriyle karşılaştırmadan ziyade ikili karşılaştırmaya ihtiyaç duyar (2n-3, burada n kriter sayısını ifade etmektedir). Yöntemde öncelikle "en iyi" ve "en kötü" kriterleri belirlenir. Daha sonra bunları mantıklı bir şekilde diğer kriterlerle ikili olarak karşılaştırılır. Karşılaştırmalar içi 1-9 arası bir ölçe kullanılır. İki kriter aynı önem sahipse "1" kullanılır. İki kriter arasında çok önemli bir fark varsa "9" değeri kullanılır. "En iyiden-diğerlerine" ve "diğerlerinden-en kötüye" olmak üzere iki özel vektör tutarlılık kontrolü yapmaktadır (Rezaei, vd., 2016; Rezaei, 2020). BMW yöntemi coğrafyanın yanı sıra mühendislik, afet yönetimi, enerji gibi birçok alanda aktif bir şekilde kullanılmaktadır (Ali, vd., 2019; Gül, vd., 2020; Tercan, 2021). Uygulama adımları şu şekildedir:

1. **Adım:** Değerlendirilecek kriterler belirlenir. Karar vermede kullanılacak kriterler (c1, c2…cn) ile gösterilir.
2. **Adım:** Belirlenen kriterler arasından en iyi (en önemli, en çok istenen) ve en kötü (en az önemli, en az istenen) kriterler belirlenir. Bu aşamada ikili karşılaştırma yapılmaz.
3. **Adım:** 1-9 arasındaki sayıların kullanılması, en iyi kriterin diğer kriterlerden ne kadar farklı olduğunu belirler. En iyi ile diğerleri (Best to other) için vektör şu şekilde oluşturulur: $A_B = (\alpha_{B1}, \alpha_{B2}, ..., \alpha_{Bn})$ burada α_{Bj} kriterine göre en iyi kriter B'nin tercihini gösterir. Kriterlerin kendileriyle karşılaştırılması ise ($\alpha_{BB} = 1$) bu şekilde formüle edilir.
4. 1-9 arasındaki sayıların kullanılması, en kötü kriterin diğer kriterlerden ne kadar farklı olduğunu belirler. Diğer-En Kötü vektörü şu şekilde oluşturulur: $A_B = (\alpha_{1w}, \alpha_{2w}, ..., \alpha_{nw})$ burada α_{jw} kriterinin en kötü kriterine göre tercihini gösterir.
5. Ağırlığın belirlenmesi şu formülle yapılır; w_1^*, w_2^*,...., w_n^* Gerekli dönüşüm yapıldığında, problem şu şekilde oluşturulur: min ξ

$$\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi \text{ tümü için j}$$

$$\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi \text{ tümü için j}$$

$$\Sigma w_j = 1 w_j \geq 0, \text{ tümü için j}$$

Problem çözmede optimum ağırlıklar ve formülleriyle hesaplanır. Bulunan optimum ağırlık değerleri çalışma çıktısında kullanılmak üzere ArcGIS'e aktarılır. Burada çakıştırma analizlerinden biri olan "Weight Sum" analizinin uygulama aşamasında her bir kriter ayrı ayrı girilerek sonuç haritası oluşturulur.

3.3. Kriterlerin Seçimi

Belirli bir alanda enerji üretilebilmesi için uygun yerlerin seçilmesi oldukça önemli bir konudur. Herhangi bir yerde ister güneş enerji panelleri, dalga enerji istasyonları olsun, ister rüzgâr enerji gülleri olsun kurulacağı yerin doğru seçilmesi önemlidir. Nitekim enerji istasyonların uygun alanlara kurulması verimliliği, uzun süre enerji sağlanabilirliği, güvenliği, ulaşılabilirliği gibi faktörleri direkt olarak etkilemektedir. Bu nedenle literatürde yer seçimi konusu özelinde birçok çalışma yapılmıştır (Gorsevski, vd., 2013; Noorollahi, vd., 2016; Baseer, vd., 2017; Messaoudi, vd., 2019; Tercan, vd., 2021; Xu, vd., 2020; Shorabeh vd., 2022; Langer, vd., 2022; Effat ve El-Zeiny, 2022). Bu çalışmaların temel amacı kurulacak rüzgâr enerji santrali için uygun yerlerin bulunmasıdır. Çalışmalarda uygun yerlerin tespiti için çeşitli kriterler (rüzgâr hızı, yükselti, eğim, vb.) kullanılmıştır. Bu çalışmada da Tunceli ilinin rüzgâr enerji santrali için uygun yerlerin belirlenmesi hedeflenmektedir. Bu doğrultuda hem literatür kaynaklarına hem de çalışma alanı özelliklerine göre 4 ana kriter içerisinde toplam 16 kriter belirlenmiştir. Bunlar topografya ana kriter içerisinde; yükselti, eğim, arazi kullanımı, bitki örtüsü ve litoloji, sosyo-ekonomik ve çevre koşulları ana kriter içerisinde; doğa koruma alanları, maliyet ve kuş göç rotaları, teknik ana kriter; rüzgâr hızı, kapasite faktör dağılımı ve rüzgâr güç yoğunluğu ve son olarak lokasyon ana kriteri içerisinde; elektrik hatlarına uzaklık, yola uzaklık, kentsel alanlara uzaklık, faylara uzaklık ve akarsu-göllere uzaklıktır (**Tablo 2**).

Yükselti (A1): Yükselti, RES kurulumlarında önemli bir kriterdir. Yükselti kriteri birçok çalışmada kullanılmış olup çok

Tablo 2: Çalışmada Kullanılan Kriterler.
Table 2: Criteria Used in The Study.

Topografya	Sosyo-Ekonomik Koşullar	Teknik	Lokasyon
Yükselti	Nüfus Yoğunluğu	Rüzgâr Hızı	Elektrik Hatlarına Uzaklık
Eğim	Maliyet	Kapasite Faktör Dağılımı	Yola Uzaklık
Arazi Kullanımı	Kuş Göç Rotaları	Rüzgâr Güç Yoğunluğu	Yerleşim Alanlarına Uzaklık
Bitki Örtüsü			Faylara Uzaklık
Litoloji			Akarsu-Göllere Uzaklık

yüksek rakımlı araziler RES kurulumları için önerilmemiştir (Uyan, 2013; Noorollahi, vd., 2016; Ali, vd., 2019; Shorabeh, vd., 2022). Diğer taraftan yüksek rakımlı araziler rüzgârı engelleyici yüzey şekillerinin daha az olması, daha az rüzgâr türbülansına neden olduğu gibi rüzgâr hızlarının da tutarlı olduğu belirtilmektedir. Bu nedenle yüksek rakımlı araziler RES kurulumu için uygun alanlar olarak gösterilmektedir (Baban ve Parry, 2001; Effat ve El-Zeiny, 2022). Ancak yüksek rakımlı arazilerde ulaşabilirlik, yüksek inşaat maliyetleri, enerji transferi ve ekipman nakliyesi gibi sebepler santral kurulumunu etkilemektedir. Yapılan bazı çalışmalarda RES kurulumu için 2000 m ve üzeri yüksekliğe sahip alanlar sınır değer olarak kabul edilmiştir (Bennui, vd., 2007; Uyan, 2013; Noorollahi, vd., 2016). Çalışma alanı yüksek bir topografyaya sahiptir. Dolayısıyla çalışma alanı özelinde kurulacak rüzgâr enerji santralleri için 2000 m yükseklikler sınır değeri olarak kabul edilmiştir (**Şekil 4**). Ancak bu sınır değerler sonuç haritasında bütünlük bozulmaması adına ayrılmayarak gösterilmiştir. Nitekim sonuç haritasında da söz konusu alanlar genellikle uygun olmayan alanlara denk gelmektedir.

Eğim (A2): Arazinin çok fazla eğimli olması rüzgâr enerji santral kurulumlarında istenmeyen bir durumdur. RES kurumunda yüksek eğim derecesine sahip alanlar yüksek altyapı maliyetlerine neden olacağından ekonomik değildir. Literatürde bazı çalışmalar %3'lük eğim değerini sınır değer olarak kabul ederken (Uyan, 2013), uygunluk için maksimum eşik değerinin %10 (Baban ve Parry, 2011) ile %30 (Tegou, vd., 2010) arasında olduğu belirtilmektedir. Bununla birlikte bazı rüzgâr türbinleri %30'dan daha yüksek olan eğimli arazilere de kurulmuştur (Tegou, vd., 2010). Dolayısıyla RES kurulumlarında eğim dereceleri çalışma alanı özelliklerine göre değişebilmektedir. Bu çalışmada çalışma alanındaki yüksek eğim dereceleri dikkate alınarak, %0-10'dan, %30'a kadar olan araziler uygun olarak kabul edilmiş ve bu doğrultuda ağırlık değerleri verilmiştir (**Şekil 4**).

Arazi Kullanımı ve Bitki Örtüsü (A3-4): Arazi kullanımı enerji yatırımları için en kritik faktörlerde biri olduğu için mevcut arazinin kullanımlarına dikkat edilmelidir (Jangid, vd., 2016). Literatürdeki çalışmalara göre hem güneş hem de rüzgâr santralleri için en uygun alanların çorak ve boş araziler olduğu belirtilmektedir (Uyan, 2013; Jangid, vd., 2016; Ali, vd., 2019). Ek olarak bitki örtüsünün olduğu alanlarda uygun alanlar olarak değerlendirilebilmektedir. Ancak uzun boylu bitkiler türbülans yoğunluğunu hızlandırabileceği ve rüzgâr hızını yavaşlatarak döner ekipmana zarar verebileceğinden dolayı daha uzun bitki örtüsü yerine kısa bitki örtüsünün olduğu alanlar tercih

edilmelidir (Gorsevski, vd., 2013; Ali, vd., 2019). Dolayısıyla rüzgâr enerji santralleri için boş, çorak ve kısa bitkilerin olduğu alanlar uygun alanlardır (**Şekil 4**).

Litoloji (A5): Yer yapısı RES kurulumlarında etkili olan bir faktördür. Zeminde bulunan kayaçların dayanıklı olması doğal (özellikle deprem) ve beşerî nedenlerden kaynaklanabilecek veya türbinlerin neden olduğu sarsıntıların daha az oranda hissedilmesine etki ederek, ortaya çıkacak problemleri engelleyecektir (Özşahin ve Kaymaz, 2013). Dolayısıyla yer yapısının sağlam olduğu alanlar uygun alanlardır. Bu nedenle çalışma alanın jeoloji haritası oluşturulmuş ve bu bilgilere göre derecelendirme yapılarak ağırlık değerleri verilmiştir (**Şekil 4**).
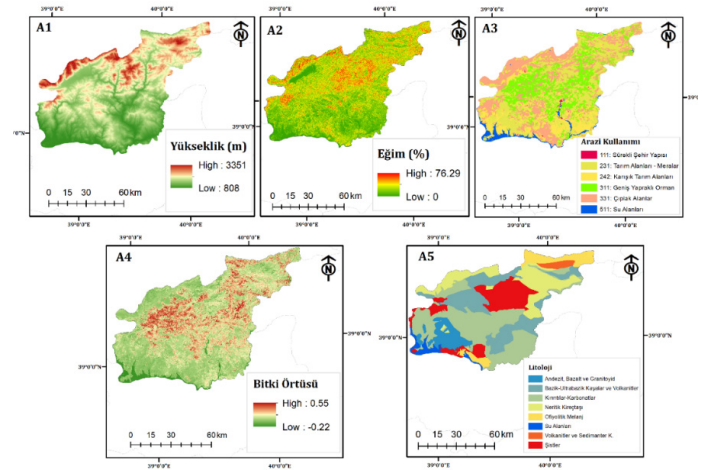
Şekil 4: RES Yeri Seçimi için Topografya Kriterler: Yükselti (A1), Eğim (A2), Arazi Kullanımı (A3), Bitki Örtüsü (A4) ve Litoloji (A5)
Figure 4: *Topography Criteria for Wind Power Plant Site Selection: Elevation (A1), Slope (A2), Land Use (A3), NDVİ (A4) and Lithology (A5)*

Sosyo-ekonomik ana kriterler (nüfus yoğunluğu, maliyet ve kuş göç rotaları) çalışma alanındaki durumlarına ve literatüre göre ayrıntılı olarak açıklanmaktadır:

Nüfus Yoğunluğu (B1): Nüfus yoğunluğu rüzgâr enerji santrallerinden üretilen enerjinin tüketilmesi adına önemli bir kriterdir. Nüfus yoğunluğunun fazla olduğu alanlar nüfusu az alanlara göre daha fazla enerji tüketirler. Yoğun nüfuslu alanların yakınında bulunan rüzgâr enerji santrallerinden üretilen enerjinin transferi durumunda daha az iletim hattı kullanılarak enerji transfer maliyeti azaltılmış olacaktır. Bu nedenle rüzgâr enerji santralleri, enerji transferinin kolay olması ve daha ekonomik olması nedeniyle nüfusun yoğun olduğu bölgelere kurulmalıdır (Gorsevski, vd., 2013). Çalışma alanı için TÜİK'ten alınan 2022 nüfus verileri baz alınarak, ArcGIS yazılım araçlarından "Kernel Density" aracı kullanılmış ve nüfus yoğunluğu haritası oluşturulmuştur. Bu yoğunluk haritasında nüfusun yoğun olduğu

alanlar daha uygun alanlar olarak belirlenmiş ve buna göre ağırlık değerleri girilmiştir (**Şekil 5**).

Maliyet (B2): RES kurmak isteyen yatırımcılar kâr elde edebilmek için en yüksek ekonomik getiriyi hedeflemektedir. RES kurulum maliyeti hem kurulum öncesi hem de kurulum sonrası dönemlerde mevcuttur. Kurulum öncesinde arazi, uygun yer seçimi, rüzgâr panel maliyetleri gibi maliyetler öne çıkarken, kurulum sonrasında verimlilik, işletme ve bakım maliyetleri öne çıkmaktadır (Haaren ve Fthenaki, 2011). Aslında enerji santral kurulumlarındaki bu tür maliyetler temelde yola ve elektrik hatlarına uzaklık, yükseklik, eğim, arazi kullanımı gibi bazı faktörlere bağlıdır. Dolayısıyla bu tür kriterler baz alınarak bir maliyet hesabı yapılabilir. Çalışma kapsamında maliyete etki eden kriterlere (yola ve elektrik hatlarına uzaklık, yükseklik, eğim, arazi kullanımı) ArcGIS yazılım araçları içerisindeki "Weight Sum" aracı kullanılarak bir çakıştırma (overlay) analizi uygulanmış ve maliyet için uygun alanlar tespit edilmiştir (**Şekil 5**).

Kuş Göç Rotaları (B3): Göçmen kuşların kullandığı belirli kuş rotaları bulunmaktadır. Araştırmacılara göre göçmen kuşlar esas olarak türbin motoruyla çarpışmalarından dolayı bazı küçük etkileri olduğunu belirtmektedir (Aydin, vd., 2010; Baseer, vd., 2017; Haaren ve Fthenaki, 2011). Çalışma alanın kuzeyi ve güneyinden geçen iki kuş göç rotası bulunmaktadır (Kiziroğlu ve Erdoğan, 2015). Çalışma kapsamında belirlenen kuş göç rotaları baz alınarak bir tampon (Buffer) analizi uygulanmış ve bu rotalara olan uzaklıklar hesaplanmıştır (**Şekil 5**).
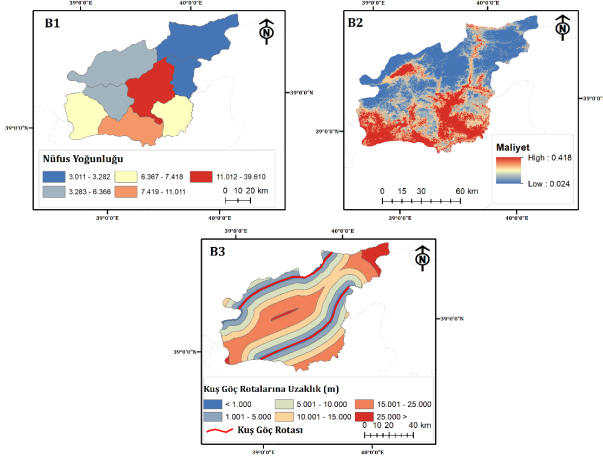
Şekil 5: RES Yeri Seçimi için Sosyo-Ekonomik Kriterler: Nüfus Yoğunluğu (B1), Maliyet (B2) ve Kuş Göç Rotalarına Uzaklık (B3)
Figure 5: Socio-Economic Criteria for Wind Power Plant Site Selection: Population Density (B1), Cost (B2) and Distance to Bird Migration Routes (B3)

Teknik ana kriterleri (rüzgâr hızı, kapasite faktör dağılımı ve rüzgâr güç yoğunluğu) çalışma alanındaki durumlarına ve literatüre göre ayrıntılı olarak açıklanmaktadır. Söz konusu teknik kriterler içerisinde rüzgâr hâkim yönü gibi veriler veri temin güçlüğünden değerlendirilmeye alınmamıştır. Dolayısıyla değerlendirilecek çıktı haritası çalışmada kullanılan kriterler üzerinden hesaplanmıştır.

Rüzgâr Hızı (C1): Rüzgâr hızı RES'ler için en temel kaynaklardan biridir. Ortalama rüzgâr hızı, rüzgâr çiftliği kurulum sahalarının ekonomik fizibilite ve teknik uygulanabilirliğinin belirlenmesi için oldukça önemli bir kriterdir. Rüzgâr hızı arttıkça rüzgâr panellerinden üretilen enerji miktarı da doğru orantıda artmaktadır (Jangid, vd., 2016; Höfer, vd., 2016). Literatüre göre uygun rüzgâr hız değerleri hızı çoğu çalışmada farklılık göstermektedir. Örneğin, Gorsevski ve ark. (2013) uygun rüzgâr hızının 7,5 m/s, Ali ve diğerleri (2019) minimum 4 m/s, Shorabeh ve ark. (2022) büyük rüzgâr çiftlikleri için 5 m/s ve küçük rüzgâr çiftlikleri için 4 m/s, Saraswat ve diğerleri. (2021) 5-6 m/s rüzgâr hızlarının uygun olduğunu belirtmiştir. Söz konusu verilen bu rüzgâr hız değerleri bir rüzgâr santralinin ihtiyaç duyduğu en düşük rüzgâr hızlarını göstermektedir. Çalışma alanındaki rüzgâr hızları ortalama 3 ile 6 m/s arasında değişmektedir (**Şekil 6**). Bu çalışmada 100 m'deki rüzgâr hızı kullanılmış ve minimum rüzgâr hızı 4 ile 6 m/s olan alanlar uygun alanlar olarak belirlenmiştir.

Kapasite Faktör Dağılımı (C2): Rüzgâr her zaman sabit bir şekilde esmediği için rüzgâr kapasite faktör değerinin hesaplanması gereklidir. Nedaei, vd., (2014) yapmış olduğu çalışmaya göre RES'ler için ortalama kapasite faktör değeri %25-40'tır. Global Wind Atlas'tan alınan verilere göre çalışma alanı ve çevresinin kapasite faktöre dağılımı %1 ile %45 arasında değişmektedir. Çalışma alanının büyük bir bölümünde kapasite faktör dağılım değerleri düşük seviyelerdedir. Bölgenin sadece doğu ve kuzey doğusundaki bazı bölgelerde kapasite faktör dağılımı yüksektir (**Şekil 6**).

Rüzgâr Güç Yoğunluğu (C3): Rüzgâr güç yoğunluğu rüzgâr hız dağılımına göre belirlenmektedir. RES kurulumlarında önemli bir kriterdir. RES için rüzgâr güç yoğunluğunun belirlenmesi gerek ekonomik yönden gerekse sürdürülebilir bir şekilde enerji üretme adına gereklidir (Özşahin ve Kaymaz, 2013). Çalışma alanı rüzgâr güç yoğunluğu 200 m'de yaklaşık $\%_0$ 55 – 600 arasında değişmektedir. Bölgenin büyük bir kısmı düşük rüzgâr yoğunluğuna sahiptir. Çalışma alanında rüzgâr güç yoğunluğunun yüksek olduğu alanlar kısmen doğu ile kuzey doğu bölgesidir. Söz konusu alanda rüzgâr güç yoğunluğu 200 m'de yaklaşık $\%_0$ 800'lere kadar çıkmaktadır (**Şekil 6**).
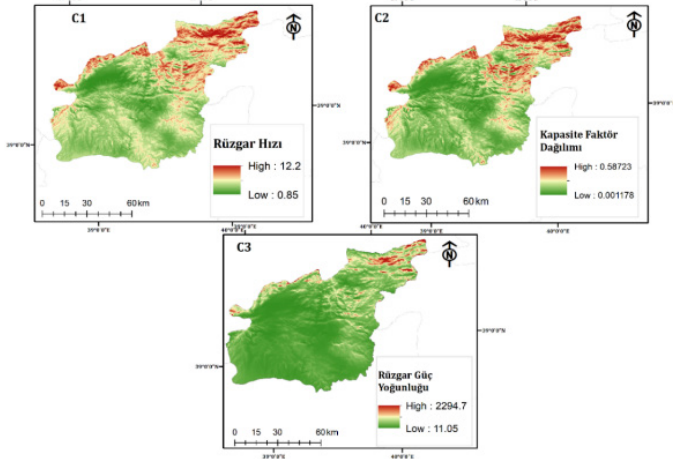
Şekil 6: RES Yeri Seçimi için Teknik Kriterler: Rüzgâr Hızı (C1), Kapasite Faktör Dağılımı (C2) ve Rüzgâr Güç Yoğunluğu (C3)
Figure 6: *Technical Criteria for Wind Power Plant Location Selection: Wind Speed (C1), Capacity Factor Distribution (C2) and Wind Power Density (C3)*

Lokasyon ana kriterleri (elektrik hatlarına uzaklık, yola uzaklık, kentsel alanlara uzaklık, fay hatlarına uzaklık ve akarsu-göllere uzaklık) çalışma alanındaki durumlarına ve literatüre göre ayrıntılı olarak açıklanmaktadır:

Elektrik Hatlarına Uzaklık (D1): RES'ler aracılığıyla üretilen enerjini dağıtımı için mevcut elektrik hatları oldukça önemlidir. Ayrıca altyapı maliyeti, güç kaybının azaltılması ve transfer verimliliğini arttırmak için RES alanlarının elektrik hatlarına yakın olması gereklidir (Baseer, vd., 2017; Xu, vd., 2020; Tercan, 2021). Bu çalışma kapsamında çalışma alanının mevcut elektrik hatları oluşturulmuş ve her bir elektrik hattı için yakınlık analiz uygulanmıştır. Yakınlık analizi 5 sınıf (1000, 5000, 15000, 25000, 25000m+) olacak şekilde oluşturulmuştur (**Şekil 7**).

Yola Uzaklık (D2): Rüzgâr santrallerinin inşaat ve bakım maliyetlerini en aza indirmek için önerilen rüzgâr santrali yeri ile yol ağı arasındaki mesafenin mümkün olduğunca kısa olması gerekmektedir (Tegou, vd., 2010; Baseer, vd., 2017; Shorabeh, vd., 2022). Bu çalışmada yol verileri hazırlanmış ve yakınlık analizi uygulanmıştır. Yakınlık analizi 5 sınıf (1000, 5000, 15000, 25000, 25000m+) olacak şekilde oluşturulmuştur. Buna göre yol ağının daha sık olduğu alanlar uygun alanlar olarak değerlendirilmiştir (**Şekil 7**).

Yerleşim Alanlarına Uzaklık (D3): RES'lerden üretilen elektrik enerjisi şehirlerde, sanayi alanlarında, büyük veya küçük çaplı işletmeler olmak üzere çeşitli alanlarda kullanılmaktadır. Dolayısıyla RES'lerin yerleşim alanlarına yakın olması hem ekonomik hem de enerji verimliği açısından önemlidir. Ayrıca RES'lerin yerleşim alanlarına yakın olması yaşanabilecek

herhangi bir sorunda sorunun giderilmesi için tedarik imkânı daha kolay olmaktadır. Diğer taraftan literatürde RES'lerin oluşturduğu gürültü ve görüntü kirliliği de önemli olarak vurgulanmaktadır. Dolayısıyla RES alanları yerleşim birimlerine makul bir yakınlıkta olması gereklidir (Siyal, vd., 2015; Höfer, vd., 2016; Baseer, vd., 2017; Anwarzaia ve Nagasakab, 2017). Çalışma kapsamında yerleşme alanları tespit edilmiştir. RES kurulumu için yerleşilmiş alanlar hariç tutulmuştur. Yerleşim alanına uygun yakınlık analizi (Buffer) uygulanmıştır. Yakınlık analizi 5 sınıf (1000, 5000, 15000, 25000, 25000m+) olacak şekilde oluşturulmuştur (**Şekil 7**).

Fay Hatlarına Uzaklık (D4): Depremler RES'lere zarar verebileceğinden dolayı yer seçiminde dikkat edilmesi gereken bir konudur. Dolayısıyla bölgeye kurulacak bir RES için fay hatlarının yerlerinin bilinmesi ve buna göre kurulması gereklidir. Çalışma kapsamında MTA'dan temin edilen fay hatları için yakınlık (Buffer) analizi uygulanmıştır. Yakınlık analizi 5 sınıf (1000, 5000, 15000, 25000, 25000m+) olacak şekilde oluşturulmuştur (**Şekil 7**).

Akarsu-Göllere Uzaklık (D5): Akarsuya yakın alanlar pürüzlülük etkisinin yüksek olduğu alanlar olması nedeniyle RES kurulumu için uygun değildir (Özşahin ve Kaymaz, 2013). Çalışma kapsamında akarsu ve göl alanları belirlenmiş ve yakınlık (Buffer) analizi uygulanmıştır. Yakınlık analizi 5 sınıf (1000, 5000, 15000, 25000, 25000m+) olacak şekilde oluşturulmuştur (**Şekil 7**).
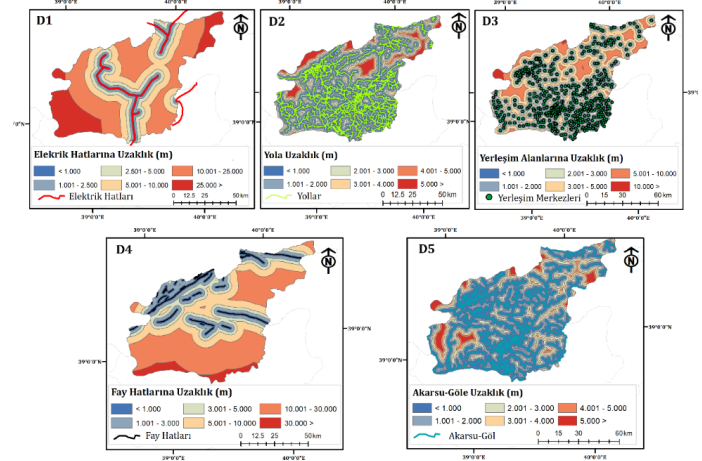
Şekil 7: RES Yeri Seçimi İçin Lokasyon Kriterleri: Elektrik Hatlarına Uzaklık (D1), Yola Uzaklık (D2), Yerleşim Alanlarına Uzaklık (D3), Fay Hatlarına Uzaklık (D4) ve Akarsu-Göle Uzaklık (D5)
Figure 7: *Location Criteria for Wind Power Plant Location Selection: Distance to Power Lines (D1), Distance to Road (D2), Distance to Residential Areas (D3), Distance to Fault Lines (D4) and Distance to Stream-Lake (D5)*

4. BULGULAR

4.1. BWM ile Kriter Ağırlıklarının Belirlenmesi

Çalışma kapsamında her bir kriterin ağırlık değerlerinin hesaplanabilmesi için BWM yöntemi kullanılmıştır. İlk olarak yazarlar tarafından belirlenen anketler uzman ekip tarafından doldurulmuştur. Devamında anketler LİNGO 19.0 yazılımına işlenmiş ve BWM yönteminin önermiş olduğu formüle göre her bir kriterin ağırlık değeri hesaplanmıştır (**Tablo 3**). Ağırlıkların tutarlılık oranları (CR) Rezai (2015) tarafından önerilen yönteme göre yapılmıştır. Uygulanan yönteme göre tutarlılık oranların "0" değerine yaklaştıkça tutarlılıkları artmaktadır. Buna göre hesaplanan tutarlılık oranlarında tutarsız sonuçlanan anketlerin uzmanlar tarafından tekrar değerlendirilmesi istenmiş ve düzenlenen anketlerde tutarlılık sağlanmıştır.
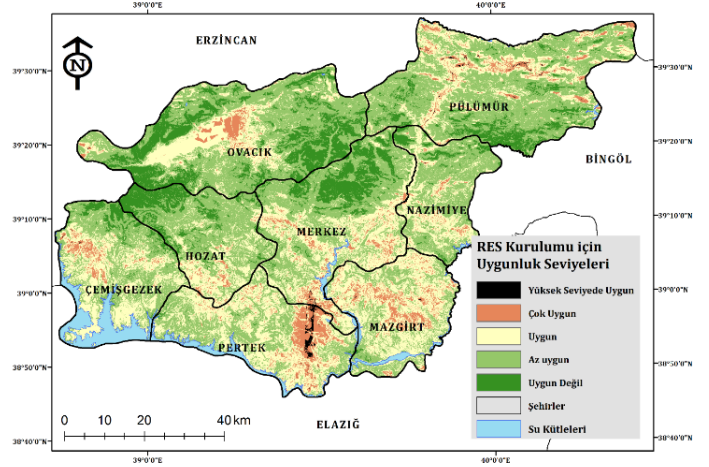
Şekil 8: Tunceli RES Kurulumu İçin Nihai Uygunluk Haritası
Figure 8: Final Suitability Map for Tunceli WPP Installation

Tablo 3: BWM Kullanılarak Hesaplanan Global Ağırlıklar.
Table 3: Global Weights Calculated Using BWM.

Kod	Kriter	Global Ağırlık	Kod	Kriter	Global Ağırlık
A1	Yükselti	0.09580129	C1	Rüzgâr Hızı	0.15103401
A2	Eğim	0.10938737	C2	Kapasite Faktör Dağılımı	0.08554323
A3	Arazi Kullanımı	0.04286227	C3	Rüzgâr Güç Yoğunluğu	0.09940695
A4	Bitki Örtüsü	0.01956718	D1	Elektrik Hatlarına Uzaklık	0.10502373
A5	Litoloji	0.04426656	D2	Yola Uzaklık	0.05134499
B1	Nüfus Yoğunluğu	0.02660771	D3	Yerleşim Alanlarına Uzaklık	0.04232569
B2	Maliyet	0.05692227	D4	Faylara Uzaklık	0.0391251
B3	Kuş Göç Rotaları	0.01533375	D5	Akarsu-Göllere Uzaklık	0.01544797

4.2. RES Kurulumu için Uygunluk Haritasının Üretilmesi

Çalışma kapsamında üretilen her bir kriter haritası, anket aracılığıyla tespit edilen ve BWM yöntemiyle hesaplanan ağırlık değerleri bir araya getirilmiş ve ArcGIS yazılım araçlarından olan "*Weight Sum*" aracı kullanılarak sonuç haritası üretilmiştir. RES kurulumu için hazırlanan uygunluk haritası "*yüksek derecede uygun*", "*çok uygun*", "*uygun*", "*az uygun*" ve "*uygun değil*" olacak şeklinde beş sınıfta incelenmiştir. Uygunluk haritasında özellikle "yüksek seviyede uygun" alanların net olarak gösterilmesi için söz konusu uygu alanlar oldukça daraltılmıştır. Bu sayede çalışma alanında RES kurulumu için en uygun alanlar direkt olarak gösterilmiştir (**Şekil 8**). Analiz sonuçlarına göre uygun alanların toplam alana oranı çok düşük seviyelerdedir. Özellikle "yüksek seviyede uygun" alanlar yaklaşık 260 km²'lik bir alan ile çok azdır (**Tablo 4**).

Analiz sonuçlarına göre RES kurulumu için uygun alanlar çoğunlukla güney, güneydoğu ve kuzeydoğu bölgeleridir. Söz konusu alanlar kuzeyde Pülümür, güneyde Pertek ve Mazgirt çevresidir. **Tablo 4**'te görüldüğü üzere "Yüksek Seviyede Uygun", Çok Uygun"

Tablo 4: RES Sınıfları ve Mekânsal Dağılım.
Table 4: WPP Classes and Spatial Distribution.

Uygunluk Sınıfları	Uygunluk Değerleri	Alan	
		%	km²
Yüksek Seviyede Uygun	< 0.19	0.34	259
Çok Uygun	0.19-0.21	5.3	4.020
Uygun	0.21-0.24	32.4	24.554
Az Uygun	0.24-0.25	52.8	40.036
Uygun Değil	0.25>	9.02	6.834
Toplam		**100**	**75.703**

ve "Uygun" alanlar toplam alandaki oranı %38 seviyelerinde olup yaklaşık 350 km²'lik bir alana denk gelmektedir. Genel olarak değerlendirildiğinde çalışma alanının 3'te 1'inden fazla bir alan RES kurulumu için uygun alanları oluşturmaktadır (**Tablo 4**).

Tablo'5'te ilçeleri göre uygun RES alanlarının mekânsal dağılımı gösterilmektedir. Buna göre uygun RES kurulumu için Pertek ilçesinin ön plana çıktığı görülmektedir. Devamında ise sırayla Mazgirt, Merkez ve Pülümür ilçesi gelmektedir. En fazla "Uygun Değil" ve "Az Uygun" alana sahip ilçe ise yaklaşık %75'lik bir oranla Çemişgezek ilçesidir. Söz konusu ilçe RES kurulumu için uygun değildir (**Tablo 5**).

Tablo 5: İlçelere göre RES Sınıfları ve Mekânsal Dağılımı
Table 5: WPP Classes and Spatial Distribution by Districts

Uygunluk Sınıfları-Değerleri	Merkez		Ovacık		Pertek		Pülümür		Hozat		Ç.Gezek		Mazgirt		Nazimiye	
	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%
Yüksek Seviyede Uygun (<0.19)	1.82	0.15	0.44	0.03	14	1.67	7.2	0.5	0	0	0.74	0.08	0.89	0.12	0.13	0.01
Çok Uygun (0.19-0.21)	60	5.29	44	3.19	90	10.69	66	4.67	15	2.32	31	3.65	71	10	15	2.82
Uygun (0.21-0.24)	358	31.83	273	19.55	411	48.73	347	24.3	150	22.7	355	41.71	390	55	159	29.1
Az Uygun (0.24-0.25)	568	50.43	807	57.73	332	39.14	904	63.3	391	59	428	50.28	238	34	345	63.1
Uygun Değil (0.25>)	138	12.27	272	19.48	1.6	0.19	101	7.10	105	15.8	36	4.24	0.86	0.12	26	4.85
Toplam	1127	100	1398	100	850	100	1427	100	662	100	852	100	702	100	547	100

Analiz çıktılarına göre fiziki coğrafya şartlarının çok fazla uygun olmadığı, yükseltinin ve engebeli alanların fazla olduğu Pülümür çevresi ve kuzeyi RES kurulumu için uygun alanlar olarak tespit edilmiştir. Bölgede her ne kadar yüksek ve engebeli alanlar fazla olsa da rüzgâr hızının, kapasite faktör dağılımının ve rüzgâr güç yoğunluğunun yüksek olduğu bir yerdir. Çalışma kapsamında uygulanan anket sonuçlarında da en önemli kriter rüzgâr hız kriteri olarak belirlenmiştir. Dolayısıyla bu bölgenin RES kurulumu için uygun alanlar olarak görülmesindeki en büyük etken rüzgâr hızı ve rüzgâr hızının etkilediği kriterlerin yüksek ağırlık değerine sahip olmasındadır. Diğer taraftan bu bölgede "yüksek seviyede uygun" olarak tespit edilen alanlar kısmen diğer alanlara göre daha az engebeli, ulaşım yollarına hâkim, yerleşim yerlerine yakınlık gibi avantajlara sahiptir. Şekil 9'da Pülümür'ün kuzeyindeki "yüksek seviyede uygun" alan olarak belirlenen bir alan örnek olarak gösterilmektedir. Görüldüğü üzere bu alan söz konusu avantajlara sahiptir.
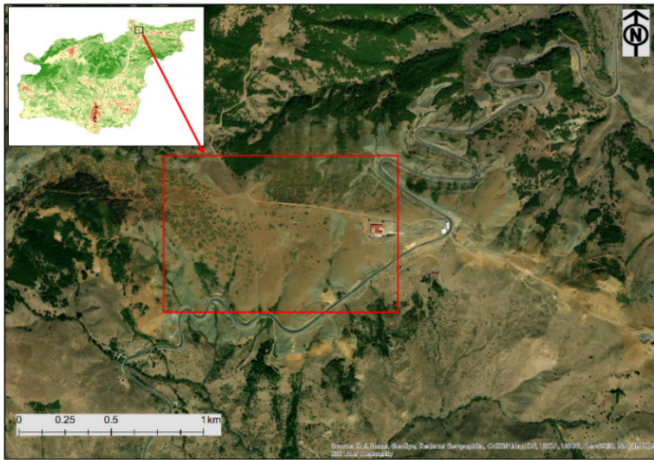
Şekil 9: Pülümür'ün Kuzeyinde RES Kurulumu için "Yüksek Seviyede Uygun" Alan
Figure 9: "Highly Suitable" Area for WPP Installation in The North of Pülümür.

Çalışma çıktılarına göre Tunceli ilinde RES kurulumu için en uygun alanlar Pertek ve Mazgirt ilçesi çevresidir. Özellikle Pertek ilçesinin doğu kesimi "yüksek seviyede uygun" olarak

sınıflandırılan alan içinde en büyük paya sahiptir. Hatta diğer bölgelerdeki "yüksek seviyede uygun" alanlar göz ardı edilirse -ki bu alan diğer bölgelerde çok azdır- sadece Pertek'in doğu kesimi RES kurulumu için en uygun alandır. Çalışma kapsamında bu alana araştırmacılar tarafından arazi çalışması yapılmış ve analiz sonuçları ile gerçek alanın kıyaslaması yapılmıştır. Gerçekten de arazi çalışmasının yapıldığı Pertek ilçesi, Beydamı Köyü civarı RES kurulumu için uygun alan olarak değerlendirilebilir. Söz konusu alanda yüksek gerilim elektrik hattın varlığı, ana yola yakınlığı, yerleşmenin bulunması, yükseltinin nispeten az ve eğimin ideal seviyelerde olması gibi etkenler RES kurulumu için uygun şartları oluşturmaktadır (**Şekil 10**).

Analiz çıktılarına göre RES kurulumu için en uygun alan olarak görülen Beydamı, Tozkoparan ve Yeniköy civarında tarım arazilerinin yanı sıra birçok boş alan mevcuttur. RES kurulumlarında uygun boş alanlar oldukça önemlidir. Özellikle etrafına göre kısmen yüksek ve az eğimli, düz alanlar RES yer seçimi için ideal alanları oluşturmaktadır. Çalışma kapsamında yapılan arazi çalışma gözlemlerinde Beydamı Köyü çevresinde

Şekil 10: Pertek İlçesine Yapılan Arazi Çalışmasından Görünüm
Figure 10: View from The Field Study in Pertek District

nispeten yüksek, az eğimli ve kısmen mesa görünümlü yükseklikler dikkat çekmiştir (**Şekil 11**). Bu alanlar RES kurulumları için değerlendirilerek köyün enerji tüketimine katkı yapması sağlanabilir. Ayrıca bölgede hâkim geçim kaynağı olan hayvancılık için süt işleme merkezleri gibi hayvansal üretimi destekler işletmelerin kurulması halinde bu işletmelerin enerji ihtiyaçlarının bir kısmı RES'ler aracılığıyla sağlanabilir.

Şekil 11: Beydamı Köyü ve Çevresinde RES Yapılabilecek Alanlar
Figure 11: Areas Where WPP Can Be Made in and Around Beydamı Village

Çalışma sonuçlarına göre yükseltisi fazla olan, çok eğimli, çok yoğun ormanlıklar, ana yollara ve elektrik hatlarına uzak olan yerler "az uygun" ve "uygun olmayan" alanlara denk gelmektedir. Bu alanlar çoğunlukla Munzur ve Mercan sıradağları çevresi, Munzur ve Pülümür vadisi çevresi, Hozat ve Çemişgezek'in kuzeyinde yer alan yüksek alanlardır. Söz konusu alanlar yerleşmenin de çok kısıtlı olduğu, zorlu fiziki ve iklim şartların yaşandığı alanlardır. Dolayısıyla bu alanlar sadece RES kurulumu için değil, çeşitli beşerî faaliyetler içinde uygun değillerdir.

5. SONUÇ

Dünyada her geçen yıl artan enerji talebi, ülkeleri bu talebi fosil yakıtlara ek yenilebilir kaynaklardan karşılamaya itmektedir. Sürdürülebilirlik ve çevresel etki faktörleri baz alındığında yenilenebilir enerji kaynakları son derece önemlidir. Rüzgâr enerjisi de hem dünyada hem de ülkemizde kapasitesi son derece artan yenilenebilir enerji kaynaklarındandır.

Bu çalışmada BWM-CBS entegre bir şekilde kullanılarak Tunceli için en uygun RES alanı belirlenmiştir. Bu kapsamda literatüre ve çalışma alanı özelliklerine göre toplam 16 kriter belirlenmiş ve bu kriterler uzmanlar tarafından değerlendirilerek çalışmada kullanılmıştır. Çalışmada yöntem olarak Best-Worst metodu kullanılmıştır. BWM ikili karşılaştırmaya dayanan bir ÇÇKV yöntemidir. BWM çıktıları CBS'ye aktarılmış olup ArcGIS araçlarından "Weight Sum" aracı kullanılarak çakıştırma analizi uygulanmış ve RES kurulumu için uygun alanlar belirlenmiştir.

Tunceli için çalışma kapsamında önerilen uygun RES alanları toplam alanın yaklaşık %38'ine denk gelmektedir. Bu alanlar kısmen Pülümür'ün kuzey çevresi ile Pertek ve Mazgirt çevresidir. Özellikle Tunceli'nin güneyinde yer alan Pertek ve Mazgirt çevresi RES kurulumu için gerek oran gerekse alan bakımında önde gelmektedir. Bu alanlarda gerek yükseltinin kısmen az olması, rüzgâr ile ilgili faktörlerin etkinliği ile lokasyon açısından da ulaşılabilir olması RES kurulumdan ön plana çıkmasında etkili olmuştur.

Çalışma çıktılarına göre "az uygun" ve "uygun değil" alanlar ise yaklaşık %62 seviyelerindedir. Bunun temel sebebi Tunceli ilindeki rüzgâr hızı ve bölgenin zorlu fiziki coğrafya şartlarıdır. Özellikle çalışma alanın kuzey bölgesinde yer alan Munzur ve Mercan dağlarında yükseklik 3000 m'leri bulmakta olup çok yüksek eğim değerlerine sahiptir. Aynı şekilde çalışma alanın çoğu bölgesinde yükselti ve eğim değerleri oldukça fazladır. Ek olarak çalışma alanının belirli bölgeleri hariç (Pülümür'ün kısmen kuzeyi ile Pertek ve Mazgirt çevresi) genellikle rüzgâr hızları düşüktür. Dolayısıyla bu şartlarında etkisiyle RES kurulumunda uygun alanlar sınırlı bir alana denk gelmiştir.

Çalışma çıktılarına göre RES kurulumu için en uygun bazı alanlara arazi çalışması yapılmıştır. Arazi çalışması analiz sonuçları ile gerçek alanın karşılaştırılması adına oldukça önemlidir. Söz konusu arazi çalışmasında Beydamı Köyü ve çevresinde RES kurulumu için uygun olabilecek alanlar fotoğraflanmış ve eklenmiştir. Nitekim bu bölge gerek yükselti, eğim ve rüzgâr hızı ile ilgili parametreleri doğrultusunda uygunluğu gerekse ana yola, elektrik hatlarına ve bir yerleşim alanına yakınlığı ile uygun olması RES kurulumu için uygun alan olarak ön plan çıkmıştır.

Bu çalışmada BWM-CBS'yi entegre ederek kullanmasına rağmen belirli sınırlılıkları vardır. Çalışma kapsamında sadece 4 ana kriter içerisinde toplam 16 kriter kullanılmıştır. Çalışmadaki çıktı bu kriterler doğrultusundadır. Ayrıca rüzgâr türbin tipi ve şekli gibi teknik detaylar dikkate alınmamış olup genel olarak değerlendirilmiştir. Bu da çalışmanın diğer bir sınırlılığıdır. Gelecek çalışmalarda kriter sayısı ve türbin tipi ayrıntılı olarak el alınırsa daha kesin sonuçlara ulaşılabilir.

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Vulnerability of Tribal Communities to Climate Variability in Lahaul and Spiti, Himachal Pradesh, India

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ABSTRACT
India is home to many physiographic divisions, climatic regions, diverse cultures, and ethnicities. The greater Himalayan and trans-Himalayan regions are home to many tribal communities. However, climatic variability brings new challenges to the tribal households in mountainous regions, particularly in India's greater Himalayan and trans-Himalayan regions. This study aims to create a Tribal Household Livelihood Vulnerability Index (THLVI) that takes into account factors such as exposure, sensitivity, and adaptive capacity. The research focuses on three subdivisions in the Lahaul and Spiti district, namely: Lahaul, Udaipur and Spiti, which are part of the western Himalayas cold deserts. The data for the THLVI was collected from 300 randomly selected households in 62 villages through a survey of indigenous people. The results of the study reveal that the vulnerability of tribal households varies across different socio-economic and ecological conditions due to differences in adaptability, sensitivity, and exposure to climate change. In the Lahaul and Udaipur subdivisions, the vulnerabilities of social networks, water, and health were found to be 0.390, 0.262, 0.545, and 0.525, 0.514, 0.512, respectively. The THLVI based on IPCC values ranges from -1 (least vulnerable) to +1 (most vulnerable). For further research, the THLVI index can be used as a tool to assess the livelihood vulnerability of tribal communities living in Himalayan regions, furthermore the sustainable livelihood policies can be formulated in order to strengthen the livelihood security.
Keywords: Vulnerability; Climate Change; Tribal livelihood; Adaptation; Himachal Himalayas

1. INTRODUCTION

The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) was released, which concluded that the Himalayas were a highly vulnerable mountain in the world (IPCC, 2014). The western Himalayas are more vulnerable to climate change when compared to the eastern Himalayas (ICIMOD, 2011). Its effects disproportionately impact the young, poor, elderly, sick and marginalized populations.

The mountain inhabitants live under constant threat and risk posed by climate change, which is becoming more severe every passing year. This risk is attributed to specific socio-economic features and mountain characteristics like marginality, limited accessibility, remoteness, fragility and dependency on primary resources. Although mountainous regions are abundant in several kinds of resources, it is a fact that mountain inhabitants are among the most vulnerable and poorest in the world. The over-exploitation of natural resources by the government and other agencies as well as its remoteness, make these mountain tribal communities vulnerable. (Pandey et al., 2017). The risk and vulnerability to the inhabitant communities multiplied with socio-ecological changes in the region, and have escalated over time. This resulted in frequent occurrences of extreme events like, scorching heat, landslides, cloudbursts, and flash floods. Furthermore, there has been a resultant upsurge in temperature and erratic precipitation throughout the mountain region in the past few decades.

The communities that rely heavily on natural resources are greatly impacted by the effects of climate change, which led to severe and lasting consequences on their livelihood and well-being (Kofinas and Chapin III, 2009). Therefore, it is projected that the vulnerability of rural tribal households are perceptibly heightened due to climate change. It further triggered irreversible risks to the human ecosystem, leading to an increased number of people in penury and causing more serious damage to the ecology of the area (Li et al., 2014; Lioubimtseva, 2015). In order to develop strategies for adaptation, knowledge of climate-related hazards that could occur in the mountainous region with existing populations and the assets available is important. It could even provide the rationale needed for proper implementation of such strategies. (Oppenheimer et al., 2014; Zhang et al., 2014). There are various methods used to estimate climate change to minimize vulnerability (Pandey et al., 2016; UNDP, 2014; Vignieri, 2015), which has been emphasized in studies on the vulnerability and resilience of socio-economic systems in different geographical regions (Kates et al., 2001).

This vulnerability was defined by various authors in several ways (Füssel, 2006). For this study, the definition of vulnerability given by IPCC (2007) was adopted, i.e., "Vulnerability is a degree that their system has not able to cope up with severe impacts of climate change" (IPCC, 2007). Three components are effectively conceptualized in this definition: adaptive capacity, sensitivity, and exposure (Adger, 2006). However, it cannot be reduced to a single quantifiable measure (Alwang et al., 2001).

In this research, the Tribal Household Livelihood Vulnerability Index (THLVI) was modified and applied to rural household's calculations, by using important characteristics such as topographical location, household income, educational status, livelihood, diversification, and extent of agricultural and as well as non-agricultural land in an environmentally vulnerable area of Lahaul and Spiti.. The THLVI has three overarching dimensions; exposure, sensitivity, and adaptive capacity, and it is made of eight major components and forty-six sub-components. The outcomes of THLVI are indicative of vulnerability that tribal communities could face. The proposed tribal index based on a bottom-up approach could explain the differences that primarily exist in tribal household livelihood susceptibilities. The findings of this research paper could be important for policy making and directing government efforts towards the necessary action for poverty eradication, combating climate change, and sustainable development in the Lahaul and Spiti district of the trans-Himalayan region. Several academic studies were conducted to better comprehend the relationship between climate change and mountain susceptibility (ICIMOD, 2011).

This study could contribute knowledge through creating an index that assessed the vulnerability posed by climatic variability upon the tribal communities in Himachal Himalaya. The broader objectives of this study were to understand and map determinants of the vulnerability of tribal communities; to assess the vulnerability; and discuss the sustainable adaptation practices and measures in Lahaul and Spiti. This study did not pose a hypothesis but rather sought answers to certain questions to achieve the objectives.

1.1. Climate change vulnerability assessment

To study climate change and scientifically assess its impact, a variety of methods and approaches have been developed. The evaluation of indicators of climate-induced vulnerability examines crucial connections that exist between people and their physical and social environments to develop a better understanding of the climate, its variability and impact. Other

geographical data analysis on poverty, health status, and globalisation are used to target food aid, including the World Food Program's Vulnerability Analysis (World Food Programme, 2007; Chen et al., 2006; O'Brien et al., 2004; and Holt, 2007). In this study an attempt was made to quantify visible multi-dimensional matters appropriately using the relevant indicators and sub-indicators. These are frequently put together to create a composite index, which enables the integration of many variables. For example, the Human Development Index uses factors such as life expectancy, health, education, and living standards as indicators to offer a comprehensive portrait of national well-being (UNDP, 2007). The Water Poverty Index uses parameters like water provision and water utilization for assessing the deviation from a predetermined standard. This is done by using a 'gap method' by Sullivan (2002, p. 1204). The Human Development Index is an example of a composite indices used to determine the weighted averages for individual metrics. For choosing the weighting methods, Vincent (2004, 2007) and Sullivan et al. (2002) recommended consulting with experts and holding stakeholder discussions.

To address this issue, approaches were developed and contributed (Polsky et al., 2007). It is crucial to remember that a variety of fields heavily rely on the IPCC's assessed vulnerability. The IPCC definition is dependent on the exposure, sensitivity, and capacity for adaptation (IPCC, 2001). Exposure to climate-related occurrences, such as a flood or increase in snowfall is necessary to gauge size and duration. Sensitivity measures how much exposure alters the system. Additionally, "adaptive capacity" is the ability to bounce back after exposure (Ebi et al., 2006).

Fussel and Klein (2006) systematically defined first and second-generation vulnerability assessments for the sake of convenience. First-generation vulnerability valuations were based on the assessment of climatic impact relative to baseline or threshold conditions, whereas second-generation assessments were the ones that incorporated adaptive capacity measures. There are a multitude of interpretations on second-generation studies and how to apply the parameters of exposure, sensitivity, and adaptive capacity to quantify as well as reduce the risk of vulnerability (O'Brien et al., 2004; Vincent, 2004; Thornton et al., 2006; Polsky et al., 2007).

Several recent studies in South and Southeast Asia used the Socio-economic Vulnerability Index to quantify vulnerability posed by climatic variability-induced incidents/extreme events (Sam et al., 2017), the Livelihood Vulnerability Index (Alam et al., 2017; Bhattacharjee & Behera, 2018), the socio-ecological vulnerability index (Pandey & Bardsley, 2015) as well as the modified Livelihood Vulnerability Index (Madhuri et al., 2014). Many of the studies focused on vulnerability related to extreme natural hazards (Devi et al., 2016; Alam et al., 2017; Sam et al., 2017; Bhattacharjee & Behera, 2018). Robust social networks and a supportive institutional framework were highlighted as the major techniques for decreasing vulnerability (Sam et al., 2017) as well as economic diversification, including migration (Bhattacharjee & Behera, 2018) in the Himalayas and South Asia.

1.2. The Tribal Household Livelihood Vulnerability Index

Aryal et al. (2014), noted that the vulnerability to climate change varied from one place to another depending on the community's location, socio-cultural setup, and economic practices. Indigenous communities that relied on natural resources for their livelihood were more prone to climate change-induced vulnerabilities. Indigenous communities that relied on climate change had a negative impact on those who depended on natural resources for their livelihood. When determining a household's development requirements, the sustainable livelihoods approach considers all natural, social, physical, financial, and human capital assets (Chambers and Conway, 1992). This approach is effective in helping households cope with shocks such as natural disasters. However, climate change adds an additional layer of complexity to the issue of household livelihood security. While the sustainable livelihoods approach considers some aspects of climate change vulnerability, such as sensitivity and exposure and therefore a new approach is needed to more fully evaluate the risks to livelihoods posed by climate change and account for micro level household adaptation strategies.

To assess the impact of climate change-induced vulnerability on populations in the district of Lahaul and Spiti, Himachal Pradesh, this study used the Tribal Household Livelihood Vulnerability Index (THLVI). The Tribal Household Livelihood Vulnerability Index combines existing indicators with new indicators to comprehensively measure households' exposure to natural hazards and climate variability, the socio-economic characteristics that affect adaptive capacity in terms of food, water, migration, and health resources, and sensitivity to the impact of climate change. The THLVI combines components of previous methods as well as other components to measure a household's exposure to natural hazards and climate variability.

It uses socio-economic characteristics that affect adaptive capacity in terms of food, water, migration, and health resources, and sensitivity to the impact of climate change. The THLVI can be used as a composite index made up of eight components, or it can be aggregated into three contributing factors of exposure, sensitivity, and adaptation capability that the Intergovernmental Panel on Climate Change (IPCC) identified as vulnerability index(Table 1).

An advantage of this approach is that it uses primary as well as secondary data to construct the index. This helps to avoid gaps in the data and reduces a reliance on climate models that may not provide accurate projections relevant to community development scheduling (Sullivan, 2006; Patz et al., 2005).

The THLVI is made to be adaptable so that development organizations, policymakers, and public health professionals can use it to examine the demographic, socioeconomic, water, and health elements that affect climate vulnerability at meso and micro level that is community level. Sectoral vulnerability ratings can be separated to identify possible areas for intervention, and it can be honed and concentrated to meet the requirements of different geographic regions.

2. METHODS

2.1. Study Area

Lahaul and Spiti is a district located in the state of Himachal Pradesh. Physiographically, it is considered a cold desert situated in the western part of the Indian Himalaya.. It is the biggest district in Himachal Pradesh, covering an area of 13,835 square kilometers. It is situated between the latitudes of 31°44′ 57″ N to 32° 59′ 57″ N and the longitudes of 76° 29′ 46″ E to 78° 41′ 34″ E (Fig.1), and surrounded by snow-capped mountains. Lahaul and Spiti is the least populated district as compared to other districts of the state as well as India. It shares an international boundary with Tibet (China). Due to its isolation, it is difficult to obtain a clear and coherent history of the Lahaul and Spiti district.

The area has long been home to people who endured and withstood the harshness of nature and the difficult living conditions in these isolated, mountainous regions. Located near the border with Tibet and bordering the districts of Ladakh, Chamba, Kangra, Kullu, and Kinnaur, the Lahaul and Spiti valleys have some differences in their physical and cultural characteristics. The Spiti valley is wider but more rugged and

barren, while the Lahaul valley is narrower but has green patches of forests. The altitude in the Spiti valley ranges from around 10,000 feet at the entrance to about 16,000 feet near Kunzum La, while the elevation in the Lahaul valley ranges from about 6,500 feet at Arat nallah to about 14,000 feet near the source of Chandra Bhaga River.

High Rocky Mountains covered in snow and glaciers rise to 6,600 meters above mean sea level in both valleys. The Chandra and Bhaga River valleys up to the confluence near Tandi, as well as the major Chandra Bhaga valley as far as Thirot Nallah, are all part of the Lahaul region. The valleys of the main Spiti River and its tributary, the Pin River, make up the Spiti region. The population of Lahaul and Spiti was 33,244 in 2001 but in 2011 it declined to 31,564 which made a negative population growth rate of -5.1%.

2.2. Calculating the THLVI: A Composite Index

The Tribal Household Livelihood Vulnerability Index (THLVI) is divided into eight components: socio-demographic profile, livelihood approaches, social system, health, food, migration, water, climate variability and natural disasters (Table 1). Each component is made up of several sub-components, which were identified through a review of literature on each major component.

To calculate the THLVI, a balanced weighted average is used (Sullivan et al., 2002). In this approach, each sub-component makes an equal contribution to the overall index, regardless of the number of sub-components in the major components. To ensure that all sub-components are compared, they are converted into an index which is used to calculate the life expectancy index derived from that employed in the Human Development Index. This index is calculated as the ratio of the difference between the existent life expectancy and a pre-selected minimum life expectancy, and the range between the pre-selected maximum and pre-selected minimum life expectancy (UNDP, 2007). To standardize the sub-components for comparision they are transformed into an index using the formula:

$$Index\ ri = (Sr - Smn) / (Smx - Smn) \qquad (1)$$

Where *Sr* is the raw sub-component for region r, *Smn* is the minimum value for the sub-component calculated using data from all three regions, and *Smx* is the maximum value for the sub-component. For example, if the sub-component average time to travel to the primary water source location ranges from 1
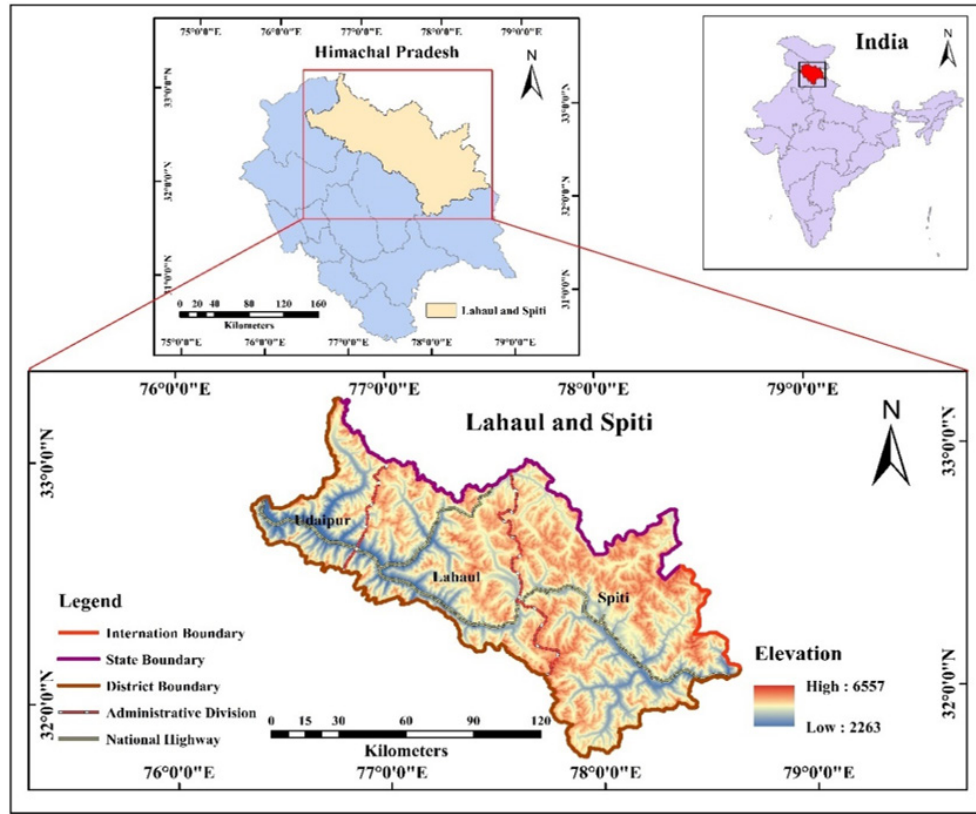
Figure 1: Location map of Lahaul and Spiti district.

to 80 minutes in each region, the minimum and maximum values of 1 and 80 and say 40 minutes to collect water, then 40 is the raw value of sub-component.

Some sub-components were computed by taking the inverse of their original values, examples include the mean index for agricultural livelihood diversity, as a rise in the crude indicator was assumed to decrease vulnerability. For example, a household that engaged in both farming and animal husbandry could be considered less vulnerable than a household that only farms. The maximum and minimum values were also transformed using this logic, and the standardized index was calculated using Equation 1.

To compute the value of each major component, the sub-components were averaged using Equation 2 after they had been standardized:

$$Mr = \sum_{i=1}^{n} indexri \frac{1}{n} \qquad (2)$$

Where Mr is the value of the main component, indexri comprised of sub-components indexed by "i", and "n" represents the total number of sub-components within the major component. The main components are Food (F), Water (W), Migration (M),

Socio-Demographic Profile (SDP), Livelihood Approaches (LA), Social System (SS), Health (H), and Climate Variability and Natural Disasters (CVND).

To obtain the sub-district level THLVI, the values for each of the eight main components for each region were averaged using Equation 3:

$$THLVIr = \frac{\sum_{i=1}^{n} WmiMri}{\sum_{i=1}^{n} Wmi} \qquad (3)$$

Where THLVIb is the Tribal Household Livelihood Vulnerability Index for Region r, Wmi is the weight of each main component based on the number of sub-components it contained, and Mri is the value of each main component. The weights are included to ensure that all sub-components contributed equally to the total THLVI score (Sullivan et al., 2002). The THLVI was scaled from 0 (least vulnerable) to 1 (most vulnerable).

2.3. Calculating the THLVI-IPCC: IPCC framework approach

The THLVI-IPCC is an alternative technique for calculating the THLVI that incorporates the IPCC's definition of vulnerability. It

Table 1: Major components and their sub-components of Tribal Household Livelihood Vulnerability Index (THLVI) .

Major Components	Sub-components	Explanation of Sub components	Survey Question	Source
Socio-demographic profile (AC)	Dependency ratio	The proportion of the population under 15 and over 65 years old to the population 19 to 64 years old.	Could you kindly make a list of everyone that eats and sleeps in this residence, including their ages and genders? Please add any visitors who ate and slept in your home for the last three days.	Hahn et al., (2009). Measure DHS: Model Questionnaire with Commentary
	Female-headed Households	The percentage of families with a female as the principal adult. If a male head of family is absent for more than six months each year, the female is considered the household's leader.	Are you the family's head of household?	Hahn et. al. (2009)
	Households in which the head of the household has not completed all the metrics.	The percentage of families where the head of the family did not finish the tenth grade.	Would you ever go to school?	Hahn et. al. (2009)
	Percentage of orphaned households	The percentage of families with at least one orphan living with them. Children under the age of 18 who lost one or both parents are known as orphans.	Are there any children under the age of 18 from other families who live with you because one or both of their parents have passed away?	Hahn et. al. (2009)
	Household with a combined family.	In each house, there is just one family	Are you a member of a joint family?	Derived from Hahn et. al. (2009)
	Household having nuclear family	More than one family live in a house	Do you live in nuclear family?	Derived from Hahn et. al. (2009)
Livelihood Options (AC)	Percent of families with a family member who works in a separate community	Percentage of families with at least one family member who works as their major source of income outside of the community.	How many members of your family commute to work in a different community?	Taken with from the World Bank (1997). Questionnaire: Uttar Pradesh and Bihar living conditions survey.
	Percentage of families whose primary source of income is agriculture	Only agriculture is reported as a source of income by a certain percentage of families.	Do you or a member of your family keep pets? Do you or someone else in your family go to the forest, rivers, etc. to collect something to sell?	Taken from World Bank (1997).
	Percent of irrigated land	Percent of households having fully irrigated land.	Have your agricultural land all irrigated or not?	Derived from Zhang Qin (2018).
	The average measure of agricultural livelihood diversification	The inverse number of agricultural livelihood activities +1 recorded by a household	Do you or anybody else in your family keep animals? Do you or someone else in your family go out into the wilderness, the forest, rivers, etc. to collect items to sell?	Taken from DHS (2006)
	Percent of un-irrigated land	Percent of households having non-irrigated land.	Have your agricultural land all irrigated or not?	Derived from Zhang Qin (2018).
	As a source of income, Percent of households relied on sources other than agriculture.	The percentage of families that report having a source of income other than agriculture.	Do you have income from other than agriculture?	Derived from World Bank (1997).
	Percent of households reliant on both agriculture and other sources	Percentage of families that say they earn money from both agriculture and non-agricultural sources.	Do you have from both source agriculture as well as other than agriculture?	Derived from World Bank (1997).
	Per family average land availability (Bigha)	Average landholdings of households.	How many bighas land in your home?	Derived from Zhang Qin (2018).
	Average number of livestock	Average number of livestock in your households.	How many animals are in your home?	Derived from Hahn et. al. (2009).

Table 1: Continue.

Major Components	Sub-components	Explanation of Sub components	Survey Question	Source
Health (S)	Average travel time to a medical institution (minutes)	Time it takes for a household to go to the nearest health institution on average.	What is the average time it takes you to travel to a medical facility?	Hahn et. al. (2009).
	Percent of the total of homes with a family member suffering from a chronic disease	Respondent specified the proportion of households that have at least one family member with a chronic disease	Is there anyone in your family who suffers from a chronic illness?	Hahn et. al. (2009).
	Percent of families depended on traditional medicines	Percent of families that solely depend on traditional medicines of that region.	When you are ill, then do you go to traditional doctors?	Derived from Pandey et. al. (2018).
	Percent of families depended on English medicine	Percent of families that solely depend on English medicines of that region.	When you are ill, then do you go to English doctors?	Derived from Pandey et. al. (2018).
	Percent of families depended on both type of medicines	Percent of families that solely depend on both English and traditional medicines of that region.	When you are ill, then do you go to both English and traditional doctors from time to time?	Derived from Pandey et. al. (2018).
	Percent of households having toilet within premises	Percent of households having toilet within or outside premises.	Do you go toilet outside?	Developed by authors for this study.
	Per-capita availability of beds in hospital (per 1000)	Availability of beds in local hospital.	How many beds in your nearest hospital?	WHO (2017)
	Per-capita availability of doctors in hospital (per 1000)	Availability of doctors in your local hospital.	How many doctors in your nearest hospital?	WHO (2017)
Migration (AC)	Average quantity of migrants in families	A typical number of persons from households leave their territory and go to another location in search of a better living.	How many people from your family leave home for employment or education, etc.	Derived from (Maharjan et al., 2020)
	Percent of migrants due to employment	Percent of households that migrate due to employment.	How many people are migrating due to employment?	Derived from (Maharjan et al., 2020)
	Percent of families getting remittances	Percent of household getting remittances from their migrated people.	How many migrated persons send remittances to their families?	Derived from (Maharjan et al., 2020)
Water (S)	Percentage of homes that get their water from a natural source	The percentage of homes have a natural water supply.	What source do you use to get your water?	Taken from DHS (2006)
	Time to reach to water source on average (minutes)	The average amount of time it takes for a household to get to their principal water supply.	How much time takes you to get to your water source?	Taken from DHS (2006)
	Percentage of households without a reliable water supply	Percent of households reporting that water is not accessible from their major water source daily	Is this water available daily?	Taken from World bank (1997)
	The inverse of the average amount of water held each home.	(The average number of litres of water stored by each home + 1) is the inverse of (the average number of litres of water stored by each family + 1).	What kind of containers do you use to keep water? How many are there? How many litres do they contain?	Derived from Hahn et. al. (2009).
Social Systems (AC)	Percent of people who neither received or nor aided others	Percent of households, who helped relatives in the form of income.	Does your family get money from sibling's home and vice versa?	Derived from Hahn et. al. (2009).
	Percent of household visiting their relatives to attend social functions (last 12 months)	Percent of households, how many households go to each other family home.	Does your family go to siblings' home and vice versa?	Derived from Hahn et. al. (2009).
	For last 12 months, what percentage of households went to their local government for help	The percentage of families that said they had not sought their local government for help in the previous 12 months.	I Have you or a member of your family sought help from your community leader in the last 12 months?	Taken from WHO (2003).
Food (S)	Percent of families whose only source of food is a family farm	Percentage of households who receive most of their food from their own farms.	Where does the majority of your family's food come from?	Hahn et. al. (2009).
	The average number of months a household worked for food	The average number of months that families struggle to feed their families.	Is there enough food for your family throughout the year, or are there periods during the year when there is not enough? How many months of the year does your family struggle to eat enough?	Taken from World Bank (1997).

Table 1: Continue.

Major Components	Sub-components	Explanation of Sub components	Survey Question	Source
Food (S)	Crop diversity index on average	The inverse of (a household's number of crops multiplied by 1).	What kinds of crops does your family raise?	Taken from World Bank (1997)
	Crops that are not saved by a certain percentage of households	Percentage of households who do not store crops.	Do you and your family store part of the crops you harvest to consume later?	Derived from Hahn et. al. (2009).
	Households that do not store seeds as a percentage	Percentage of homes without seeds from one year to the next.	Do you and your family preserve seed for the next year?	Derived from Hahn et. al. (2009).
	Percent of households eating just vegetables	Percentage of households that taking only veg in food habit.	Are you vegetarian?	Developed by authors for this study.
	Percentage of households that eat both vegetables and non-vegetables	Percentage of households that taking both veg and non-veg in food habit.	What is your food habit?	Developed by authors for this study.
Climate variability and natural disasters (E)	Injuries or deaths among household members because of recent natural catastrophes	Percentage of households reporting animal harm or death because of the disaster.	Was any animal killed or wounded because of the disaster?	Hahn et. al. (2009).
	Percent of households that did not get a warning about impending natural disasters or calamities	In the previous six years, the percentage of homes that did not get a warning of the most severe landslide, cloudburst, flood, and snowstorm.	Did you receive advance notice of the landslide, cloudburst, flood, or snowfall?	Hahn et. al. (2009).
	Animals in families that have been injured or killed because of recent natural catastrophes	Percentage of households reporting animal harm or death because of the disaster.	Was any animal killed or wounded because of the disaster?	Derived from Hahn et. al. (2009).
	Monthly average of average snowfall mean standard deviation (years 2009 to 2020)	For each region, the standard deviation of the average daily month snowfall from 2009 to 2020 was averaged.	Data from the regional centre from 2009 to 2020; weather station data from the provinces	Indian Meteorological Department.
	Average monthly standard deviation of average sunshine (years 2009 to 2020)	For each region, the standard deviation of the average daily month sunlight from 2009 to 2020 was averaged.	Data from the regional from 2009 to 2020; weather station data from the provinces	Indian Meteorological Department.
	Monthly average rainfall mean standard deviation (years 2009 to 2020)	For each region, the standard deviation of the average daily month precipitation from 2009 to 2020was averaged.	Data from the regional centre from 2009 to 2020; weather station data from the provinces	Indian Meteorological Department.

AC- Adaptive Capacity; S- Sensitivity; E- Exposure

consists of eight major components: exposure, climate variability, demographic profile, livelihood strategies, social networks, adaptive capacity, sensitivity, and present level of health and security of food and water. These components are used to determine the vulnerability of tribal communities. The frequency of recent natural catastrophes serves as a proxy for exposure, whereas the average standard deviation of temperatures and precipitation over the same time serves as a proxy for climatic variability. The demographic profile, livelihood strategies, and social networks of a district are used to determine adaptive capacity, while sensitivity is measured by the assessment of food, water and health. The THLVI-IPCC is calculated using subcomponents of these major components, as well as equations 1-3. The major components of the THLVI-IPCC are combined using a categorization scheme, rather than being merged into the THLVI in a single step.

$$CFr = \frac{\sum_{i=1}^{n} WmiMri}{\sum_{i=1}^{n} Wmi} \qquad (4)$$

The IPCC defines three contributing factors for a region: exposure, sensitivity, and adaptive capacity. These factors are represented as CFr for region r. The major components of region d are represented by Mri, with the weight of each component being represented by Wmi. The number of major components in each contributing factor is represented by n. The three contributive factors are calculated by using the following equation:

$$THLVI - IPCCr = e_r - a_r \times S_r \qquad (5)$$

The THLVI for region r, expressed using the IPCC vulnerability framework, is represented by THLVI–IPCCr. The calculated exposure score for region r is represented by e, which is equivalent to the Climate Variability or Natural Disaster major component. The calculated adaptive capacity score for region r is represented by a, which is the average of the four main components: sociodemographic, livelihood, migration, and

social network variables. The sensitivity estimates score for region r is represented by S, which is the weighted average of the Health, Food, and Water major components. The THLVI–IPCC is scaled from -1 (least vulnerable) to +1 (most vulnerable).

2.4. Household Survey

Primary data was collected through fieldwork. The Random sampling method was used for data collection and proportionately villages were selected from three regions Lahaul, Udaipur and Spiti respectively. Thus, a total of 300 households (131 from Lahaul, 95 from Udaipur, and 74 from Spiti) were surveyed in these three regions and from that out of 62 villages surveyed 31 villages from Lahaul, 19 villages from Udaipur and 12 villages from Spiti were done. The households surveyed were chosen based on various factors, including the size of the village, the type of settlement (e.g., socio-ethnic), the primary means of livelihood, and the level of accessibility and transportation. To ensure the reliability of the collected data, a local guide was recruited as a language interpreter during the survey. The senior-most member of each selected household was interviewed, with each interview lasting at least 30 minutes. The indicators of various components and sub-components used in this research were selected from a variety of sources, including peer-reviewed literature, input from farmers, and the experiences of professionals working in the area and residents. These indicators encompassed both biophysical and socio-ecological-economic parameters that reflected the current social and environmental conditions in the region.

3. RESULTS

The purposive random sampling was adopted for the data collection as the preference was given to the households headed by an elderly person, especially women. Results of the calculated sub-components values in Table 2, THLVI (Table 3) and THLVI-IPCC (Table 4) are discussed below.

3.1. THLVI: Lahaul, Spiti and Udaipur

Table 2 shows the values for each sub-component of the THLVI of each three regions, as well as the minimum and maximum values for all three regions. The major components and the overall THLVI for all three regions are in Table 3.

The dependency ratio values were higher in Lahaul (0.094) as compared to Spiti (0.086) and Udaipur (0.088). However, overall, Spiti had a higher vulnerability in the Socio-Demographic

Profile index than Lahaul and Udaipur (SDP Lahaul 0.354; SDP Udaipur 0.271; SDP Spiti 0.412). Female respondents frequently identified their spouse as the head of the house. Then, the female respondent was considered the head of the family. The average percentage of female heads of household in Lahaul was 59.4%, 18.0% in Udaipur, and 34.6% in Spiti. Over 9% of households in Spiti reported raising an orphan, with 2% reporting raising more than one.

In Lahaul, the proportions were 5.97% and 2.08% in Udaipur. Spiti also had a higher vulnerability in the Livelihood options component (0.388) compared to Lahaul (0.367) and Udaipur (0.35). Additionally, Lahaul households on average reported employing more people than Spiti and Udaipur households and compromisingly the livelihood diversification indices have Lahaul 0.367, Udaipur 0.35, and Spiti 0.388 (Table 3).

Lahaul had a higher vulnerability in the Livelihood Strategies as compared to Spiti and Udaipur. More households in Udaipur and Spiti reported having family members who worked outside the community. When the three sub-components were combined, Lahaul had a higher total Livelihood Strategies vulnerability score than Udaipur and Spiti.

The Social Networks indicators varied between regions. Overall, households in Spiti had a higher vulnerability on the Social Networks component (0.564) compared to Lahaul (0.390) and Udaipur (0.525) (Fig. 2).

Lahaul households were reported to be more vulnerable to chronic diseases than households in Spiti and Udaipur (chronic disease: Lahaul 0.403, Spiti 0.382, Udaipur 0.270). The total score for the sub-components of the health vulnerability for Lahaul (0.578) was higher than that for Udaipur (0.526) and Spiti (0.512).

The percentage of Spiti households (78.24%) reported that they are mostly dependent on their crops for food requirements compared to Lahaul households (88.02%), and Udaipur households. Additionally, Lahaul households reported growing 1.4 time of crops on average, while Spiti households reported growing 3.2 times of crops on average.

As far as natural disaster sub components under exposure is concerned, all three regions had similar numbers of vulnerability based the average rainfalls, snowfalls, and extreme temperature events that occurred in the last 11 years. However, when data on the percentage of households that did not receive a warning and

Table 2: Tribal Household Livelihood Vulnerability Index (THLVI) of Lahaul, Udaipur and Spiti region have minimum and maximum values of sub-components values.

Major component	Sub-component	Units	Lahaul	Udaipur	Spiti	Maximum value	Minimum value	Indexed value calculated by Eq. 2		
Socio-demographic profile	Dependency ratio	Ratio	0.47	0.44	0.43	5.0	0	0.094	0.088	0.086
	Female-headed Households	Percent	10.45	6.25	17.65	100	0	0.104	0.062	0.176
	Households in which the head of the household has not completed all the metrics.	Percent	67.16	54.17	70.33	100	0	0.671	0.541	0.703
	Percentage of orphaned households	Percent	32.83	45.83	29.66	100	0	0.328	0.458	0.297
	Household with a combined family.	Percent	32.83	45.83	37.60	100	0	0.328	0.458	0.376
	Household having nuclear family	Percent	5.97	2.08	9.33	100	0	0.597	0.020	0.933
Livelihood Approaches	Percent of families with a family member who works in a separate community	Percent	13.43	8.33	12.67	100	0	0.134	0.083	0.127
	Percentage of families whose primary source of income is agriculture	Percent	65.67	58.33	63.94	100	0	0.657	0.583	0.639
	Percent of irrigated land	Percent	89.55	93.75	87.45	100	0	0.895	0.937	0.874
	The average measure of agricultural livelihood diversification	1/livelihoods	0.25	0.20	0.33	1	0	0.25	0.20	0.33
	Percent of un-irrigated land	Percent	10.25	6.25	12.55	100	0	0.104	0.062	0.125
	Source of income, Percent of households relied on sources other than agriculture.	Percent	11.94	16.67	10.04	100	0	0.119	0.167	0.1
	Percent of households reliant on agriculture and other sources	Percent	32.83	43.75	30.76	100	0	0.328	0.437	0.308
	Per family average land availability (Bigha)	Bigha	19.92	13.60	18.76	50	0	0.398	0.272	0.375
	Average number of livestock	Count	8.34	7.58	12.35	20	0	0.417	0.379	0.617
Social Systems	Percent of people who neither received or nor aided others	Percent	22.38	33.00	35.17	100	0	0.119	0.542	0.352
	Percent of household visiting their relatives to attend social functions (last 12 months)	Percent	83.58	83.33	83.66	100	0	0.216	0.2	0.837
	In the last 12 months, what percentage of households went to their local government for help	Percent	88.05	45.83	50.38	100	0	0.836	0.833	0.504
Migration	Average quantity of migrants in families	Count	2.55	4.77	3.25	10	0	0.255	0.477	0.325
	Percent of migrants due to employment	Percent	68.32	61.76	50.75	100	0	0.683	0.618	0.507
	Percent of families getting remittances	Percent	52.63	55.55	70.38	100	0	0.526	0.555	0.704
Health	Average travel time to a medical institution (minutes)	Minutes	52.98	48.33	50.03	60	0	0.883	0.805	0.834
	Percent of the total of homes with a family member suffering from a chronic disease	Percent	40.29	27.08	38.21	100	0	0.403	0.270	0.382
	Percent of families depended on traditional medicines	Percent	16.41	2.08	45	100	0	0.164	0.020	0.45
	Percent of families depended on English medicine	Percent	17.91	70.83	20.0	100	0	0.179	0.708	0.2
	Percent of families depended on both type of medicines	Percent	65.57	27.08	35.0	100	0	0.656	0.270	0.35
	Percent of households having toilet within premises	Percent	98.5	100	100	100	0	0.985	1	1
	Per-capita availability of beds in hospital (per 1000)	Ratio	3.7	3.3	2.6	5	1	0.675	0.575	0.4
	Per-capita availability of doctors in hospital (per 1000)	Ratio	0.68	0.56	0.48	1	0	0.68	0.56	0.48

the percentage of households that experienced disaster-related injuries or deaths over the last six years was considered, Udaipur was found to be more vulnerable than Lahaul and Spiti.

Table 2: Continue.

Major component	Sub-component	Units	Lahaul	Udaipur	Spiti	Maximum value	Minimum value	Indexed value calculated by Eq. 2		
								Lahaul	Udaipur	Spiti
Food	Percent of families whose only source of food is a family farm	Percent	100	97.91	80.33	100	0	1	0.979	0.803
	The average number of months a household goes without food	Months	7.72	7.43	7.23	12	0	0.643	0.619	0.602
	Crop diversity index on average	1/ crops	0.24	0.20	0.33	1	0.1	0.155	0.111	0.255
	Crops that are not saved by a certain percentage of households	Percent	88.24	100	78.24	100	0	0.882	1	0.782
	Households that do not store seeds as a percentage	Percent	17.65	60.42	23.52	100	0	0.176	0.604	0.235
	Percent of households eating just vegetables	Percent	0	0	0	100	0	0	0	0
	Percentage of households that eat both vegetables and non-vegetables	Percent	100	100	100	100	0	1	1	1
Water	Percentage of homes that get their water from a natural source	Percent	60.0	70.0	55.0	100	0	0.6	0.7	0.55
	Time to get to a water source on average (minutes)	Minutes	12.31	65	60	80	5	0.154	0.812	0.75
	Percentage of households without a reliable water supply	Percent	25.37	50.0	40.0	100	0	0.254	0.5	0.4
	The inverse of the average amount of water held each home.	1/Litres	0.039	0.044	0.056	1	0	0.039	0.044	0.056
Climate variability and Natural disasters	Injuries or deaths among household members because of recent natural catastrophes	Percent	22.05	14.58	30.76	11	0	0.220	0.146	0.308
	Percent of households that did not get a warning about impending natural disasters or calamities	Percent	45.59	60.42	52.65	100	0	0.456	0.604	0.526
	Animals in families that have been injured or killed because of recent natural catastrophes	Percent	26.47	12.5	17.03	100	0	0.265	0.125	0.170
	Mean standard deviation of average annual snowfall (2009 to 2020)	Centimetres	16.7	16.7	16.7	50	10	0.58	0.58	0.58
	Mean standard deviation of average monthly sunshine/temperature (2009 to 2020)	Hours	6.71	6.71	6.71	10	0	0.671	0.671	0.671
	Mean standard deviation of average monthly rainfall (2009 to 2020)	Millimetres	8.97	8.97	8.97	40	10	0.885	0.885	0.885
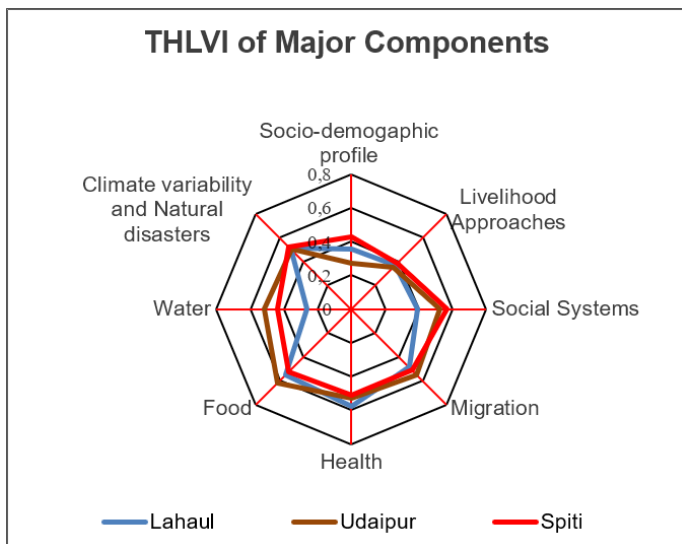
Figure 2: Spider diagram of THLVI's major components of the Lahaul, Udaipur and Spiti.
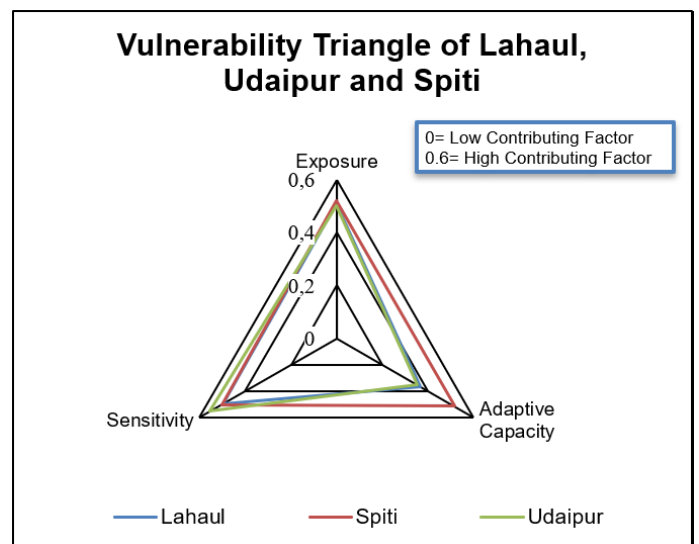
Figure 3: Triangle diagram of THLVI-IPCC for Lahaul, Udaipur and Spiti.

The proportion of missing replies in the questionnaire varied respondents to respondents and can be seen as limitations of questionnaire survey. However, when calculating the climate variability and natural disaster values, Spiti households were found to be more susceptible than Lahaul and Udaipur households. Overall, Spiti showed higher THLVI (0.477) than Lahaul (0.449) and Udaipur (0.469) respectively (Table 3).

3.2. THLVI-IPCC assessment: Lahaul, Udaipur and Spiti

The data depicted in Figure 3 suggests that the comparatively low estimated adaptive capacity in Udaipur households was due to demographic imbalances and a high percentage of families who raised orphans. Adaptation observations such as livelihood diversification, planned migration, food, and water were the main reasons behind Udaipur's low THLVI-IPCC result.

THLVI-IPCC calculations vulnerability is less in Udaipur region (0.003) and more in Lahaul (0.073) and Spiti (0.083) (Table 4). Spiti families could be more exposed to the effects of climate change than Lahaul and Udaipur households, according to the aggregate THLVI-IPCC ratings (Fig. 3).However, it is uncertain whether these approaches are sufficient to compensate for climatic changes within the range of possible climate variations. Additionally, Figure 3 shows that although Lahaul family's demographic pressures and low rates of school attendance are not reported in the same manner, similar response techniques were prevalent in Udaipur.

4. DISCUSSION

It was well-established in scholarly literature that agriculture is the primary source of livelihood for Himalayan villages (Macchi et al., 2014; Gerlitz et al., 2016). Many scholars documented the increasing and disparate vulnerability faced by agricultural communities over time (Pandey and Jha, 2011; Tiwari and Joshi, 2012; Panthi et al, 2015). As Shukla et al. (2018) noted, "The Himalayan region's agricultural populations are disproportionately vulnerable because of difficulties in sustaining their livelihoods brought on by a variety of internal and external variables."

The landscape changes dramatically as soon as one passes across the Rohtang Pass from Manali. Green conifer-lined slopes give way to harsh, brown alpine peaks. The selected components were aggregated under 46 different sub-components for three major components of Lahaul, Spiti and Udaipur. THLVI was calculated at the village level using various major and sub-components. In the major components, exposure was very high in Spiti. At the village level, the more vulnerable to exposure were Marango Rangarik (0.789), Chicham Khas (0.585) and Pinjoor (0.559); then Lahaul and within its villages, Jobrang (0.856), Kowaring and Sissu (0.689) and then Udaipur and within its village's exposure are Madgram (0.559), Jahalman and Manrung (0.522) respectively. Climate change directly affected the livelihood of people in the Lahaul and Spiti district.

The second major component 'Sensitivity' comprises Health, Food, and Water. Sensitivity is directly proportional to vulnerability. If we are more sensitive, then the possibility of exposure is also high and vice versa. There is only one season for cropping, which runs from April to October, when the mean minimum and maximum temperatures range from approximately 12°C to 24°C. Although they can range from as low as 5°C to 30°C. During the winter months, temperatures drop well below freezing (-20°C to -10°C). Rainfall also varies between regions, with an average annual rainfall of 250 mm ranging from as low as 90 mm to as high as 1200 mm. Most of the rainfall is received as snowfall in the winter from November to early March. The rainfall in Spiti is generally scarcer than in Lahaul, and Udaipur.

Unlike other tribesmen in the nation, the tribal farmers of Spiti were discovered to be highly inventive and fast learners. The crops in this region underwent a higher degree of revolution compared to other districts in the state. The cultivators are dominated by marginal and small farmers. The sensitivity is very high due to the high demand for food and water melting at a speedy rate. This causes Lahaul and Spiti to become mainly a six-month natural cage due to heavy snowfall. In Lahaul's villages Lepchang (0.614), Stingiri (0.600) and Jobrang (0.599) have attained the lowest sensitivity in between three regions. In Udaipur's villages Kurched (0.594), Madgram (0.569) and Jholing (0.566) attained very high sensitivity in these three regions. Spiti's villages sensitivity is lower than Lahaul because of 365 days of connectivity. In villages, Marango Rangarik (0.701) had the highest and Tabo (0.338) the lowest sensitivity.

The adaptive capacity of a community regulates its susceptibility to hazards or disasters by adjusting exposure and sensitivity or responsiveness levels. Adaptive capacity includes socio-demographic profile, social system, migration and Livelihood strategies. Households of Spiti were more vulnerable to dangerous relief and the cold Himalayan winds have a negative effect on Spiti. The high number of children who were orphaned and the single-parent households in Udaipur limited its ability to

implement various adaptation strategies. On the other hand, Spiti had both high vulnerability and high adaptive capacity. Udaipur could be more vulnerable to the outcomes of climate change than Lahaul and Spiti when considering the existing state of health as well as the security of food and water. In comparison to Lahaul and Udaipur, Spiti showed a stronger potential for adaptation based on demography, livelihoods, and social networks.The values for the adaptive capacity dimensions are related to the descriptions of each surveyed village of three regions and have various irregularities of adaptive capacity in these regions. The Spiti households are moving towards nuclearization. This factor plays a significant role in the vulnerability of Spiti. Udaipur is the least vulnerable because it has more choices for livelihood. The adaptive capacity of Lahaul (0.366) and Udaipur (0.353) are almost the same. In the villages of Lahaul, Jobrang (0.599) had the highest and Darcho Sumda (0.220) the lowest adaptive capacity. The villages of Udaipur; Manrung (0.516) had the highest and Hinsa (0.297) attained the lowest. However, the adaptive capacity was far better in the Spiti region than in the two other desert regions. In the villages of Spiti, Tabo (0.590) attained the highest and Marango Rangarik (0.206) the lowest. Sheep, churi and goats were the most prominent livestock owned by households in this region. Among cattle, Churi (a cross breed between cow and yak) was the most common dairy animal, preferred by every household. Farmers keep yaks for ploughing, and the average milk yield of Churi is 1.5 to 2 killograms per day. To meet the main fodder needs, farmers utilized dry grass, straw, and leftover pea crops in the winter, while relying on indigenous legume varieties and wild willow branches during the summer months. The households of Lahaul, Udaipur, and Spiti reported high numbers of people migrating to Shimla, Manali, Chandigarh and Delhi for work, employment, education, marriages, etc.

Most households face a shortage of fodder during April-May. The emerging farm-based micro-enterprises have the potential to improve the socio-economic status and livelihood options in the district. Lahaul and Spiti authorities provide full subsidized food to more than 95% of households at the interval of 6 months.

5. CONCLUSION

This study calculated the THLVI and THLVI-IPCC as modified alternate methods for assessing the vulnerability of tribal communities of mountainous regions as an impact of climate variability. The approach provided a picture of the factors of tribal household livelihood vulnerability in a mountainous region. The overall vulnerability of this district is high. Natural factors have severely impacted tribal communities. Sensitive factors can be improved by the better adaptive capacity approaches. The exposure, capacity for adaptation, and sensitivity of district may change when adaptation techniques are implemented or are anticipated to be implemented in the future. This study's replication in the same place over time could give information on how these factors evolve. Further studies on this topic should focus on the refinement of the Migration and Health sub-components of THLVI to evaluate the challenges more accurately. In general, the THLVI could offer development planners a valuable instrument to assess the livelihood vulnerability impact of climate change on communities and it could be useful in developing resilience strategies for vulnerable social groups. Ultimately, it aims to help achieve the targets of Sustainable Development Goals (SDGs).

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Iğdır Merkez İlçesinde Hava Kalitesi Sorunu ve Yerleşim Uygunluk Analizi

Air Quality Issues and Settlement Suitability Analysis in Iğdır Central District

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ABSTRACT

Air pollution can be a concern during certain seasons, specifically in autumn and winter, in the city center of Iğdır owing to the city's geomorphological and climatological features. This study aims to examine the spatial and vertical distribution of air pollution in the atmosphere of the city center of Iğdır and identify suitable areas for urban settlement. The results revealed that areas with highest pollution levels were in the city center of Iğdır and in the plain area located north of the city. The geographical conditions, specifically in winter, limit convective air movements, cause inversion, and intensify air pollution. Height of the aerosol layer expresses the upper limit that pollutants can reach in the atmosphere. In the city center of Iğdır, height of the aerosol layer approximately 1000–1100 m, especially in winter. Furthermore, pollutants are trapped between 850 m, which is the average altitude of the city center of Iğdır, and these altitudes causes the pollution to be felt more intensely. A change in the city's settlement plan (horizontally) cannot address this issue in the longterm as the same air pollution problem will occur again. Thus, settlements should be established at least above 1000–1100 meters, which is the upper level of the aerosol layer in winter, to prevent this issue.

Keywords: Iğdır, Air Pollution, Settlement, Google Earth Engine

ÖZ

Hava kirliliği sorunu sanayi faaliyetleri olmasa dahi, jeomorfolojik ve klimatolojik özelliklere bağlı olarak belirli mevsimlerde sürekli hale gelebilmektedir. Iğdır merkez ilçesi özellikle sonbahar ve kış mevsimlerinde bu sorunun yaşanmasıyla gündeme gelmektedir. Bu sorunun çözümüne odaklanılan araştırmada, alan kapsamı Iğdır ili ve merkez ilçesi; konu kapsamı ise hava kirliliği ve şehir yerleşim uygunluğu ile sınırlandırılmıştır. Araştırmanın amacı, çalışma alanında hava kirliliğinin atmosferdeki alansal ve dikey dağılışını ortaya koyarak şehir yerleşimine uygun alanları tespit etmektir. Elde edilen sonuçlara göre, Iğdır merkez ilçesinde yerleşmelerin yoğun olduğu alan ve kuzeyindeki ovalık saha, kirliliğin en fazla olduğu yerlerdir. Alandaki coğrafi şartlar; özellikle kış mevsiminde konvektif hava hareketlerini sınırlandırarak inversiyon oluşumuna ve hava kirliliğinin daha yoğun hissedilmesine sebep olmaktadır. Gezegensel sınır tabakasının göstergelerinden biri olan aerosol tabakası yüksekliği, Iğdır merkez ilçesinde özellikle kış mevsiminde 1000-1100 m civarındadır. Kirleticilerin Iğdır merkez ilçesinin ortalama yükseltisi olan 850 m ile bu yükseltiler arasına sıkışmasıyla, alanda kirlilik daha yoğun hissedilmektedir. Şehir yerleşim planında yatay olarak yapılacak bir değişiklik, sahip olunan coğrafi özellikler sebebiyle uzun süreçte yine aynı hava kirliliği sorununun yaşanmasına sebep olacaktır. Bu nedenle olası bir plan değişikliğinde yerleşimlerin, en azından kirletici gazların kış mevsiminde ulaştığı üst seviye olan 1000-1100 m'nin üzerine kurulması aynı sorunların tekrar yaşanmamasını sağlayacaktır.

Anahtar kelimeler: Iğdır, Hava Kirliliği, Yerleşim, Google Earth Engine

EXTENDED ABSTRACT

Air pollution is a well-known factor that affects the natural atmosphere when its concentration reaches a certain level. Additionally, a national act, the Air Quality Assessment and Management Regulation, has been introduced to establish minimum levels for smoke, dust, gas, vapor, and aerosol concentrations in the air (URL 1; URL 2). According to a recent report (THHP, 2021), PM10, PM2.5, SO_2, O_3, and NO_2 values from 98% of 175 stations in Turkey were found to exceed the value (20 μg/m3) defined by the World Health Organization. Moreover, the air quality of some cities is more heavily influenced by urbanization, fossil fuel usage, and topographic and meteorological factors (Çiftçi et al., 2013). In Iğdır, geomorphological structures limit the horizontal movement of air parcels and create an inversion layer (Koç, 2018). However, there has been little quantitative analysis of air quality to guide urban growth in Iğdır. This study aims to address the lack of suitability analysis based on air quality and risk mapping in Iğdır. The suitability of urban growth will be analyzed using Google Earth Engine (GEE) data sets (NO_2, SO_2, CO, UV aerosol index [UVAI]), O_3, Formaldehyde (HCHO), and ABL [Aerosol Boundary Layer]) with the Best–Worst Method (BWM).

Iğdır city center is situated at an average altitude of 850 m. The Iğdır Province is depicted in Figure 1. The Iğdır Plain was formed by the Aras River through alluvial deposition. The prevailing wind direction is over the depression of the Iğdır Plain. Figure 3 shows the frequency of annual winds. The geomorphological structure of the city provides benefits in terms of climate and agriculture.

Data for NO_2, SO_2, CO, UVAI, O_3, HCHO, and ABL were obtained from Sentinel-5P TROPOMI (TROPOspheric monitoring instrument) in the GEE data collection. The data is collected by Landsat, MODIS, NOAA AVHRR, and ALOS remote sensing platforms (Amani et al., 2020). First, pollutant data was correlated to the city center via principal component analysis (PCA) to reveal risk fields. PCA is a linear analysis tool used to reduce a large raw data matrix to only its principal components (Tezbaşaran & Gelbal, 2018; Yi & Latch, 2022). Then, the pollutants were analyzed using one of the multivariate analysis techniques, the BWM. The BWM analysis indicated the suitability for urban growth. The closer the BWM result is to zero, the more reliable the data are (Badri Ahmadi et al., 2017).

The concentrations of six different pollutants were distributed throughout Iğdır. The concentration of NO_2 ranged between 0.0000125 and 0.000032 mol/m^2. Figure 4 shows that the concentration is higher in the northern region of the city center and lower in the southern region, where the elevation is higher. SO_2 production is typically caused by the use of fossil fuels, and the average concentration ranges between 0.0000219–0.000231 mol/m2 (Figure 4). High levels of SO_2 were observed in low-lying areas. The distribution of CO concentrations followed a similar pattern to that of NO_2 concentrations, with higher levels in the north and lower levels (0.0207–0.0316 mol/m^2) in areas with higher elevation (Figure 4). The city center of Iğdır had higher values of HCHO, while the rest of the region exhibited values between 0.0000708 and 0.000131 mol/m^2 (Figure 4). Although positive values of the aerosol index resulted in negative health effects, the area of interest did not show positive aerosol index values (−1.23, −0.488), as shown in Figure 4. Tropospheric ozone, which results from reactions with other pollutants in the atmosphere, exhibited a similar trend to NO_2 and CO, being lower at higher elevations. Its concentration ranged between 0.1362–0.1394 mol/m2 (Figure 4). Aerosol height varied between 934–3020 m (Figure 10). The plain region of Iğdır represents the lowest aerosol layer height (934–1240 m) . Moreover, the height of the aerosol layer defines the highest level of particles in the atmosphere. Low aerosol layer height increases the risk of pollution evolution. Gaseous pollutants were found to be at their maximum during the winter (Figure 11). The highest wind speed in the region is approximately 1.4 m/s. The lack of wind throughout the year increases the air pollution.

Despite its small population, Iğdır suffers greatly from air pollution. The study shows that the city center and northern part of the plain are affected by pollution the most. Furthermore, height of the aerosol layer indicates the atmospheric vertical boundary for the pollutants. Thus, high pressure (917.8 hPa) in the atmosphere causes the pollutants to accumulate in the plain region. Due to the low temperatures (annual average is 12.2°C and lowest is −3.3°C), an inversion layer forms, thus limiting the movement of pollutants in the region. The air pollution risk map shows the highest risk in the northern part of the plain (Figure 13).

Based on this analysis, it can be inferred that a suitable urban growth area can be selected within the altitude range of 1000 to 1500 meters, as depicted in Figure 14. It is recommended that the settlement be located above the highest measured altitude for inversion and the aerosol layer, which is at 1100 meters (as shown in Figure 15).

1. GİRİŞ

Hava kirliliği, atmosferin doğal yapısını değiştirebilen gaz, partikül vb maddelerin canlı ve cansız varlıkları olumsuz etkileyecek düzeyde bulunmasını ifade eder. Volkanik patlamalar, toz fırtınaları hava kirliliğinin doğal nedenlerindendir. Kentleşme, fosil yakıt kullanımı ve sanayileşme ise insan kaynaklı nedenlere örnek verilebilir. Hava kirliliği, yeryüzünü küresel çapta tehdit eden çevresel faktörlerin başında gelmektedir. Kirlilikten etkilenen birçok insan hayatını yitirmiş veya bu kirliliğe bağlı hastalıklar sebebiyle yaşam kalitesini kaybetmiştir (Argun vd., 2019; Atalay & Neslihanoğlu, 2021). Özellikle düşük veya orta gelirli ülkelerde kentleşme ve sanayileşmenin etkisiyle hava kalitesi genel olarak kötüleşmektedir (Koç & Koç, 2018; Sümer, 2014; WHO, 2021). Sağlıklı bir hava kalitesi için, kirletici yoğunluğunun canlı sağlığını olumsuz etkilemeye başladığı minimum seviyeyi tespit etmek önemlidir. Bu seviyeyi belirlemek amacıyla ulusal ve uluslararası platformlarda hava kalitesi sınır değerleri açıklanmaktadır. Örneğin Dünya Sağlık Örgütü'nün (DSÖ) 2005 yılı hava kalitesi kılavuzunda azot dioksit (NO_2) seviyesi 40 µg/m³ olarak belirlenmiştir (WHO, 2006). Bu değer 2021 yılında, 10 µg/m³ olarak güncellenmiştir (WHO, 2021). DSÖ'nün güncel kılavuzunda NO_2'nin yanında partikül madde 2.5 ve 10 ($PM_{2.5}$, PM_{10}), ozon (O_3), kükürt dioksit (SO_2) ve karbon monoksit (CO) konsantrasyonları için de sınır değerler verilmektedir (WHO, 2021). Benzer şekilde Türkiye de hava kalitesini iyileştirmek amacıyla, Hava Kalitesi Değerlendirme ve Yönetimi Yönetmeliği (HKDYY) yayınlamıştır. Bu yönetmelikte kirletici maddeler ve konsantrasyon değerleriyle ilgili minimum sınırlar bulunmaktadır (URL 1; URL 2).

DSÖ verileri, küresel nüfusun %99'unun kılavuzlarda belirtilen sınır değerleri aşan veya yüksek düzeyde kirletici içeren hava soluduğunu göstermektedir (WHO, 2021; URL 3). Türkiye'de ise Temiz Hava Hakkı Platformu (THHP), 175 istasyon özelinde bazı kirleticileri (PM_{10}, $PM_{2.5}$, SO_2, O_3 ve NO_2) kapsayan bir araştırma yapmıştır. Araştırma sonucunda; bu istasyonların %98'inde, özellikle yıllık PM_{10} değerinin DSÖ'nün belirlediği seviyenin (20 µg/m³) üstünde olduğu görülmüştür. Ayrıca çalışma kapsamında Türkiye'deki illerin yarısından fazlasının, HKDYY kapsamında ilan edilen ulusal sınırları aştığı tespit edilmiştir (THHP, 2021). 2021'de Türkiye, sadece yıllık $PM_{2.5}$ ortalaması dikkate alınarak yapılan bir araştırmada 117 ülke içerisinde, en fazla konsantrasyona sahip 46. ülke olmuştur. Avrupa ülkeleri dikkate alındığında ise 6. sırada yer almaktadır (IQAir, 2021).

Hava kirliliği; sahip olunan doğal ve beşeri özellikler sebebiyle bazı illerde daha yoğun yaşanır (Çiftçi vd., 2013). Kirletici konsantrasyonu bakımından diğerlerinden ayrılan illerin başında Iğdır gelmektedir. PM_{10}'da ilk üç ve O_3'te ilk sekiz il içerisinde yer alan Iğdır, 2016-2020 yılları arası PM_{10} ortalaması değerlendirildiğinde Türkiye'deki en kirli il konumundadır (THHP, 2021). Bununla birlikte 2021'de yıllık 66,2 µg/m³ $PM_{2.5}$ değeri ile Avrupa'da ilk sırada yer almıştır (IQAir, 2021).

Iğdır ili yüksek jeomorfolojik birimlerle çevrilidir. Bu topoğrafik yapı, yatay hava hareketlerini engellemekte, özellikle kış mevsiminde sıcaklık terselmesinin oluşumunu kolaylaştırmaktadır. Böylece sahada kirletici gaz yoğunluğu artış gösterir (Koç, 2018; Sahin vd., 2020). Yaşanılan bu durum doğrudan kirliliğin kaynağı olmasa da, kirleticilerin ortamda bulunma süresini ve miktarını etkiler. Bu koşullar Iğdır merkez ilçesinde; kirletici yoğunluklarının tespitini, sebeplerinin araştırılmasını, yatay ve dikey dağılışlarının belirlenmesini gerekli kılmıştır. Ayrıca literatürde Iğdır ili için bu coğrafi koşulların sebep olduğu sorunları içeren bir yerleşim uygunluk analizi bulunmamaktadır. Bu eksiklik, araştırmanın ortaya çıkmasına sebep olan motivasyonlardan biridir.

Araştırmada Iğdır merkez ilçesine ait NO_2, SO_2, CO, O_3, Ultraviyole Aerosol İndeksi (UVAI), Formaldehit (HCHO) ve Aerosol Tabakası Yüksekliği (ATY) haritaları ve bunların bileşimini içeren risk haritası oluşturulmuştur. Kirletici gaz özellikleri dikkate alındığında; NO_2 çoğunlukla fosil yakıt kullanımı, egzoz emisyonları, termik santraller ve sanayi faaliyetleri sonucunda oluşan bir gazdır. Kısa ve uzun sürelerde maruz kalınması halinde solunum yollarıyla ilgili sağlık problemlerine sebep olabilir (Castagna vd., 2022; Cindoruk, 2018). SO_2 evsel ve endüstriyel amaçla yakılan kömür, metal ergitme ve dizel yakıtlı taşıtların kullanımı sonucu ortaya çıkmaktadır. Renksiz, asidik ve keskin kokulu olan bu gaz; kanda çözünmesi ve solunum yollarını etkilemesi nedeniyle insan sağlığına zararlıdır (Akyürek vd., 2013; Argun vd., 2019). CO ise doğal yangın veya evsel karbon kaynaklı yakıtların yetersiz yanması sonucu açığa çıkan renksiz ve kokusuz bir gazdır. Akut ve kronik zehirlenmeye sebep olabilir (Eraybar vd., 2021; Mutlu, 2018). Emici Aerosol İndeksi (AAI) olarak da adlandırılan UV Aerosol İndeksi; atmosferdeki volkanik kül, toz ve duman gibi ultraviyole radyasyonu emen aerosollerin varlığını ölçen bir indekstir (Graaf vd., 2005; URL 4). O_3 uçucu organik bileşiklerin ve azot oksitlerin (NO_x) fotokimyasal oksidasyonu sonucu açığa çıkan ikincil bir kirleticidir. Maruz kalınması insan sağlığını olumsuz etkiler. Ayrıca plastik ve boya gibi maddelere

de zarar verebilir (Li vd., 2019; Özcan vd., 2008; Schultz vd., 1999). HCHO renksiz, keskin kokulu, toksik bir gazdır. Ahşap mobilya, döşeme ve boya gibi malzemelerin yapımı, kullanımı ve onarımıyla havaya karışmaktadır. Çoğunlukla sanayi faaliyetleriyle ortaya çıkar ve atmosferde girdiği reaksiyonlarla troposferik ozon oluşumuna sebep olur (Guo vd., 2021; Vazquez Santiago vd., 2021). Düşük konsantrasyonlarda dahi göz, burun, boğaz kızarıklığı veya deride tahrişe sebep olan HCHO, kanser riski de oluşturmaktadır (Wag vd., 2021; Zhang vd., 2020; Zorlu & Tıkansak Karadayı, 2020). Sağlık başta olmak üzere, birçok alanda oluşturduğu riskler sebebiyle bahsedilen bu kirleticiler araştırmaya dahil edilmiştir.

Araştırma kapsamında, Iğdır il geneli için kirletici faktörlerin dikkate alındığı yerleşim uygunluk analizi yapılmıştır. Uygunluk analizleri, kullanım için elverişli alanların tespitini amaçlamaktadır. Yer seçimi konusunda uygulanması özellikle 1980'lerden sonra artmıştır. Çok Kriterli Karar Verme Yöntemleri (ÇKKV) en yaygın olarak kullanılan analiz metotlarındandır (Aydoğdu & Bakırcı, 2021; Chen, 2014; Parry vd., 2018; Taşdemir & Kaya, 2015). Tarımsal alan, habitat uygunluk ve doğal afetlere karşı şehir gelişimi için yer seçimi gibi farklı amaçlarla kullanılmaktadır (Değerliyurt, 2014; Kazemi & Akinci, 2018; Ozsahin vd., 2022; Utami vd., 2021). Çalışmada ise ÇKKV yöntemlerinden biri olan Best-Worst Metodu (BWM) kirleticiler dikkate alınarak, doğru yerleşim alanlarını tespit etmek için uygulanmıştır. Kirletici gazlara ait veriler Google Earth Engine (GEE) veri setlerinden temin edilmiş, ArcMap 10.4 ortamında düzenlenen yükselti ve arazi kullanım verileri metoda dahil edilerek analiz gerçekleştirilmiştir.

Araştırmanın temel amacı, hava kirliliği konusunda Iğdır merkez ilçesinin maruz kaldığı tehlikeleri tespit etmek ve il genelinde yerleşime uygun alanları belirleyerek kalıcı bir çözüm önerisi sunmaktır.

2.1. MATERYAL VE METOT

2.1. Çalışma Alanı

Doğu Anadolu Bölgesi'nin Erzurum-Kars Bölümü'nde yer alan Iğdır ilinin kuzey ve kuzeydoğusunda Aras Nehri'nin oluşturduğu Ermenistan sınırı bulunur. Doğusunda Nahçıvan Özerk Cumhuriyeti, güneydoğusunda ise İran yer alır. Kuzeybatısında Kars ve güneybatısında Ağrı ili ile komşudur. Iğdır merkez ilçesinin batısında Tuzluca, doğusunda Karakoyunlu ve Aralık ilçeleri yer alır. Merkez ilçe yaklaşık olarak 39° 55′ kuzey enlemi ve 44° 02′ doğu boylamındadır (Şekil 1). Merkez

ilçenin kurulu olduğu alan, ortalama 850 m yükseltiye sahiptir. Yükselti, merkez ilçenin kuzeyindeki Iğdır Ovası'na ve güneydoğudaki ova uzantısına (Dil Ovası) doğru azalır. Güney ve batıdaki dağlık alanlara doğru ise artmaktadır. Büyük Ağrı Dağı (5137 m) sahanın en yüksek bölümünü oluşturur. Karasu-Aras Dağları, volkanik alanlara ek olarak araştırma sahasında engebeyi arttıran diğer önemli yükseltilerdir. Kızılca (2887 m), Durak (2811 m), Zor (3196 m), Köroğlu (2895 m) ve Pamuk (2639 m) Dağları bu dağ sırasının önemli yükseltileridir (Karaoğlu & Çelim, 2018; Kaya, 2015).
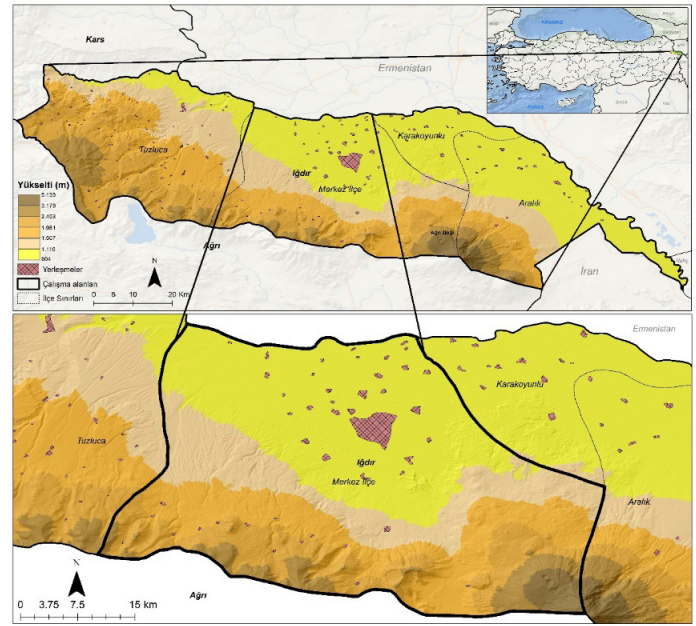
Şekil 1: Iğdır İli lokasyon haritası.
Figure 1: Iğdır Province location map.

Iğdır ilinin bulunduğu alan, Aras Nehri'nin oluşturduğu depresyonlardan biridir. Taşınan alüvyonlarla birlikte Iğdır Ovası oluşmuştur. Ovalık alan Batı Ova, Doğu Ova ve Dil Ovası olmak üzere üç faklı bölümden oluşur. Çöküntü alanına yerleşmiş bu ovalık saha, sınır ötesinde Ermenistan topraklarında da devam etmektedir. Sınır, ovalık alanı yaklaşık iki eşit parçaya böler. İl merkezi Batı Ova'nın güneyine kuruludur. Arazinin yer şekilleri genel olarak incelendiğinde; Iğdır ilinin, Aras Nehri'nin oluşturduğu KB-GD istikametinde uzanan bir depresyon içerisinde kurulu olduğu dikkat çekmektedir. Eğim %1-10 arasında değişir. Yükselti batıdan doğuya ve güneyden kuzeye doğru azalırken, ülke sınırları dışındaki dağlık alanlara doğru tekrar artmaktadır (Şekil 2). Sahip olunan bu jeomorfolojik yapı Iğdır iline iklim, tarım ürünleri gibi konularda avantaj sağlarken; araştırmaya konu olan hava kirliliğini de etkileyen temel unsurdur (Güçük vd., 2019; Kibar vd., 2014).
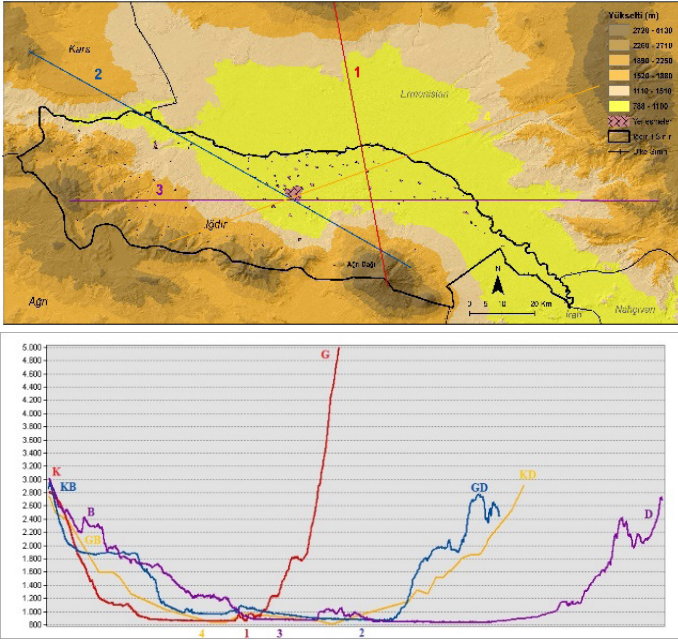
Şekil 2: Iğdır ilinin farklı uzanış yönlerine göre hazırlanmış yer şekli profilleri. (Tabandaki sayılar ilgili renkteki profil üzerinde şehir merkezinin bulunduğu yeri ifade etmektedir).

Figure 2: Landform profiles prepared according to different extension directions of Iğdır province. (The numbers on the base represent the location of the city center on the profile in the relevant color).

Iğdır ili jeomorfolojik özelliklerinin etkisine paralel olarak çevresine göre daha sıcak ve kurak bir makro klima iklime sahiptir. Komşu illerinden Kars'ta yıllık 4.7°C, Ağrı'da ise 6.2°C ortalama sıcaklıklar görülürken; Iğdır'ın yıllık ortalama sıcaklığı 12.2°C'dir. Yıllık toplam yağış tutarı, Kars'ta 506.8 mm, Ağrı'da 524.9 mm iken; Iğdır'ın toplam yağışı 259.9 mm'dir. Temmuz ayı ortalama sıcaklığı 25.9°C, ocak ayı ise -3.3°C'dir. En yağışlı ay 46.9 mm ile Mayıs, en kurak ay 9.8 mm ile Ağustostur. Haziran sonunda başlayan kurak iklim şartları eylül sonuna kadar devam etmektedir (Çelik vd., 2018; Karaoğlu, 2011; Yaltı & Aksu, 2019). Bozkır, araştırma sahasının ana bitki örtüsünü oluşturmaktadır. Meteoroloji Genel Müdürlüğü'nün (MGM*) uzun yıllar tüm parametreler* bültenine göre kış mevsimi, nispi nem oranının en yüksek olduğu zaman dilimidir. Bu mevsimde ortalama %69.8 olan nispi nem, aralık ayında en yüksek değere (% 71.8) ulaşmaktadır. Yıllık ortalama nispi nem değeri %59'dur. Kış mevsiminde daha yüksek basınç değerleri görülmekle birlikte yıllık ortalama değer 917.8 hPa'dır. Üzerine kurulu olduğu depresyon alanının uzanış doğrultusu olan KB-GD istikameti, aynı zamanda hâkim rüzgar yönünü oluşturmaktadır. Yıl içerisinde en fazla rüzgâr KB yönünden eser (Şekil 3). 1.2 m/s gibi düşük bir yıllık ortalama rüzgar hızına sahip Iğdır ilinde, ilkbahar ve yaz mevsiminde artan rüzgar hızı diğer mevsimlerde azalmaktadır. Hava kirliliğinin en yoğun şekilde hissedildiği kış mevsiminde 0.9 m/s olan rüzgar hızı, ilkbaharda 1.4 m/s ile maksimum hıza ulaşır.

2.2. Veri setleri ve yöntem
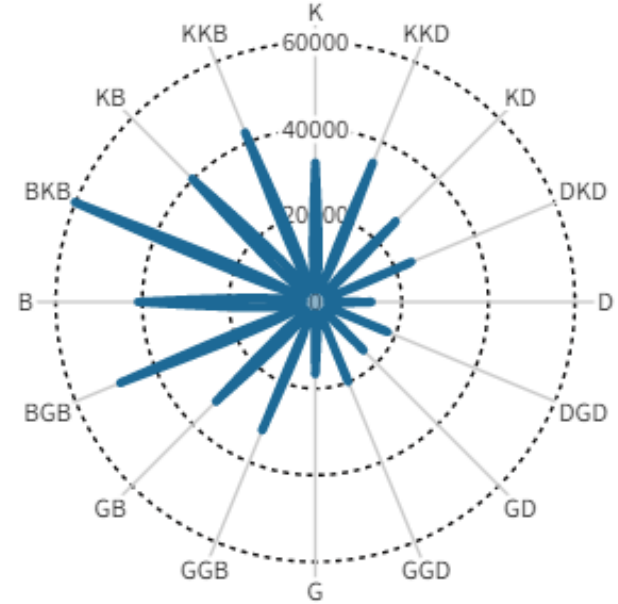
Şekil 3: Iğdır merkez ilçesi yıllık rüzgâr gülü diyagramı.
Figure 3: Annual wind rose diagram in Iğdır central district.

Araştırma kapsamında çeşitli uydu görüntülerinden elde edilen veriler analiz edilerek haritalanmıştır. Çalışmada kullanılan NO_2, SO_2, CO, UVAI, O_3, HCHO ve ATY verileri, GEE veri kataloğu Sentinel koleksiyonu içerisindeki Sentinel-5P TROPOMI'den (Tropospheric Monitoring Instrument) temin edilmiştir (URL 5). 2010 yılında tanıtılan Google Earth Engine (GEE), petabayt ölçeğinde büyük veri setlerini depolamak ve işlemek üzere tasarlanmış coğrafi veri işleme platformudur. GEE, bilimsel araştırmalar için veri teminini kolaylaştırmasının yanı sıra; hazır işlenmiş veri imkânı da sağlayan bir bulut bilişim programıdır. Bünyesinde sosyal, demografik, arazi kullanım, iklim, vejetasyon ve sayısal yükselti modeli gibi geniş kapsamlı veri türlerini barındırmaktadır. Bu veriler Landsat, MODIS, NOAA, AVHRR, ALOS gibi çeşitli uzaktan algılama platformlarını içerir (Amani vd., 2020; Mutanga & Kumar, 2019; Tamiminia vd., 2020). Sentinel-5P, Avrupa Birliği Uzay Ajansı'nın (European Space Agency/ ESA) yeryüzü gözlem programı olan Copernicus'un uydusudur. TROPOMI cihazı, Sentinel-5P'nin gaz konsantrasyonlarını ölçen çok bantlı sensörünü ifade eder (URL 6; URL7). Verilerin tamamı 1113.2 metre çözünürlükte olup, verilerden NO_2, SO_2, CO, HCHO gazları mol/m^2, ATY ise metre birimindedir. UVAI, ozon

absorbsiyonun çok az olduğu UV spektral aralığında gerçekleşen Rayleigh saçılmasındaki dalga boyuna bağlı değişikliklere dayalı olarak hesaplanır. Bu indeksin pozitif değeri ultraviyole emici aerosolün (UVAI) varlığını göstermektedir (URL8; URL 9; URL10; URL11; URL12; URL13; URL14;).

Araştırmada TROPOMI'den elde edilen veriler, Iğdır merkez ilçesi ve il genelinde kesilerek ArcMap 10.4 programında haritalanmıştır. Öncelikle merkez ilçe için düzenlenen veriler, Principal Component Analysis (PCA) yöntemi ile çakıştırılmış ve kirleticiler açısından riskli alanlar belirlenmiştir. PCA, yaygın olarak kullanılan çok değişkenli doğrusal analiz yöntemidir (Ersungur vd., 2007). Çok sayıda ham veri matrisini, birbirinden bağımsız olarak az sayıda anlamlı bileşene indirgemeye imkânı sağlar (Tezbaşaran & Gelbal, 2018; Yi & Latch, 2022). Gerçekleştirilen indirgeme sonucu yorum yapma imkânını artırırken, bilgi kaybını minimize etmesi bakımından da kullanışlı bir tekniktir (Jollife & Cadima, 2016). Araştırmada PCA, ArcMap programının *Principal Components* aracı kullanılarak uygulanmıştır. Sonrasında NO_2, SO_2, CO, UVAI, O_3, HCHO, ATY, arazi kullanım ve yükselti parametreleri kullanılarak Çok Kriterli Karar Verme (ÇKKV) yöntemlerinden biri olan Best-Worst Metodu (BWM) ile il ölçeğinde yerleşim uygunluk analizi yapılmıştır. Yöntem, en önemli ve en az öneme sahip parametrelerin uzman tarafından belirlenmesi ve bu iki kriterin diğer kriterlerle ikili karşılaştırmasına dayanır (Rezaei, 2015, 2016). Bu aşamada belirlenen 9 parametre içerisinden uzman görüşü ile ATY en iyi, arazi kullanım faktörü ise en kötü parametre olarak belirlenmiş ve parametreler ikili karşılaştırmaya tabi tutulmuştur. BWM'de tutarlılık oranı sıfıra ne kadar yakınsa, yapılan karşılaştırmalar aynı oranda güvenilir demektir (Badri Ahmadi vd., 2017). Yöntem sonucu tutarlılık oranı 0.091 olarak tespit edilmiştir. Sonuçta elde edilen ağırlık değerlerine göre uygun yerleşim alanları sınıflandırılarak haritalanmıştır.

3. BULGULAR

Araştırma sahasında uydu verilerine bağlı olarak hava kirliliğine sebep olan altı kirletici gaz incelenmiştir. Hazırlanan haritalarda kirletici yoğunluğunun en fazla olduğu alanların, ilin yer şekli uzanışı ve yükselti değerleri ile bağlantılı olduğu dikkat çekmektedir. KB-GD uzanışlı depresyon ve yükselti değerlerinin az olduğu alanlar, hava kirliliğin en yoğun hissedildiği sahalardır. Çalışma alanında yıllık NO_2 ortalama değerleri 0.0000125-0.000032 mol/m^2 arasında değişmektedir (Şekil 4). Daha çok trafik ve sanayi kaynaklı ortaya çıkan bu kirletici, merkez ilçenin kuzeyindeki ovalık alanda en yüksek değerlere sahipken, yükseltinin arttığı güney bölümde değerler azalmaktadır.

Çoğunlukla fosil yakıt kullanımı ve taşıt emisyonlarına bağlı olarak oluşan SO_2'nin araştırma sahasındaki yıllık ortalama değerleri 0.0000219-0.000231 mol/m^2 arasındadır (Şekil 4). SO_2 yoğunluğunun en fazla olduğu alanlar incelendiğinde, alçak ovalık alanlar ve dağ eteklerinin daha yüksek değerlere sahip olduğu görülür. Yükseltinin artışı kirletici yoğunluğunun azalmasında önemli bir etkendir. Hava kirliliğine sebep olan gazlardan biri olan CO'nun sahadaki konsantrasyon değerleri 0.0207-0.0316 mol/m^2 arasındadır (Şekil 4). Iğdır merkez ilçesinin kuzeyindeki depresyon alanı kirliliğin en yoğun olduğu bölgedir. Güneydeki dağlık sahalara doğru kirletici değerleri azalmaktadır. Araştırma sahasındaki HCHO değerleri 0.0000708-0.000131 mol/m^2 arasındadır (Şekil 4). Iğdır merkez ilçesinde yerleşmelerin yoğun olduğu arazi, değerlerin en yüksek seviyeye ulaştığı alandır. Literatürdeki ilgili çalışmalar da bahsedilen topoğrafya ve hava kirliliği arasındaki bu ilişkiyi takiben kirleticilerin merkez ilçenin yerleşmelerinde yoğunlaştığına dikkat çekmiştir (Argun, 2019; Güçük, 2019; Koç ve Koç, 2018; Şahin vd., 2020).

Aerosol indeksi troposferik ozon oluşumunun öncü bir göstergesidir. Artı değerler insan sağlığını olumsuz etkileyecek düzeyi ifade eder. Merkez ilçenin kurulu olduğu saha ve bu sahanın KB bölümü aerosol değerlerinin en yüksek olduğu alanlardır. İndeks değerleri -1.23, -0.488 arasında değişmektedir (Şekil 4). Merkez ilçenin tamamında artı indeks değerlerine rastlanmamaktadır. Troposferik ozon, diğer kirletici gazların atmosferde tepkimeye girmesiyle oluşan ikincil kirletici gazlardandır. Örneğin kara yolu trafiğinden kaynaklı (NO_x, uçucu organik bileşikler gibi) kirleticilerin, troposferik ozon oluşumuna sebep olduğu bilinmektedir (Yang vd., 2022). Diğer kirleticiler gibi hava kalitesini ve insan sağlığını olumsuz etkiler. Çalışma sahasında O_3 değerleri 0.1362-0.1394 mol/m^2 arasındadır (Şekil 4). Kirliliğin en yoğun yaşandığı alan merkez ilçenin kuzey bölümüdür. Güneydeki engebeli sahalara doğru O_3 değerleri azalmaktadır.

Çalışma alanına ait aerosol tabakası yüksekliği verileri incelendiğinde değerlerin 934-3020 m arasında değiştiği görülür (Şekil 5). Merkez ilçenin içerisinde bulunduğu depresyonun kuzey kısmını oluşturan ovalık alan, aerosol tabakası yüksekliğinin en düşük olduğu sahadır. Değerler burada 934-1240 m arasındadır. Bu saha, hava kirliliğinin de en yoğun şekilde hissedileceği noktadır. Merkez ilçenin ortalama yükseltisinin 850 m olduğu düşünüldüğünde, kirleticilerin yer yüzeyi ile yer yüzeyinden maksimum 300-400 m atmosfer yüksekliği arasında yoğunlaşacağı görülmektedir. Güneydeki dağlık alanlara doğru ise aerosol tabakası yüksekliği artmaktadır.
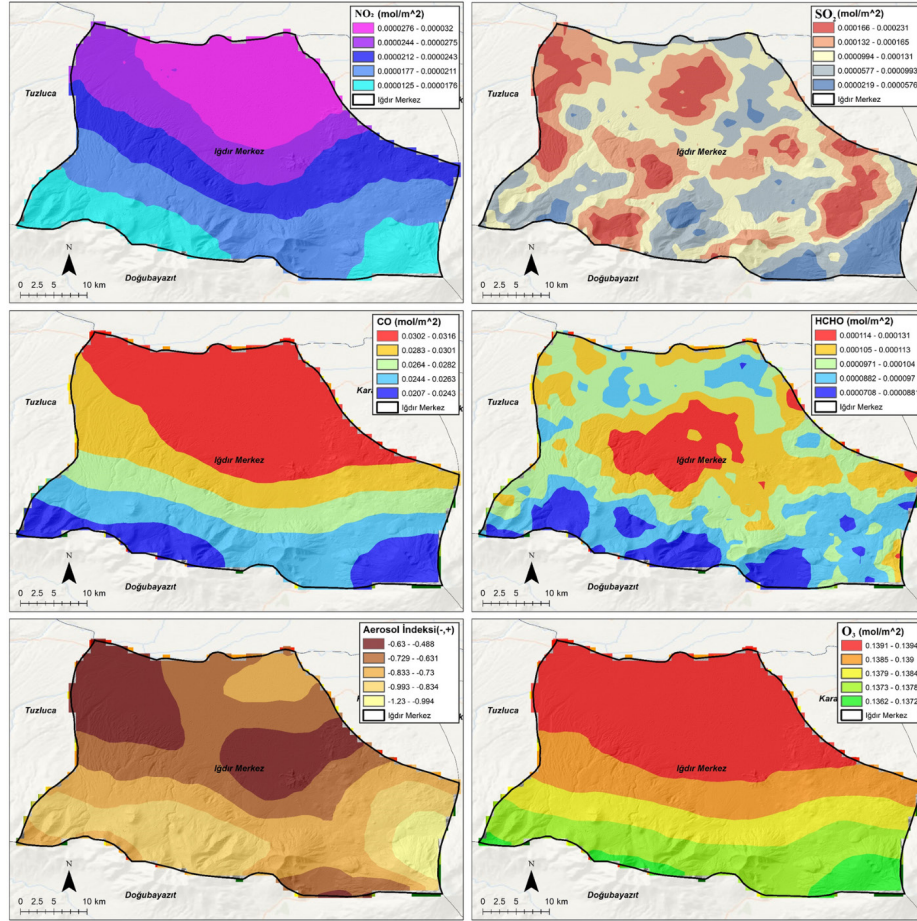
Şekil 4: Iğdır merkez ilçesine ait yıllık ortalama kirletici değerleri.
Figure 4: Annual average pollutant values of the central district of Iğdır.
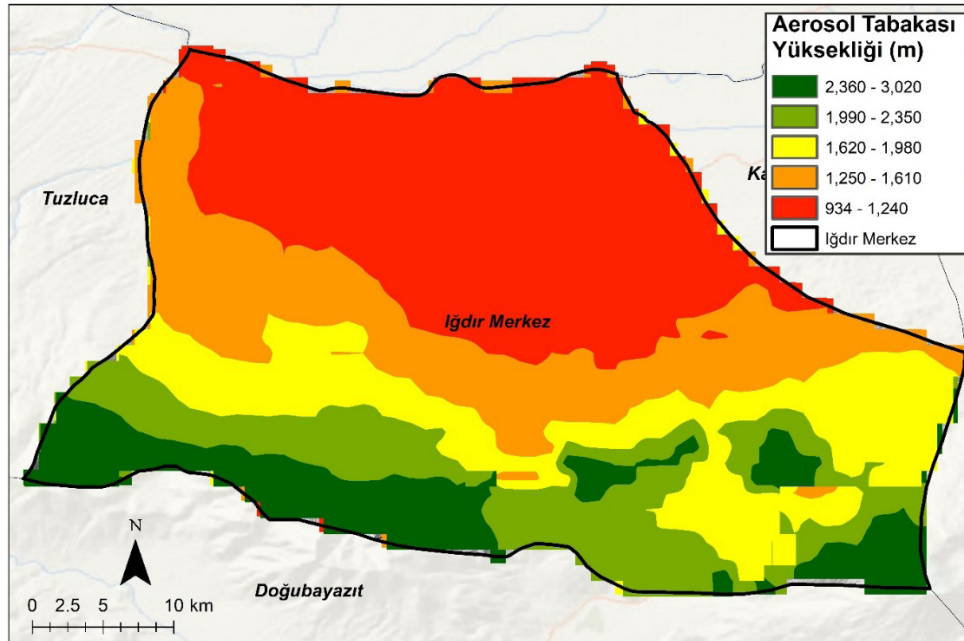
Şekil 5: Iğdır merkez ilçesine ait yıllık ortalama aerosol tabakası yüksekliği seviyeleri.
Figure 5: Annual average aerosol layer height levels of the central district of Iğdır.

Kirletici gazların yıl içindeki değişim miktarları incelendiğinde, literatürdeki çalışmaları destekleyecek şekilde (Altıkat, 2019; 2020; Koç ve Koç, 2018); NO_2, SO_2, O_3 ve CO'nun kış mevsimine ait aylarda maksimum seviyeye ulaştığı görülmektedir (Şekil 6). Sanayi faaliyetleri, ısınma ve trafikten kaynaklı emisyonların bu kirlilikte etkisi büyüktür. Ancak araştırma sahasının sahip olduğu coğrafi özellikler kirliliği oluşturan asıl etkendir. Çevresinde yükselti 5000 m'nin üzerine çıkmasına rağmen, Iğdır merkez ilçesi 850 m ortalama yükseltiye sahip bir depresyon içerisinde yer alır. Kış mevsiminde basınç ve nem değerleri en yüksek seviyeye ulaşır. Yüksek basınç ve nemlilik havayı daha kararlı hale getirerek kirleticilerin atmosferde yükselmesini, dolayısıyla kirliliğin azalmasını engeller. Yine kış mevsiminde sıcaklık ortalamalarının eksi değerlere düşmesi, yükselmeyi sağlayacak konvektif atmosfer hareketlerini sınırlandırır. Kış mevsiminde 0.9 m/s olan rüzgar hızı, en yüksek olduğu ilkbahar döneminde 1.4 m/s'dir. Iğdır merkez ilçesine ait ortalama rüzgâr hızı, Meteoroloji Genel Müdürlüğü'nün verilerinde yer alan Beaufort rüzgâr ölçeğine göre en yüksek değere sahip olduğu zaman diliminde bile esinti kategorisinde yer almaktadır. Bu durum da şehirde oluşan kirliliğin dağılışını engellemektedir. Sahip olunan iklimsel ve jeomorfolojik özellikler, özellikle kış mevsiminde oluşacak sıcaklık terselmesi (inversiyon) şartlarına zemin hazırlar. Merkez ilçeyi çevreleyen dağlık alanlarda aşırı soğuma sonucunda ağırlaşan soğuk hava, depresyon alanına doğru hareket edecektir. Oluşacak bu inversiyon durumunun, konvektif hareketlerin artacağı ilkbahar aylarına kadar sürmesi beklenir.

HCHO ve aerosol indeksi değerleri ise yaz mevsiminde daha yüksektir. Bu durum yaz mevsiminde yaşanan güneş enerjisi miktarındaki artış ve fotokimyasal süreçlerle alakalıdır. Çünkü HCHO doğal ya da antropojenik oluşumunun dışında, artan ultraviyole miktarına bağlı olarak yaşanan reaksiyon süreçleriyle de meydana gelmektedir.

Aerosol tabakası yüksekliği, hava kirliliği araştırmalarındaki en önemli parametrelerdendir. Bunun sebebi gezegensel sınır tabakası olarak ifade edilen, kirleticilerin atmosferde ulaşacağı yaklaşık üst sınırı göstermesidir. Araştırma sahasında aerosol tabakası yüksekliği, yaz aylarında konvektif hareketlere bağlı olarak 2000 m'yi aşsa da; yılın genelinde 900-1500 m arasında değişmektedir. Hava kirliliğinin daha yoğun hissedildiği kış mevsiminde ise üst sınır 1000-1100 m'lere kadar düşer (Şekil 7).
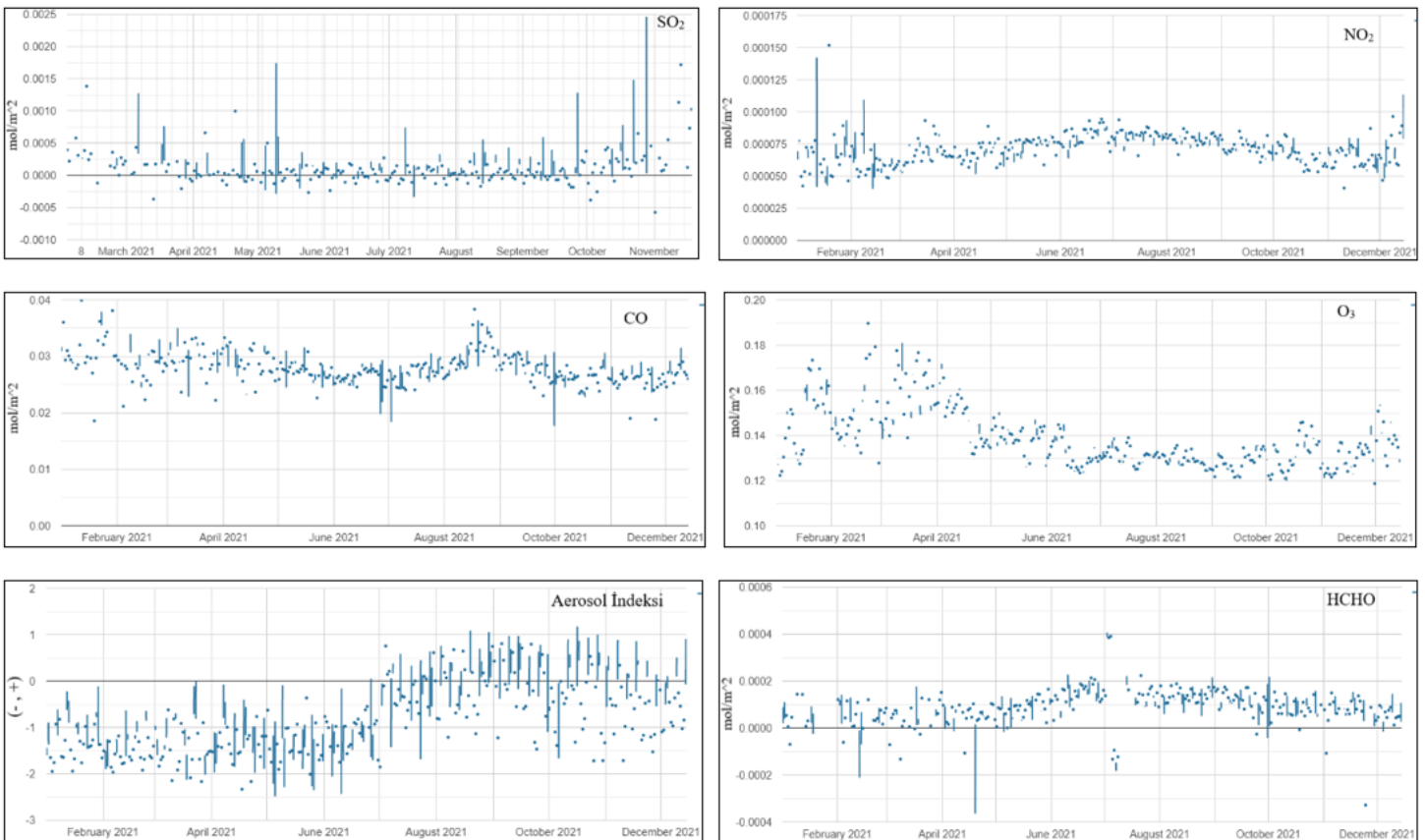
Şekil 6: Iğdır merkez ilçesinde kirletici gaz miktarlarının yıl içindeki değişimi.
Figure 6: Changes in polluting gas amounts in the central district of Iğdır during the year.
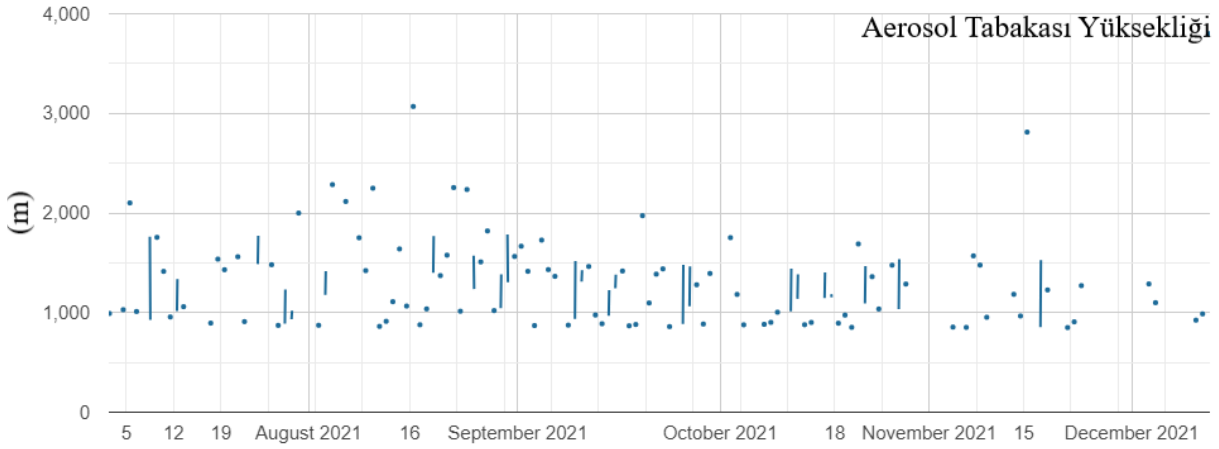
Şekil 7: Iğdır merkez ilçesinde aerosol tabakası yüksekliğinin yıl içindeki değişimi.
Figure 7: Change in aerosol layer height in the central district of Iğdır during the year.

4. SONUÇLAR

Hava kirliliği çoğunlukla insan faaliyetleri sonucunda oluşan ve süresi uzadığında sağlık açısından olumsuz durumların yaşanmasına sebep olan olaylardandır. Iğdır merkez ilçesi, nüfusu fazla olmamasına rağmen bu durumu sıkça yaşayan alanlardan biridir. Araştırma, hava kirliliği analizi ve şehir yerleşim uygunluk analizi olmak üzere iki parçadan oluşmaktadır. Hava kirliliği analizlerinde, Sentinel 5P Tropomi uydusuna ait NO₂, SO₂, CO, O₃, HCHO, aerosol indeksi ve aerosol tabakası yüksekliği verileri kullanılmıştır. Yapılan analizler sonucunda genel olarak merkez ilçede yerleşmelerin yoğun olduğu arazi ve bu alanın kuzeyindeki ovalık bölge kirliliğin en yoğun yaşandığı sahadır. Hazırlanan NO₂, CO, O₃, aerosol indeksi haritalarında bu durum açıkça gözlemlenmektedir. Yine bu haritalarda kirleticilerin mekânsal dağılışında, Iğdır ilinin içinde bulunduğu depresyonun uzanış şekli olan KB-GD yönü dikkat çekmektedir. Bu benzerlik sahada jeomorfolojik özellikler ve kirliliğin mekânsal dağılımı arasında bir ilişki olduğunu göstermektedir. Yani jeomorfolojik yapı kirleticilerin dağılımını yönlendirmektedir. Bu benzerliği kirleticilerin atmosferdeki dikey dağılışının yaklaşık üst sınırını gösteren aerosol tabakası yüksekliği haritasında da görmek mümkündür. HCHO ve SO₂'nin yüksek değerlere ulaştığı alanların dağılışı ise diğer kirleticilere göre daha homojendir.

Araştırma sahasında hava kirliliğini yönlendiren ikinci önemli etken, iklim elemanlarının sahip olduğu özellikler ve özellikle kış mevsiminde yaşanacak inversiyon şartlarına uygun yapıdır. Kuzeybatı, sahadaki hâkim rüzgâr yönüdür. Arazideki KB-GD yönlü uzanış şekli, normal şartlar altında rüzgârın kanalize olabileceği bir oluk oluşturmaktadır. Ancak Iğdır'da yıllık ortalama 1.2 m/s, kış mevsiminde 0.9 m/s ve ilkbaharda ise 1.4 m/s rüzgar hızı görülmektedir. Kış mevsimi en düşük, ilkbahar

ise en yüksek rüzgâr hızı ortalamasını ifade eder. Bu iki değer de düşük rüzgâr hızı anlamına gelmektedir. Beaufort sıkalasına göre esinti kategorisine karşılık gelir. Yani rüzgârın kirliliği dağıtıcı etkisi çok zayıftır. Bu durumu oluşturan etken ise depresyon alanına geniş ölçekte bakıldığında, sahanın hem Türkiye hem de Ermenistan tarafında yüksek dağlarla çevrili olmasıdır. Benzer şekilde sahanın sahip olduğu jeomorfolojik özellikler, iklim elemanlarından birine etki ederek hava kirliliğinin yaşanmasına sebep olmaktadır. Kış mevsiminde 917.8 hPa ile en yüksek basınç değerleri görülmektedir. Yüksek basınç şartları kirleticilerin atmosferde yükselerek seyrelmesini, dolayısıyla kirliliğin azalmasını engellemektedir. Kış mevsimi ve aylar içerisinde aralık ayı % 71.8 nispi nem oranıyla en nemli zaman dilimidir. Nemlilikte atmosfer kararlılığını arttırdığı için atmosferdeki dikey yükselişleri sınırlandırır. Yıllık ortalama sıcaklık 12.2 °C, kış mevsimi ortalama sıcaklığı ise -3.3 °C'dir. Bu sıcaklık ortalamaları da kirleticilerin dikey olarak yükselişini sağlayacak konvektif atmosfer hareketlerini tetiklemekten oldukça uzaktır. Özellikle kış aylarında araziyi çevreleyen yüksek dağlık alanlarda soğuyan havanın çökmesiyle meydana gelen inversiyon olayı, sınır tabakası yükseltisini azaltarak kirliliğin dağılmasını uzun süre engellemektedir. İnversiyonun oluşumunda da jeomorfolojik özellikler temel etkendir.

Hava kirliliğine sebep olan gaz yoğunluklarının yıl içerisindeki dağılışı incelendiğinde NO₂, SO₂, CO ve O₃ miktarlarının kış mevsiminde arttığı gözlemlenmektedir. Bu durum sınır tabakası yüksekliğinin azalmasına sebep olan iklim şartları ve inversiyon oluşumu ile alakalıdır. Nitekim sınır tabakasının yaklaşık üst sınırını gösteren aerosol tabakası yüksekliği konvektif hareketlerin arttığı yaz mevsiminde 2000 m'nin üzerine çıkarken, kış mevsiminde 1000 m'nin altına kadar düşmektedir. Bu durum da hava kirliliğinin daha yoğun yaşanmasına sebep olur. HCHO ve aerosol indeksi değerleri artan ultraviyole miktarına bağlı

olarak yaz mevsiminde yüksek değerlere ulaşmaktadır. Aerosol indeksi, yaz mevsiminde artı değerler gösterse de genel ortalamada insan sağlığını olumsuz etkileyecek miktara ulaşmamaktadır. Uydu verilerine bağlı olarak oluşturulan hava kirliliği risk haritasında en yüksek riske sahip olan alan, merkez ilçenin kuzey bölümünde yer alan ovalık sahadır (Şekil 8). Genel olarak topografik özellikler ve iklim elemanlarının yıl içerisinde gösterdiği değişimler, hava kirliliğinin araştırma sahasında yoğun olarak yaşanmasına sebep olan temel etkenlerdir.

Araştırmanın ikinci bölümünü oluşturan yerleşim uygunluk analizinde, sahaya ait hava kirliliği parametreleri ve jeomorfolojik özellikler kullanılmıştır. Yapılan analiz sonucunda kirliliğin en yoğun yaşandığı ovalık alan ve yükseltinin çok arttığı dağlık kesimler yerleşmeye uygun olmayan araziler olarak göze çarpar. Yerleşmeye en uygun alanlar ise topoğrafik olarak yaklaşık 1000-1500 m yükselti aralığına denk gelen sahalardır (Şekil 9). Bu sonuç yapılan hava kirliliği analizleri ve aerosol tabakası yüksekliği verileriyle örtüşmektedir. Şehrin yerleşim alanlarının ovanın farklı bölümlerine doğru kaydırılmasında şu sonuca dikkat edilmelidir: Sahanın coğrafi şartları, kirliliğin yeryüzü ile belirli yükseltiler arasında sıkışmasına sebep olmaktadır.

Ovalık alan üzerinde kurulacak her yerleşimin insan faaliyetlerine bağlı olarak açığa çıkaracağı gazlar, zamanla şu andaki yerleşim alanının yaşadığı kirlilik sorununu doğuracaktır.

Çünkü sahada yaşanan kirlilik, sahip olunan jeomorfolojik özellikler ve iklim elemanlarının yapısına bağlı olarak oluşmaktadır. Bu coğrafi etkenler; özellikle kış aylarında yaşanan inversiyon, gezegensel sınır tabakası ve aerosol tabakası yüksekliğini 1000-1100 m ile sınırlandırmaktadır (Şekil 10). Bu nedenle kirli hava kış mevsiminde, Iğdır merkez ilçesinin ortalama yükseltisi olan 850 m ile 1100 m arasında sıkışmaktadır. Olası bir şehir yerleşim planı değişikliğinde, yerleşim alanlarının en azından inversiyon ve aerosol tabakası yükseltisinin üst sınırı olan 1100 m üzerine kurulması sahip olunan coğrafi özelliklere daha uygun olacaktır.

Benzer bir durum yaklaşık B-D uzantılı bir depresyon içerisinde yer alan Karabük il merkezinde de görülmektedir. Önemli bir demir-çelik sanayi şehri olan Karabük, kış mevsiminde yaşanan inversiyon sebebiyle hava kirliliğini yoğun olarak yaşamaktadır. İnsanlar imkanları ölçüsünde yerleşmelerini yükseltinin daha fazla olduğu Safranbolu ilçesi yönüne taşıyarak hem kirlilik alanından mesafe olarak uzaklaşmakta hem de bu sayede inversiyon tabakasının üstüne çıkarak hava kirliliğine daha az maruz kalmaktadır.

Sonuç olarak, coğrafi şartlar belirli doğa olaylarının yaşanmasına sebep olur. Heyelan, deprem, sel gibi doğa olayları geçmişten günümüze sürekli yaşanmaktadır. Hava kirliliğini
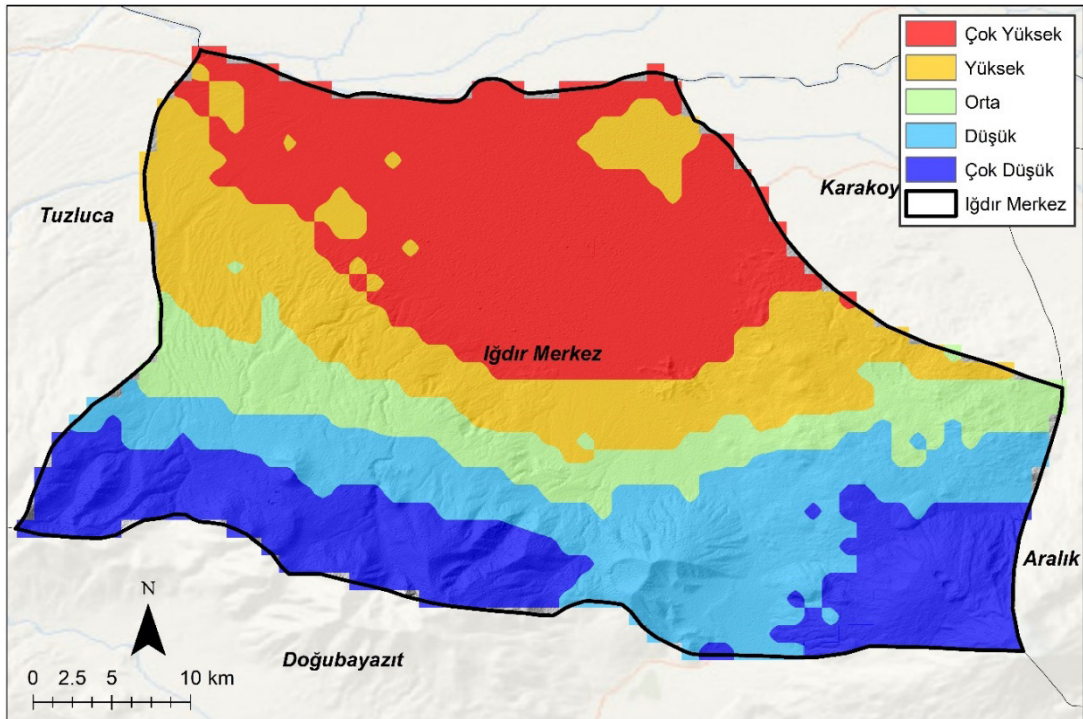
Şekil 8: Uydu verilerine bağlı olarak oluşturulan hava kirliliği risk haritası.
Figure 8: Air pollution risk map created based on satellite data.
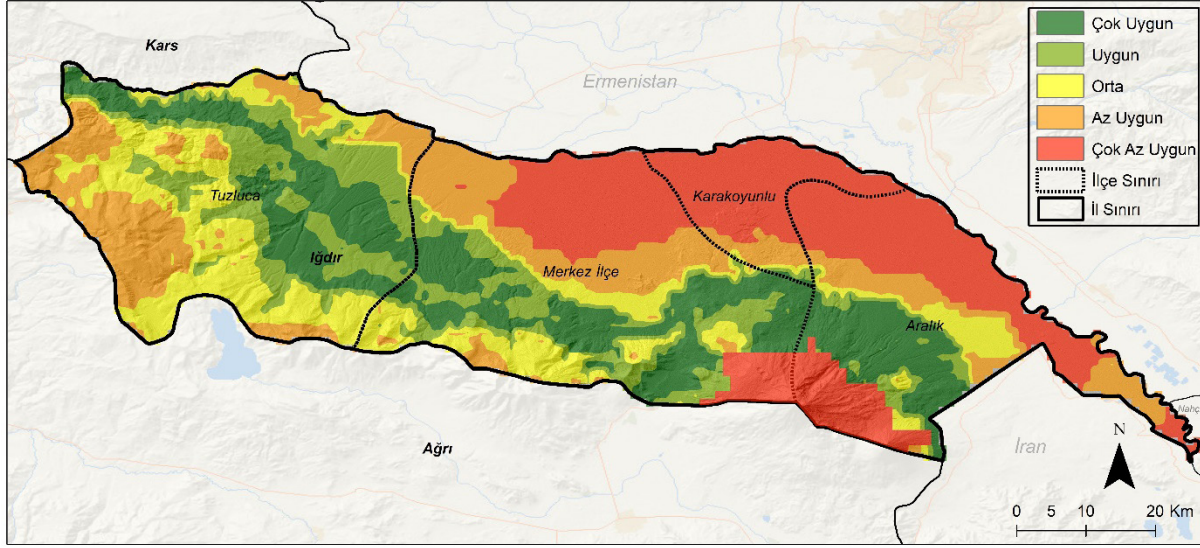
Şekil 9: Iğdır iline ait yerleşim uygunluk analizi.
Figure 9: Settlement suitability analysis of the province of Iğdır.
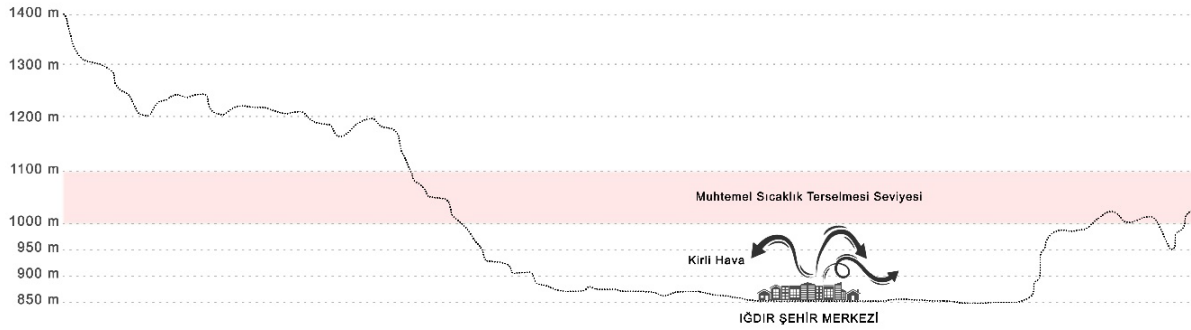
Şekil 10: Iğdır'da kış mevsiminde olası inversiyon ve aerosol tabakası yükseltisi üst sınırı.
Figure 10: The upper limit of possible inversion and aerosol layer elevation in Iğdır in winter.

yönlendiren inversiyon ve gezegensel sınır tabakasının oluşumu da bu doğal süreçlerdendir. Dikkat edilmesi gereken durum, yaşam ve faaliyet alanları belirlenirken coğrafi şartların oluşturacağı riskleri önceden tespit etmek ve en doğru şekilde davranmaktır.

5. TARTIŞMA VE ÖNERILER

Günümüzde nüfus artışına bağlı olarak, sanayileşmiş olsun ya da olmasın, şehirler özellikle kış aylarında hava kirliliği sorunu yaşamaktadır. Rüzgârlar yatay hava hareketleriyle, ısınmaya bağlı konvektif yükselimler ise dikey hava akımlarıyla hava kirliliğini azaltmaktadır. Ancak Iğdır ili gibi belirli jeomorfolojik ve klimatik özelliklere sahip alanlarda, kirliliğin azalmasını sağlayan bu doğal süreçler sekteye uğrayabilir. İnversiyon dikey hava akımlarını, yer şekilleri ise rüzgâr hızını ve yönünü etkileyerek hava kirliliğinin daha yoğun hissedilmesine

sebep olur. Yer istasyonu ölçümleri ve uydu gözlemleriyle hem hava kirliliğini oluşturan gazların hem de iklim elemanlarının takibi yapılabilmektedir. Hava kirliliği parametreleri ile iklim elemanlarının birlikte takibi, yaşanan sorunun sebeplerinin doğru teşhisine olanak sağlayacaktır. Özellikle uydu verileri geniş alanlarda noktasal ve alansal yoğunluk-dağılışın kısa sürede tespit edilmesine imkân tanır. Bu nedenle yapılacak her türlü araştırmaya daha fazla dahil edilmesi gerekmektedir. Bu veriler, yer istasyonu ölçümleriyle yapılan analiz ve çalışmalara doğruluk karşılaştırması imkânı da sunmaktadır. Bazı veri türlerinde bulutlu günlerin veri kaybına sebep olması, zaman aralıklarındaki sınırlılıklar, araştırmaları olumsuz etkilese de sağladığı geniş veri kütüphanesi problem yaşanan her alanda yapılacak bilimsel araştırmalara kaynak oluşturmaktadır.

Araştırmanın alan kapsamıyla ilgili literatür incelendiğinde (Altıkat, 2019), Iğdır ilinde meteorolojik verilerle ilişkili PM 10

karakteristikleri çalışmasında, bir yıllık süreçte meteorolojik parametrelerin PM 10 değişimleri üzerindeki etkisini mevsimsel olarak incelemiştir. Kış ve sonbaharda hava basıncı ve rüzgâr hızı, ilkbaharda nem ve rüzgar yönü, yaz mevsiminde rüzgar yönü ve rüzgar hızının PM 10 dağılışını en fazla etkileyen iklim elemanları olduğunu tespit etmiştir. Sonbahar ve kış mevsimlerinde PM 10 miktarlarının daha fazla olması araştırmanın diğer bulgularındandır. PM 10 miktarı ve diğer atmosfer kirleticileri arasındaki ilişkiyi incelediği diğer bir çalışmasında (Altıkat, 2020), Iğdır'da kış ve sonbaharın yine hava kirliliğinin en yoğun yaşandığı mevsimler olduğunu tespit etmiştir. NO_x, NO, NO_2 kirleticileri PM 10 ile en yüksek korelasyona sahip gazlardır. Bu iki çalışma araştırmanın hava kirliliğinin kış mevsiminde daha çok yaşanacağı, rüzgâr hızı, atmosfer basıncı gibi meteorolojik parametrelerin sahada yaşanan kirlilik üzerinde etkili olduğu bulgularını desteklemektedir. Güçük vd. 2019, Iğdır'da 2014-2019 yılları arasında saatlik PM 10 değişimini inceledikleri araştırmalarında topoğrafik ve meteorolojik özelliklerin PM 10 yoğunluğu üzerinde etkili olduğunu ve akşam saatlerinde yoğunlukta artışlar yaşandığını dile getirmişlerdir. Argun vd., 2019; Iğdır'da topoğrafya, iklim özellikleri, şehirleşme ve ulaşımın hava kirliliği üzerindeki etkisini incelemişlerdir. Kent yerleşiminin ovalık alan üzerinde yanlış bir yayılım gösterdiği, sanayi, ulaşım ve yerleşmelerden kaynaklanan hava kirliliğinin topoğrafik engellerden dolayı dağılamadığı, kış mevsiminde hava kirliliğinin inversiyon oluşumu sebebiyle en yüksek seviyeye ulaştığı, PM 10 düzeyinin ulusal sınır seviyesinin çok üzerinde olduğu, yıllık ortalama 1.2 m/s olan rüzgar hızının kirliliği dağıtacak seviyede güce sahip olmadığı araştırmanın önemli bulgularındandır. Koç ve Koç, 2018, Iğdır'da hava kirliliği ve iklim parametreleri arasındaki ilişkiyi inceledikleri çalışmalarında fosil yakıt kullanımına bağlı olarak artan SO_2 miktarı ve sıcaklık, rüzgâr hızı, rüzgâr yönü, nem arasındaki bağlantıları ortaya koymuşlardır. Araştırmaya göre, kış mevsimi hava kirliliğinin en yoğun yaşandığı zaman dilimidir. Topografik faktörler ve arazi kullanımı hem hava kirliliğini hem de iklim elemanlarını etkilemektedir. Iğdır'ın etrafı dağlarla çevrili bir depresyon içerisinde yer alması kirliliği artırmaktadır. Sıcaklıkların artmaya başladığı ilkbahar aylarıyla birlikte hava kirliliği azalmaktadır. Sıcaklık, bağıl nem ve hava basıncı partikül madde miktarı ile yakın ilişkilidir. Rüzgâr hızı ise kirliliğin dağılışında önemli bir faktördür. Ayrıca yerleşim alanlarında yapılan binaların rüzgâr hızını azalttığı için hava kirliliğinin artışına sebep olduğu dile getirilmektedir. Yapılacak binaların rüzgâr koridoru oluşturacak şekilde inşa edilmesi araştırmanın önerileri arasındadır.

Şahin vd., 2020, Iğdır'da hava kirliliği sorununu çok kriterli karar verme yöntemiyle ele aldıkları çalışmalarında; yer istasyonu verilerini kullanarak ilçeleriyle birlikte il merkezinin hava kalitesi özelliklerini değerlendirmişlerdir. Araştırmaya göre il merkezi kirliliğin en yoğun yaşandığı alandır. Sıcaklıkların azalışı kirliliği artırmaktadır. Ayrıca düşük rüzgâr hızı ve rüzgârın önüne engel oluşturan binalar kirliliğin alandan uzaklaşmasını olumsuz etkilemektedir. Koç ve Koç 2018, araştırmasında olduğu gibi bu araştırmada da bina yapımında rüzgâr geçişlerini sağlayacak koridorların oluşturulması önerilmektedir. Özellikle sisli ve durgun hava şartlarında aşırı nemli havanın SO_2'nin H_2SO_4'e dönüşmesine imkân sağlayacağı, bu durumun ise hava kalitesini daha da düşüreceği dile getirilmektedir. Alan yazındaki çalışmalar, genel olarak sanayi faaliyetleri ve yerleşmelerin oluşturduğu hava kirliliği üzerinde iklim şartlarının ve topoğrafyanın önemli etkisi olduğu üzerinde durmaktadır. Topografik şartların da iklim elemanlarını yönlendirdiği dile getirilmektedir. Şehir yerleşim planlarının topoğrafya ve iklim parametrelerine uygun olarak planlanması ortak öneriler içerisinde yer almaktadır. Literatürdeki önerilere ek olarak, özellikle kış mevsiminde yoğun hava kirliliğinin yaşandığı zaman dilimlerinde kirliliğe sebep olan kaynakların (üretim alanları, fosil yakıt kullanımı vb.) denetimli kullanımının sağlanması ve halkın bu konuda bilgilendirilmesi gerekmektedir. Risk düzeyinin yüksek olduğu yerleşim alanlarında ve özellikle yoğun kirliliğin yaşandığı günlerde önleyici sağlık tedbirlerinin alınması yaşanılacak sorunları azaltacaktır. Ayrıca doğalgaz kullanımının il genelinde teşvik edilerek, buna bağlı alt yapı çalışmalarıyla yaygınlaştırılması önerilmektedir.

Yapılan bu çalışma, coğrafi özellikler açısından alan yazındaki araştırmalarla bazı ortak bulgulara sahip olsa da; kirleticilerin atmosferdeki dikey dağılışının tahmini ve yerleşim alanlarının seçimi konularında literatüre fayda sağlayacaktır. İl genelinde yapılan yerleşim uygunluk analizi sonuçlarının, ilerleyen yıllarda yapılacak olası yerleşim planlamalarına katkı yapacağı düşünülmektedir.

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Bursa'da Bir Heterotopik Kaçış Mekânı: Kanalboyu*

A Heterotopian Escape Space in Bursa: Kanalboyu Street

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ABSTRACT

In this study, the development processes of Soğanlı, a suburb (a peripheral neigborhood) of the city of Bursa, and Kanalboyu Street, which is located between the Soğanlı, Çirişhane, and Çiftehavuzlar neighborhoods, were examined as a heterotopic place of escape, given that it corresponds to the concepts of heterotopia and escapism. In the first part of this article, the concept of heterotopia is examined; the heterotopia concepts of Michel Foucault and Henri Lefebvre and the third space mooted by Edward Soja and Kevin Hetherington's "counter-hegemonic spaces" are evaluated along with the critical views of several authors, and *halaza* as an original Turkish concept is highlighted. In addition, by examining the meanings that Yi-Fu Tuan attributed to the concept of escapism, it is argued that Kanalboyu Street is a breathing space for those attempting to escape from the oppressive atmosphere of the surrounding neighborhoods. Kanalboyu Street, the subject of our research, was considered a heterotopic escape place and was chosen as a case study. In the second part, the process of Kanalboyu Street's emergence, which is the subject of the research and was chosen as a sample for the heterotopic escape space, is examined. The process of being occupied by the suburb of Soğanlı, a village near Bursa City, and the current functional characteristics of Kanalboyu Street, which was formed by a stream passing through the village's land are described. While preparing the study, a descriptive survey model, a qualitative research method were used. The research data were obtained through a review of the relevant literature, long-term field observations, interviews, and mapping. The conclusion states that opening up a wide street in the unplanned and irregularly developed areas of cities can significantly improve the lives of residents.

Keywords: Heterotopic, Escapism, Bursa City, Kanalboyu Street

ÖZ

Bu çalışmada Bursa şehrinin bir kenar mahallesi olan Soğanlı'nın gelişim süreçleri ile bu mahalle ile Çirişhane ve Çiftehavuzlar mahalleleri arasında yer alan Kanalboyu'nun, heterotopya ve kaçış kavramlarına karşılık gelebilecek bir mekân olduğu düşünülmüş ve bu doğrultuda heterotopik bir kaçış mekânı olarak incelenmiştir. Yazımızın ilk bölümünde heterotopya kavramı üzerinde durulmuş, Michel Foucault'nun ve Henri Lefebvre'in heterotopya kavramlarıyla Edward Soja'nın üçüncü mekânı ve Kevin Hetherington'un, "karşı hegemonik alanlar"ı bazı yazarların eleştirel bakışlarıyla birlikte değerlendirilmiş ve Türkçe özgün bir kavram olarak "halaza"ya vurgu yapılmıştır. Ayrıca Yi-Fu Tuan'ın kaçış kavramına yüklediği anlamlar irdelenmiş ve bu açıdan Kanalboyu'nun çevre mahallelerin kasvetli atmosferinden kaçarak ferahlamaya çalışanların bir nefes alma alanı olduğu değerlendirilmiştir. İkinci bölümde, araştırmamıza konu olan ve heterotopik kaçış mekânı için bir örneklem olarak tercih edilmiş olan Kanalboyu'nun ortaya çıkış süreci incelenmiştir. Bursa şehrine yakın konumdaki bir köy olan Soğanlı'nın şehir tarafından kapılma süreçleri ve bu köyün arazisinden geçen bir dere kenarında şekillenen Kanalboyu'nun bugünkü işlevsel özellikleri tanımlanmıştır. Çalışma hazırlanırken nitel araştırma yöntemlerinden betimsel tarama modeli kullanılmıştır. Araştırma verileri ise nitel araştırma yöntemlerinden, literatür taraması ve sahada yapılan uzun süreli gözlem, görüşme ve haritalama çalışmaları ile elde edilmiştir. Sonuç bölümünde de şehirlerin plansız-düzensiz gelişmiş kesimlerinde geniş bir cadde açılmasının bu çevrede yaşayan insanların hayatlarını çok yönlü olarak kolaylaştırabileceğine dikkat çekilmiştir.

Anahtar kelimeler: Heterotopya, Kaçış, Bursa, Kanalboyu

EXTENDED ABSTRACT

Postmodernity is characterized by an emphasis on heterogeneity, uniqueness, and difference. Geography, which has studied spatial differences since its inception, also offers a postmodern perspective. Michel Foucault, a pioneer of postmodernism, favored the application of difference, fragmentation, and discontinuity, the use of multiple forms of analysis, micro-analysis interwoven with macro-analysis, and pure thought combined with precise historiography analysis. Foucault developed the concept of "heterotopia" by asserting that space has a heterogeneous structure. Various scholars have interpreted this concept differently, and some criticisms have been made. Heterotopia, which Foucault uses to describe the escape and emancipation of the body from the hegemonic order, is a place for those who do not readily adapt to predetermined structures. It offers alternative spaces in a society that lives in conformity. Within heterotopias, there are also contradictions and conflict. "Halaza spaces" that emerge and find the opportunity to develop in socially disordered environments that emerge with the loss of the effect of existing rules and norms during disintegration, transition, or rapid change, are also a form of heterotopia. They are independent and disconnected free spaces that develop outside the control of sovereign powers. They are highly reflexive, more resistant and durable, and always open to change and transformation because they do not develop under someone's control. reflexive

Soğanlı was a village located 5 km north of the city center of Bursa, and it was incorporated into the city in 1984 as a neighborhood. In 1935, Tabakhaneler Region settled on the land of Soğanlı village, and in 1938, the Sümerbank Merino Wool Industrial Weaving Factory was established. However, the expansion of the city toward the lands of this village began with the opening of the intercity bus terminal in 1961 at the location of the current Bursa City Square and the development of the automotive industry site in Gaziakdemir District. The Tuna, Çirişhane, and Fatih neighborhoods began to take shape with the unplanned urbanization that began in the 1970s with Küplüpınar and spread along the Yalova Road. With the development of Alemdar and Çiftehavuzlar in the 1980s, Soğanlı village became a part of the city, and in 1984, the remaining parts of the village were incorporated into the municipal boundaries. Our research focuses on Kanalboyu Street, which was developed from the mid-1970s to the 1990s along the Cilimboz Creek that flows through this village. Just after the construction was completed in 2009, hedge plants and trees were planted along the creek's walls, which were incorporated into the canal. Consequently, the creek in the middle of the street has been altered into a park. Neighborhoods on both sides of the street consist of houses on rather narrow, unpaved streets lined with irregular structures. When vehicles are parked on these narrow streets, it becomes impossible for both vehicles and pedestrians to move. On both sides of Kanalboyu Street, the population density in an area of 1 decare is 35 people per square meter. In other words, 55,000 individuals reside 500 meters east and west of the street. We can think of Kanalboyu Street, the part of the city that spontaneously developed in an irregular and unplanned manner—a spontaneously unplanned irregular heterotopic escape area—as a breathing space, a corridor for the people trapped in this congested section of the city.

In 21st-century urban areas, escaping reality requires shifting away from settled or everyday environments and moving closer to the outdoors and nature. Our research area, Kanalboyu Street, is where those who try to escape the mundanity and gloom of the surrounding neighborhoods come to rest and relax. Additionally, they can indeed find almost everything they need in the shops that line the street, and they can buy more cheaply, freely, and outdoors. Kanalboyu Street is not only a place to breathe, relax, and spend time but also marks the connection between the inhabitants of this neighborhood and the rest of the world. In other words, the most important function of Kanalboyu Street is that it serves as a transportation corridor, allowing residents to access nearly all parts of the city. Another key function of Kanalboyu Street is that, as a commercial area, it meets nearly all the needs of a medium-sized city and provides shopping opportunities, as nearly all types of commerce and workplaces are located along the street. Moreover, cultural and health functions are provided by educational and medical institutions and workplaces located on and around the street. When analyzing the functional characteristics of Kanalboyu Street, we find that, despite its location on the periphery of a big city such as Bursa, its business and commercial areas can meet nearly all the basic needs of the surrounding population, as if it were the center of an independent settlement. This situation reveals a heterotopic structure in which a significant element of the city's functions is carried out outside the central business district.

In the neighborhoods on both sides of Kanalboyu Street, there is a heterogeneous population consisting of the residents of the old Soğanlı village, the majority of whom are from Bursa districts, and those from almost every other region of the country, particularly the Balkans, Eastern Anatolia, and the Black Sea provinces. It is possible to draw important inferences about the identity, culture, and ties of

the places where these people originated based on the place names constructed by people from various locations. From this perspective, examining the names of Kanalboyu Street's workplaces affords highly meaningful results.

With the expansion of Bursa City toward the plain, Kanalboyu Street, formed by unplanned irregular construction along the Cilimboz Creek, which joins the Nilüfer Stream, is an alternative space that shares the functions of the central business district. It is a place of sanctuary for those who feel stressed by the city's irregular and extremely narrow streets, its unplanned development, and its haphazard buildings. It also serves as a highly active transportation corridor and a significant entertainment district for locals. With these characteristics, the area has emerged as a heterotopic escape territory.

1. GİRİŞ

Coğrafya, insanın içinde yaşadığı doğal ve kültürel ortamı bir bütün halinde inceleyen, mekânlar arasındaki benzerlik ve farklılıkları ortaya koyan bir bilim dalıdır. Fakat mekânlar arasında benzerliklerden ziyade farklılıklar ön plana çıkmaktadır. Yani coğrafyanın asli görevi mekânsal farklılıkları oluşturan ögeleri bulup ortaya çıkartmak, onları tanımlamak ve tanıtmaktır. Postmodern bilgi farklılıklara karşı duyarlılığı artırmıştır. Postmodernliğin temel özelliklerinden birisi, heterojenlik, biriciklik ve farklılık üzerindeki vurgusudur. Coğrafyada eskiden beri hep önemli olan "alansal farklılık" bu bilim dalının baştan beri postmodern bir anlayışa sahip olduğunu göstermektedir.

Postmodern düşünürler, geleneksel sosyal bilimlerin "toptanlaştırıcı" tavırlarına, her şeyi bütünleştirme arzularına karşı çıkarlar. Farklılık anlayışı üzerinde odaklaşan postmodernizm, toplumsal yaşamın "küresel bütünlük" sergilediği düşüncesini reddeder ve birbirine bağımlılığı yadsımamakla birlikte, günlük yaşamımızın otomatik bir şekilde yönlendirilmesine de karşıdır. Postmodernizmin öncüsü kabul edilen Michel Foucault (1926-1984) tüm çalışma hayatı boyunca, baskıcı, düşünceyi totaliterleştirici olarak gördüğü modernleşmeye düşmanca bir tavır almış, *"farklılığı, parçalanmışlığı ve kesikliliği, tek başına olan gerçeklerden daha çok, çoklu çözümleme biçimlerini, makro-çözümlemeyle örülmüş mikro-çözümlemeleri, kesin tarihsel incelemelerle karışmış saf düşünceyi"* tercih etmiştir (Peet, 1998'e atfen Özgüç-Tümertekin, 2010: 320). Kısacası Foucault, araştırmaya tabandan yaklaşımı yani, –günlük yaşam ve yerel algılar üzerinde odaklaşmayı– desteklemiştir. Michel Foucault, 1967'de Tunus'ta "Des Espaces Autres" (Öteki Mekânlara Dair) başlıklı konferansta sunduğu, ancak öldüğü yıl olan 1984'te yayınlanan yazısında, *"İçinde yaşadığımız, bizi kendi dışımıza çeken, özellikle yaşamımızın, zamanımızın ve tarihimizin erozyona uğradığı mekân, bizi kemiren ve aşındıran bu mekân, heterojen bir mekândır."* (Foucault, 2014: 294) diyerek mekânın heterojen bir yapısı olduğunu vurgulamış ve 'heterotopya' kavramını geliştirerek bunu altı temel ilkeye dayandırmıştır. Foucault'un heterotopya yaklaşımı pek çok araştırmaya konu olmuş ve üzerinde çeşitli tartışmalar yaşanmıştır. Bu araştırmada heterotopya kavramı, örneklem olarak belirlenen araştırma alanı özelinde yorumlanarak elde edilen sonuçlar ortaya konulmuştur.

1.1.Farklılığın Yeri: Heterotopya

Heterotopya, antik Yunancada *diğer*, *farklı*, *öteki* anlamına gelen "hetero" ile *yerler* anlamına gelen "topia" kelimelerinin birleşiminden oluşmakta ve "farklı yerler", "öteki yerler", "diğer yerler", anlamına gelmektedir. Heterotopya aslında çoğul bir isimdir, fakat pek çok kaynakta tekil bir isim olarak kullanılmaktadır. Daha bilindik olan ütopya ve distopya tanımı üzerinden yaklaşacak olursak, ütopya her şeyin iyi ve ideal olduğu; distopya her şeyin kötü olduğu; heterotopya ise şeylerin farklı olduğu yer anlamına gelmektedir (Çavdar, 2018). Aynı kökenden türeyen heterotopi ise tıbbi alanda kullanılmakta ve bir doku ya da organın olması gereken yerin dışında bir yerde ortaya çıkması durumunu ifade etmektedir. Yani, özgün yerinde olmayan dokular için kullanılır. Nedeni bilinmeyen bu aykırılıklar bir bozulmuşluğa ya da işlemeyen bir yapıya yol açmadığı gibi, bedenin işleyişini de bozmaz (Sohn, 2008). Fakat Michel Foucault heterotopyaları, toplumsal dünyanın bir kısmının var olandan değişik bir "O" biçimde düzenlendiği; bu farklı düzenlemenin onlara öteki imi yüklediği yerler olarak tanımlar. Foucault'a göre heterotopya, hiçbir kategoriye uymayan, gündelik hayatın askıya alındığı, ayrıksı yerlerdir ve bir yerde konumlansalar bile gerçek bir yerleri yoktur. Bütün tekinsiz kategorileri bir arada barındırırlar ve toplumların ürettiği ama asla çözemediği çelişkileri ortaya sererler. Heterotopyalar rahatsız edicidirler; dilin altını gizlice oyarlar (Foucault, 1984). Foucault, heterotopya kavramını daha tanımlı kılmak adına heterotopyaların bazı değişkenlerini, özet olarak ortaya koymakta ve heterotopyaların ayırıcı niteliklerine ilişkin olan değişkenleri altı başlıkta toplamaktadır. Foucault'nun heterotopya için belirlediği bu altı ilkeden üçüncüsü, birbiriyle bağdaşmayan çok çeşitli alan ve mekânların örtüştürülmesiyle bir şekilde düzenleri değiştiren tek ve gerçek mekân oluşturma, altıncısı ise işlevsel olarak toplumdaki diğer alanlarla yakından ilişkili olmaktır (Foucault, 2014). Bu iki ilkede ifade edilen nitelikler bizim incelediğimiz alana daha uygundur. Fakat Foucault'nun heterotopik mekânları var olan düzen ile çatışan mekânlar olsalar da, içinde eylemsellik barındırmayan durağan mekânlardır. Bizim incelediğimiz mekân ise gündelik hayatın akışkanlığı içinde hareketli ve değişim-dönüşüm içindeki yerlerdendir.

Foucault heterotopya kavramıyla, hâlihazırda var olan toplumsal süreçlerle teması, içindeyken ötekilik, başkalık ve dolayısıyla alternatiflerin bulunabileceği mekânsal üretimler sunmaktadır. Heterotopya, farklı yerleri, kültürde bulunabilecek gerçek mekânların ve diğer tüm gerçek mekânların aynı anda temsil edildiği, tartışıldığı ve tersine çevrildiği, etkin bir şekilde yasallaştırılmış bir tür ütopyayı temsil eder. Ancak Foucault'nun heterotopyaları, egemen güçlerin "planlı/düzenli" müdahalesinin sonucunda düzen dışı kalmış mekânları kapsar. Toplumsal mekânın düzenini bozan, disiplin dışında kalan bu yerler, farklılığın mekânını, ötekinin alanını, yine egemen güçler

tarafından belirlenen sınırlar içinde tanımlar (Stavrides 2016: 151). Foucault'ya göre bu tür mekânların tarihi bize mekânsal biçimlerin radikal anlamda farklı toplumsal süreçlerle nasıl ve hangi yollardan ilişkilendiğini; bunların toplumun ve onun ütopik panzehirlerinin tipik olarak tutunduğu bağdaşıklığını nasıl bozduğunu gösterir (Harvey, 2008: 227). Dolayısıyla bireyi hayal gücünden yoksun bırakan her türlü önceden belirlenmiş kalıp ve yapının karşısında ötekilik, başkalık ve farklılığın düşünsel ve biçimsel olarak farkındalık yarattığı her durumda heterojen mekânların bir temsili olarak heterotopya toplumsal süreçleri mekânsal biçimlerde dönüştürme mantığı ile oluşturulmuştur. Bu "farklı şey"in bilinçli bir plandan doğmuş olması şart değildir; insanların salt yapıp ettikleri, hissettikleri, duyumsadıkları ve gündelik yaşamlarındaki anlam arayışının parçası olarak ifade ettikleri şeylerden doğar. Bu tür pratikler her yerde heterotopik mekânlar üretir (Harvey, 2013: 38).

Foucault'nun heterotopyayı sadece kurumsal baskı mekânları içerisinde incelemiş olduğunu, ancak, coğrafi bir hassasiyetle heterotopya kavramının genelleştirilmesi için, kentsel diyalektik içerisinde incelenmesi gerektiğini savunan Harvey, Foucault'nun heterotopyalarını durağan ve kısır olarak değerlendirir. Ona göre, Foucault sadece örgütlenmiş kurumsal baskının mekânları üzerinde yoğunlaşarak, ileri sürdüğü görüşün genellenebilirliğini zayıflatır (Harvey, 1997). Bu noktadan hareketle Henri Lefebvre'in alternatif heterotopya kavramını öncüller. Lefebvre heterotopyaları farklılığın, kuralsızlık durumunun, potansiyel dönüşüm süreçlerinin mekânı olarak görür, onları diyalektik bir şehirleşme düşüncesinin içine yerleştirir. Lefebvre'deki heterotopi tanımı ile tıpta kullanılan "heterotopi" terimi arasında bir benzerlik bulunduğu savunulabilir. Olağan düzenin dışında, tipik olmayan yerleşim anlamına gelir. Bu tanım Foucault'dan çok, Lefebvre'in tanımına yakındır. Foucault'nun anlayışındaki "heterotopya" bir "yerinden olmuşluk"tan (dislocation) çok "konumsuzluk" (no-location) tarifler; hatta ötekinin istenmeyen konumlanışı hâkimdir; bu biçim tabanlı değil, içerik tabanlı bir durumdur. Hâlbuki Lefebvre'in heterotopi kavramı tamamıyla bir yerinden olmuşluk durumuna denk düşer; planlanmış olanın ötesine geçen, olaysallık barındıran mekânsallaşmadır (Çavdar 2018: 947). Lefebvre'e göre şehirsellik bir sistem değildir. Çünkü biçim ve içerik birbirinden bağımsız hareket eder. Şehirsellik ne bir sistem ne bir nesne ne de bir öznedir; Lefebvre için şehirsellik, sadece merkezilik ve çok-merkezilik tarafından kurulan bir biçimdir. Şehirsel biçim içerisinde "içerik" diyalektik olarak yer alır. Bununla birlikte şehirselliğin biçimi bir şekle

sahip değildir, o biçimsizdir, çünkü sonsuzdur (Lefebvre, 2003: 119). Heterotopi de biçimsizdir, çünkü potansiyel olarak değişebilir karakterdedir. Heterotopi, tek bir biçime sahip olmaktan ziyade bir akışkanlığı tarif eder; ötekiliğin ve farklılığın şehirselliğe sızma eğiliminde ve akışkanlık içerisinde bir devinime sahip olduğunu belirtmek gerekir. Ayrıca Foucault heterotopyaları ütopyalar ile karşılaştırırken Lefebvre "izotopi" ile karşılaştırır. Lefebvre'nin izotopi olarak bahsettiği mekânlar, aynı olanın, yakın düzenin mekânlarıdır. İzotopik mekânlar, egemen ideolojinin işlemesine ve gelişmesine izin veren "tahakküm mekanizmaları" olarak kullanılan alanlardır. Heterotopiler ise hem dışlanmış hem de iç içe girmiş olan, öteki yer ve ötekinin yeri, uzaklardaki düzendir. Heterotopi, ötekinin yeridir, farklılık ve çoğulluktur; tıpkı şehirsel yaşam gibidir. Kamusal yaşamın dışında değildir, şehrin yapısına karışmıştır (Lefebvre, 2003: 37-38). Lefebvre bu tür alanlara örnek olarak parkları, meydanları ve kavşakları verir, Hâlbuki Foucault'nun örnekleri; hapishaneler, huzurevleri, müzeler, kütüphaneler, mezarlıklar… dır. Lefebvre, heterotopiyi şehir hayatının sıradan, gündelik rutiniyle harmanlar. Ona göre heterotopi, bir nevi "anomi"dir.[1] Anomik gruplar, heterotopik mekânları şekillendirirler, gündelik ve sıradan görünenin ardında bu mekânlar aracılığıyla ani ve hızlı değişimler yaratabilirler (Lefebvre, 2014: 123). Bu mekânlar, metadan arındırılmıştır, onu üreten failler tarafından yaşamın yeniden üretimi için sahiplenilmiştir. Bu çalışma, Foucault'nun disiplin toplumuna ve mekânlarına sıkıştırdığı heterotopyayı şehirsel gündelik yaşamın içine katmaya çalışan Lefebvre'in heterotopisinin daha iyi anlaşılmasını sağlayacak bir vaka sunumudur.

Ötekileştirme için üçüncüleştirme kavramına vurgu yapan Edward Soja, Foucault'nun heterotopyasını, kendi üçüncü mekân formülasyonunda, Foucaultcu yaklaşıma kesinlik ve tanım getirmenin bir yolu olarak tartışır. Soja'nın üçüncü mekân (thirdspace) anlayışı, Lefebvre'in mekân üçlemesinin (spatial triad) ve Foucault'nun heterotopya kavramın güncellenmiş şeklidir de denebilir. Soja'nın birinci mekân ile ifade ettiği, genellikle coğrafyacıların daha çok maddi ögeler ile ifade ettikleri mekâna karşılık gelir. Bir anlamda Lefebvre'in mekânsal pratik dediği, maddileşmiş ilişki ve uygulamalar birinci mekâna karşılıktır. Yani şehir hayatının haritalandırılabilir alanı içindeki biçim ve ögeleridir. İkinci mekân ise, mekân hakkındaki fikir ve düşüncelere, yani Lefebvre'in mekânın temsilleri ve temsilin mekânları olarak adlandırdığı soyutlamaya karşılık düşer. Buna göre şehirsel mekân, mekân hakkındaki zihinsel haritaya, yani

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[1] **Anomi**, dağılma, geçiş veya hızlı değişme dönemlerinde mevcut kural ve normların etkisini kaybetmesi ile toplumu kucaklayan yeni kural ve normların ortaya çıkmaması yüzünden meydana gelen boşluk, kuralsızlık, normsuzluk, kanunsuzluk. Yani, hangi normu izleyeceklerini bilemez hale gelen bireylerin bütünleşmelerini giderek imkânsızlaştıran bir toplumsal düzensizlik ortamıdır (Tolan, 1981).

şehir imgesine karşılık gelir. Soja'nın üçüncü mekân anlayışı ilk ikisini içine alan bir yöntemin sonucudur. Kendi ifadesiyle, *"... birinci ve ikinci mekâncı bakış açısını içine alan, mekânın insani üretimini farklı bir düşünme tarzı olarak, fakat aynı zamanda coğrafi imgelerin karmaşıklığından bahsetmek. Bu alternatif üçüncü bakış açısında şehrin mekânsal ayrıntıları, "yaşanan mekân" olarak bir yandan yapılaşmış bireyin, diğer yandan kolektif deneyimin ve eylemin yeri olarak araştırılır"* (Soja, 2000: 12'ye atfen Yıldırım, 2015: 1304). Üçüncü mekân anlayışı, tarihsel ve sosyal olarak yaşadığımız beşerî coğrafyanın anlaşılmasının iyi bir yoludur. O bu yaklaşımı Marksist coğrafyanın sosyal olanın mekâna üstün tutulmasını eleştirmek için ele aldığını belirtir. Bu amaçla sınıfın mekânı olduğu kadar mekânın da sınıfı şekillendireceği, sosyo-mekânsal diyalektik (socio-spatial dialectic) ilişki ve süreçler yapılaşması düşüncesini geliştirir (Yıldırım, 2015: 1305). Üçüncü mekân: *"tüm geleneksel mekânsal düşünme tarzlarına doğrudan meydan okurcasına, anlam ile metin arasındaki ilişkiyi kavramaya yönelik ele alış biçimlerini yapısökümüne[2] yönelik mekânsallığın alternatif bir tasarımının iddiasıdır"* (Soja 1986: 163). Lefebvre'den farklı olarak Soja'da mekânın epistemolojik triyalektiği, temsilî olmayan bir mekân anlayışını içerir. Soja'nın üçüncü mekân kavramının aksine, melezlik ve kültürel farklılıklara dikkat çekmek için üçüncü mekânı kullanmış olan Homi K. Bhabha'nın (1994) anlatımıyla üçüncü mekân, içinde temsil karşıtlığıyla malul, ötekilik, hibritlik, her şeye açıklık ve eş zamanlı olarak her şeyi içeren mekân anlamına gelir (Kipfer, 2008: 9). Lefebvre ise birbirinden bağımsız üç mekân öngörmez, birbirine diyalektik olarak bağlı mekânların üretiminden bahseder. Triyalektik bu manada *"mekânsal, tarihsel ve sosyal arasında ikilikçi ve indirgemeci olmayan bir düşünüş sunar"* (Merrifield, 1999: 345).

Foucault'nun kültürel coğrafya üzerinde önemli bir etkiye sahip olduğunu belirten ve heterotopyayı ve Foucault'nun mekân üzerine yazılarını kuramlaştırmaya koyulan Kevin Hetherington, heterotopiyi alternatif düzenleme alanları olarak tanımlar (Hetherington, 1997). Heterotopyalar, sosyal dünyanın bir kısmını kendilerini çevreleyenlerden farklı bir şekilde organize eden ve yeni düzenleme yollarını mümkün kılan bir sosyal düzeni temsil ettikleri ve bu nedenle *"merkezi"* mekânlardan ayrı olarak var olan *"karşı hegemonik alanlar"* olarak görülebileceğini öne sürer (Hetherington, 1997: 42). Heterotopya'nın yeni bir kültürel coğrafyaya hitap edebilir olduğunu belirten Hetherington, heterotopyaları yeni sosyal düzen biçimleri, alternatif düzen alanları ve işleri farklı bir şekilde yapma alanları olarak tanımlar (Hetherington, 1997). Heterotopik mekânlar, şehirleşmeyi kontrol eden hegemonik gücün ve hafızamızın ürettiği yanılsamanın etkileşimi ile ortaya çıkan yeni bir olgudur. Bu yeni bilgi oluşumu, kontrol mekanizmalarının düzenleri, kolektif hafıza ve sosyo-mekânsal bir ötekileşme arasındaki çatışma ve mücadelenin ürünüdür. Yani sosyal kontrolün sembolik ve politik sistemleri aracılığıyla farklılaşan alanlar oluşturan kültürün ürünleridir. Bu yüzden onları anlamak çok zordur. Çünkü heterotopyaların epistemolojisi bildiklerimizden farklı çalışır. Farklı düzenlerin üst üste binen katmanları ve biçimsel kalıpların gerçek veya sosyo-ekonomik güç dengelerinin bir sonucu olarak sanal bir iletişim ağı oluşturduğunu düşünebiliriz. Böylece içinde yaşadığımız şehrin bir semtinin tüm sakinleri için ortak bir kültür algılamanın imkânsız olduğu ortaya çıkar. Günümüzde alışılmışın dışında toplumsal yaşam olarak tanımlanan heterotopyalar, bu çağdaş dinamizmin bir sonucu olarak toplumsal yaşamın "içinde" yer almaktadır. Heterotopyaları gerçek mekânlar değil, üretiminde farklı, iç içe ve değişken etkinleştiriciler aracılığıyla inşa edilen bir mekân düzeni, bir mekân anlayışı olduğunu da söyleyebiliriz. Bütün bu nedenlerden dolayı, heterotopyaları içine düştüğü karmaşadan kurtarmak önemlidir. Heterotopyaların doğasını ve toplumsal mekânsallığı anlamak, sanayileşme sonrası toplumumuzun ürünü olan ve yaşadığımız mekânlarda kendini gösteren karmaşık ağı anlamamıza yardımcı olur. Bu karmaşıklığın özünü ayrıntılı olarak anlayarak, çağdaş kentsel alan ağındaki zorluklarla başa çıkmak mümkündür (Papo 2017). Olaya bu açıdan baktığımızda, bizim incelediğimiz alanı tanımlamak için en uygun bakış açısı, Hetherington'un heterotopya tanımlamasıdır.

Özetle heterotopya başkalığın yeridir, ötekinin mekânıdır, diğer yerlerle kurduğu farklılık ilişkisiyle var olur; bir kültürün içinde ya da kültürler arasında, önceden belirlenmiş kalıplardan farklılaşanların ait olduğu yerdir. Heterotopyanın, aynı anda hem biçimsel hem de zihinsel etki gösterme potansiyeli olan bir kavram olması, onu postmodern şehirlerin en güçlü araçlarından biri kılmıştır. Heterotopyaların postmodern şehir yaklaşımındaki yerini güçlendiren en temel özelliği, devasalığı ve kapsayıcılığı reddetmesi ile ütopyadan farklılık arz etmesidir. İnsan faktörünün değişkenliği ve ne yapacağının öngörülemezliği, egemen güçlerin bu mekânlar üzerindeki amaç-sonuç ilişkisini zaman zaman tersine çevirmiştir. Böyle anlarda heterotopyalar yeni bir anlam kazanarak bireyin modern toplumun disiplin ve tam kontrol ideali altında direniş, meydan okuma ve kargaşa potansiyelini barındıran farklı yerler haline gelmiştir (Ay, 2017).

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2 **Yapısökümü,** anlam ile metin arasındaki ilişkiyi kavramaya yönelik ele alış biçimleridir.

Yani heterotopya düşüncesinin öngörülmüş geleneksel bütün tutumları yıkıma uğratma mantığı ile farkındalık yaratıldığı her durumda, bir hacim kazandığını ve kurumsallaştırıldığını görmekteyiz. Kısacası heterotopya kavramı bağdaşık yaşam süren topluma alternatif mekânları sunar. Foucault'nun hegemonik düzen altında bulunan bedenin özgürleşme ve kaçma çabasını ifade etmek için kullandığı heterotopya kavramı okuyucunun algısında bir çeşit ötekilik, farklı bir yer olarak yorumlanabilir. Ayrıca heterotopyaların içinde de çelişkiler ve karşıtlıklar vardır. Genel olarak, heterotopya içinde olmak bir yanılsama gibidir. Her gerçek mekânda bir yanılsama mekânı yaratan heterotopyalar, çevrelerindeki etkinlik(ler)le ilgili işlevleri bir araya getirirler. Tam olarak sınırları çizilmemiş olan heterotopya kavramı hâlâ yorumlanmaya açık bir yerde durmaktadır.

Tüm bu tanımlamalardan bağımsız olarak halk arasında kullanılan "halaza" kavramını gündeme getirmek istiyorum. Halaza, ekin toplanırken tarlaya dökülen tanelerden ertesi yıl kendiliğinden yetişen seyrek ekinlere verilen addır. Ayrıca ana-baba, okul terbiyesi görmeyen kendi kendine yetişen çocuklar için "halazaya yetişmiş" tabiri kullanılır[3]. Yani belli bir plan ve programa tabi olmaksızın kendiliğinden, kuralsız, kaidesiz oluşan mekânlara pekâlâ halaza mekânlar diyebiliriz. Halaza mekânlar egemen güçlerin kontrolü dışında geliştikleri için, bağımsız, bağlantısız, özgür mekânlardır. Birilerinin himayesinde gelişmedikleri için kendi başlarının çaresine bakabilen, daha dirençli, daha dayanıklı mekânlardır. Değişime ve dönüşüme de her zaman açıktırlar. Çünkü dağılma, geçiş veya hızlı değişme dönemlerinde mevcut kural ve normların etkisini kaybetmesi ile ortaya çıkan toplumsal düzensizlik ortamları bunların ortaya çıkmasını ve gelişmesini sağlarlar. Fakat toplumu kucaklayan yeni kural ve normların ortaya çıkması, bu tür mekânların yasallaştırılmasına, genel işleyiş içerisine alınmasına imkân sağlar. Hatta bu normalleşme-yasallaşma süreci bir nevi uzlaşma ile karşılıklı tavizler ile gerçekleşir. Yani bir dayatma ile güç kullanarak bu tür mekânları ortadan kaldıramazsınız. Bizim incelediğimiz alan da halaza bir mekân olarak ortaya çıkmış, zamanla normalleşmiş-yasallaşmış bir mekândır.

1.2.Bir Kurucu Unsur Olarak Kaçış

Kaçış (Escapism), İngilizce sözlüklerde genelde heyecan verici, ama imkânsız etkinlikler hayal ederek gerçeklikten kaçınma yolu olarak açıklanır. Kaçış, günlük hayatın hoş olmayan ya da sıkıcı yönlerinden, hayal gücü veya eğlenceyi içeren etkinlikler yoluyla zihinsel sapmadır (URL-1). Kaçış, kişinin kendini sürekli bunalım veya genel üzüntü duygularından uzak tutmak için kullandığı bir araçtır. Açılma, ferahlama, gezinti anlamlarına gelen Arapça teferrüç kelimesi de Osmanlı kültüründe, *"gam dağıtmak amacıyla yapılan gezinti"* şeklinde yer almıştır. Bursa'da, şehrin bittiği kırsal alanın başladığı nokta olarak, Uludağ'a çıkan teleferiğin başlangıç noktasını da içeren bir mahallenin adı da Teferrüçtür. Yani Bursalıların eskiden beri özümseyip kültürüne kattığı teferrüç kelimesi İngilizce Escapism'in tam karşılığıdır. Esprili[4] bir anlatımla, aylak olmak üzere yola çıkan, ama sınırlarını aşacak sinirlere sahip olmadıkları için gerisin geriye dönenlerin yaptığı kısa gezintiye "teferrüç" denir.

Yi-Fu Tuan, Kaçış (Escapism) kitabında kaçma fikrine farklı bir bakış açısıyla yaklaşıyor. Ona göre insanlık gerçeklerle yüz yüze gelmekten kaçıyor: Dışarıdaki havadan, sesten kaçmak için evlerimize, doğadan kaçmak için ise şehirlere, ölüm gerçeğinden kaçmak içinse birtakım inanışlara ve kurumlara sığınırız. İnsanın doğası bu gerçekleri kabullenmek istemiyor; çünkü içimizdeki ilkel (hayvani) duygular bunları düşünmemizi engelliyor (Tuan, 2015). Normalde olumsuz bir çağrışımı olan "Kaçış"ın, olumlu bir yanı da vardır. Bir şeyden kaçtığımızda genellikle başka bir şeye kaçıyoruz. Bu nedenle, gerçeklerden kaçışı incelerken, hem iyiyi hem de kötüyü -doğal ve kültürel- çeşitli mekânsal ölçeklerde olduğu kadar hayal gücünün mekânlarını da kucaklıyoruz. Tuan, insanların hem doğayla bağlantı kurmayı hem de doğadan kaçmayı istediklerini, ancak özlemimizin evrensel olmasına rağmen, yerine getirilmesinin imkânsız olduğunu öne sürüyor. Gerçeklerden kaçış, tipik olarak, yerleşik veya günlük ortamlardan uzaklaşmayı, dışarıya, doğaya daha yakın olmayı içerir. Ancak Tuan, bunun tersinin de aynı derecede mümkün olduğunu savunuyor: Tüm kültürler gerçeklerden kaçıştır - doğadan kaçıştır diyor. Kültür ile sadece belirli edinilmiş alışkanlıklar, belirli araçların üretimi ve kullanımı değil, bütün bir düşünce ve inanç, alışkanlıklar ve gelenekler, beceriler ve eserler dünyasını kastettiğini ifade eden Tuan, kültür, insanın gerçeklerle yüzleşmeme eğilimiyle, şu ya da bu şekilde kaçma yeteneğimizle, inanmaya alıştığımızdan daha yakından bağlantılıdır diyor. Zaten var olan pek çok şeye insan olmanın ne olduğuna dair başka bir tanım eklemek isteyen Tuan, insan, gerçeği olduğu gibi kabul etmeye doğuştan yatkın olmayan bir hayvandır. İnsanlar, tüm hayvanlar gibi yalnızca boyun eğip uyum sağlamakla kalmaz; önceden belirlenmiş bir plana göre

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3   Derleme Sözlüğü (https://sozluk.gov.tr/)
4   "Espri, kıtlıkta bolluk arz eden bir cevherdir." - Necip Fazıl Kısakürek

dönüşürler, dönüşmeden önce olağanüstü bir şey yaparlar, yani orada olmayanı "görürler". Orada olmayanı görmek, tüm insan kültürünün temelinde yatar demektedir (Tuan, 2015: 26).

Yi-Fu Tuan'a göre insanlar, bazen akılsızca, çoğu zaman da yaratıcı ve ustaca bir şekilde kaçmanın yollarını aramışlardır. Atalarımız tarih öncesi zamanlarda, doğanın haşin koşullarından kaçmak için barınaklar inşa edip tarımla uğraşmaya başlayarak yerleşik hayata geçmişlerdir. Günümüzde, kentsel tehlikelerden kaçmak için kentlerin eteklerindeki daha güvenli ve yeniden şekillendirilen mesire yerleri ve parklar dünyasını kullanıyor (Tuan, 2015: 42-47). Evet, günümüz şehir toplumunun gerçeklerden kaçma yollarının başında hafta sonları piknik yapmak geliyor. Fakat daha büyük bir kitle şehir gerçeklerinden kaçmanın yolunu yine şehir içinde bir mekânda tatmin etmeye çalışmaktadır. Bunlar genelde AVM'leri tercih ediyorlar. Ancak AVM'lerde vakit geçirmek pahalıya maloluyor. Bu bedeli ödemekte zorlananlar, daha ucuz mekânlar olarak parkları tercih ediyorlar. Bir parkta bir bank üzerine oturup birileri ile sohbet etmek, çekirdek çitlemek pek çok insanın en önemli rahatlama yolu. İşte Kanalboyu tam da böyle bir yerdir. Mahalle aralarının sıkıcı kasvetli havasından kaçanlar Kanalboyu'nda dinlenmeye, rahatlamaya çalışırken, diğer yandan da cadde boyuna dizilmiş dükkânlardan AVM'lerde aradıkları hemen her şeyi buluyorlar. Daha özgürce, daha ucuza ve açık havada AVM imkânlarına sahip olmaktadırlar. İşte bu düşünce ve bakış açılarıyla bu araştırmada Soğanlı mahallesine ve Kanalboyuna dair gözlemlere dayalı yorumlar yapılmış ve özgün sonuçlar ortaya konulmuştur.

2.1. Soğanlı Köyünden Soğanlı Mahallesine

Eski Bursa Merkez İlçe köylerinden olan Soğanlı, 1984'te Bursa şehrine mahalle olarak eklenmiş, 1987'deki büyükşehir düzenlemesinde Osmangazi İlçesi'ne bağlanmıştır. Soğanlı Bursa şehrinin kuzey bölümünde, doğuda Çirişhane ve Çiftehavuzlar, güneyde Gaziakdemir, batıda Alemdar mahalleleri ve kuzeyde Avrupa Konseyi Bulvarı (Yakın Çevre Yolu) ile çevrelenmiştir. Avrupa Konseyi Bulvarının kuzeyinde de büyük bir arazisi vardır. Tüm bu komşu mahalleler ile bunların

doğusundaki Fatih, Tuna ve Küplüpınar mahalleleri de Soğanlı köyü arazisinde oluşmuşlardır.

Soğanlı adının, Bursa'nın soğan ihtiyacının bu köyden karşılandığı için verilmiş olduğu sanılmaktadır. 1530 tarihli tahrir defterinde köyün adı Soğanlık olarak geçmektedir. Bir vakıf köyü olan Soğanlı'nın geliri Kaplıca İmaretine gitmekteydi. Köyün güneybatısında, Sırameşeler Ormanlar mevkiinde Eşekyedi olarak anılan yerde önceleri Bigados veya Sitos adını taşıyan bir yerleşme varmış, ancak bugün izleri silinmiştir. Soğanlı köyü bu antik yerleşmenin yerini almış olmalıdır. Ayrıca köyde eskiden çok sayıda geniş çiftlikler varmış, ünlü Numune Çiftliği ile Ethem Köstem ve Süter çiftlikleri bu köy sınırları içinde yer alıyormuş. Numune Çiftliği içinde Fransızların yaptığı ünlü köşk, 1980'li yıllarda yıkılmıştır. Halkın adak yeri olarak kullandığı, Numune Çiftliği içindeki Ali Baba mezarı da zamanla kaybolmuştur (URL-2).

Hicri 1316 (1898) ve 1325 (1907) tarihli Hüdavendigar Vilâyeti Salnamelerinde 50 hane olarak kayıtlı olan köyün nüfusunun Cumhuriyet sonrasındaki gelişimi çizelge 1'de verilmiştir. 1915'ten 1955'e kadarki 40 yıllık süreçte nüfusunu 4 kat artıran Soğanlı, 1955-1960 arasında nüfusunu ikiye katlamış, 1960-1970 arasında fazla bir gelişme göstermemiş, nüfusu sadece 500 kişi artmıştır. 1970-1980 döneminde de köy nüfusu tekrar 4 kat artarak 10 bin kişinin üzerine çıkmıştır. Özellikle iç göçler sonucu hızla büyüyen köy zamanla şehirle birleşmiş ve 1984'te bir mahalle olarak belediye sınırları içine alınmıştır. Belediye sınırları içine alındıktan sonra da nüfusu artmaya devam eden mahallenin 2000 yılından bu yana nüfusu 25 bin civarında seyretmektedir. Nitekim 2000 yılında 25.644 kişi olan nüfusu 2007 ADNKS'de 25.002, 2010'da 24.904, 2015'de 24.114 ve 2020 kayıtlarında da 26.272'dir.

Aslında Çiftehavuzlar, Çirişhane, Gaziakdemir, Alemdar, Fatih, Tuna ve Küplüpınar mahalleleri de Soğanlı köyünün arazisi içinde gelişmiştir. Bugün bu mahallelerin toplamında 130 bin kişi yaşamaktadır. Şehir merkezine 5 km mesafede yer alan Soğanlı köyü arazisine, ilk olarak 1935 yılında Tahtakale'deki

Çizelge 1: Soğanlı köyünün nüfusu (1915-1980).
Table 1: Population of Soğanlı village (1915-1980).

YIL	1915	1927	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
Toplam	241	283	563	619	678	793	938	2.080	1.815	2.586	5.843	10.779
Erkek			305	331	376		513	1.063	950	1.348	3.151	5.581
Kadın			258	288	302		425	1.017	865	1.238	2.692	5.198

Kaynak: DİE verileri

dericiler Sıcaksu/Tabakhaneler bölgesine taşınmıştır.[5] İkinci olarak, 1938'de Sümerbank Merinos Yünlü Sanayi Dokuma Fabrikası köy arazisinde kurulmuştur. Fakat şehrin bu tarafa doğru yayılması yaklaşık 20 yıl sonra 1960'lı yıllarda başlamıştır. Bugünkü Bursa Kent Meydanı'nın bulunduğu yerde 1995 yılına kadar hizmet verecek olan şehirlerarası otobüs terminali (Santral Garaj) 1961 yılında açılmıştır. 1960-1970 arasında Soğanlı köyü arazisinde Gaziakdemir Mahallesindeki sanayi sitesi oluşmuştur. 1970'li yıllarda Küplüpınar Mahallesi ile başlayan ve Yalova yolu boyunca günden güne yağ lekesi gibi yayılan kontrolsüz yapılaşma ile Tuna, Çirişhane ve Fatih mahalleleri şekillenmeye başlamıştır. Alemdar ve Çiftehavuzlar'ın da oluşmasıyla 1980'li yıllarda Soğanlı köyü artık şehrin bir parçası haline gelmiş ve 1984 planlamasında Bursa belediyesi sınırları içine katılmıştır. Bu köyün belediye sınırları içine alınmasıyla 730 dönüm köy merası belediyenin tasarrufuna geçmiştir. Yaklaşık 60 ha'lık alan kaplayan Bursa'nın Hayvanat Bahçesi ve Botanik Parkı ile günümüzde (2022) yapımı süren Soğanlı Millet Bahçesi ve Soğanlı Kentsel Dönüşüm projesi bu arazi üzerinde yapılmıştır.[6]

Araştırmamıza konu olan Kanalboyu, bu köy arazisi içinden geçen Cilimboz deresi boyunca 1970'li yılların ortalarından 1990'lara kadar yavaş yavaş şekillenmiştir. Son yıllarda Kanalboyu'nun kuzeybatı kesimindeki boş araziler üzerinde "kentsel dönüşüm" (?!) projesi gerçekleştirilmiştir. İlk 4 etabı 2016-2018 yılları arasında tamamlanan ve 8. etap inşaatı süren (2022) Soğanlı Kentsel Dönüşüm projesi kapsamında yaklaşık 42 ha alan üzerinde toplam 2 bini aşkın konut ve 250 ticari birim inşa edilmiştir. Bu nedenle 2016'da 24 bine kadar gerileyen Soğanlı nüfusu, 2018'den itibaren artarak bugün 26 bin kişinin üzerine çıkmıştır.

Bugün mahallede, köyün yerleşik halkından (Manav) başka, büyük çoğunluğu Dağ yöresi (Orhaneli, Keles, Büyükorhan ve Harmancık ilçeleri) köylerinden ve Mustafakemalpaşa ile Karacabey ilçelerinden gelenler ile Bulgaristan göçmenleri yaşamaktadır. Daha önce 1938 yılında zorunlu göçe tâbi tutulan Tuncelilerin bir kısmı Soğanlı köyüne de yerleştirilmiştir. Ama günümüzde bunlardan pek fazla kişi kalmamıştır. Ancak, Doğu Anadolu bölgesinden özellikle Muş'tan göç edenler ile

Samsunlular başta olmak üzere Karadeniz illerinden ve diğer bölgelerden gelenler de mahallede yer almaktadır. Soğanlı Kentsel Dönüşüm projesi kapsamında yapılaşan yerlere ise çok daha heterojen bir nüfus yerleşmiştir. Yani çok farklı yerlerden değişik zamanlarda gelmiş insanlar mahallede yaşamaktadır. Bu durum Aristo'nun Politika isimli eserinde ifade ettiği *"birbirine benzeyen değil, farklı insanlar ancak bir şehir meydana getirebilir"* düşüncesine uygun olarak, belli bir grup insandan oluşan Soğanlı köyünün, birbirinden bağımsız ve birbirine benzemeyen insanların bir mekân içinde heterojen bir bütünlük oluşturacak şekilde şehir mahallesi olan Soğanlı'ya dönüşmesinin göstergesidir.

2.2. Cilimboz Deresinden Kanalboyuna

Uludağ'ın kuzey yamaçlarından doğan, Alacahırka mezarlığı güneybatısında travertenlerden oluşan yüksek bir kayalık kütleyi yararak derin bir vadi oluşturan dere, Hisar ile Muradiye arasından geçip Altıparmak civarında yeraltı kanalına girmekte, Stadyum caddesini yeraltı kanalında geçen dere, Merinos parkı kuzeyinde yeraltından çıkarak kanal içinden akmakta, Avrupa Konseyi bulvarında Nilüfer çayına katılmaktadır. 1750 m'si Kanalboyu'nda kanal içinde, yaklaşık 2 km'si Gaziakdemir, Merinos ve Stadyum caddeleri boyunca yeraltı kanalında ve yine yaklaşık 1 km'si Altıparmak ile Alacahırka arasında tekrar kanal içinde akan Cilimboz deresinin 3 km'si de, Alacahırka'dan Uludağ'ın yükseklerine kadar olan bölgede uzanır. Böylece toplamda yaklaşık 7,5 km uzunluğunda olan Cilimboz, aslında uzunluğu ve havza genişliği açısından küçük bir deredir. Alacahırka mezarlığı batısındaki Pınarbaşı köprüsü güneyinde Uludağ'ın eteklerindeki su toplama havzası yaklaşık 5 km^2 kadardır. Havzanın en yüksek yerleri 850 metrelerdedir. Pınarbaşı köprüsü civarında 250 m olan yükseklik hesaba alındığında havzanın ortalama eğimi % 20 kadardır. Fakat özellikle eskiden ve günümüzde, havza genişliği ile kıyaslanamayacak kadar çok su taşımaktadır.

Bursa Kalesi surlarının dere yatağı kenarına kadar uzanması nedeniyle Eski Bursa şehrinin batı sınırlarını oluşturan Cilimboz Deresi'nin kaynağında eskiden çok sayıda manastır

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5   Buradaki tabakhaneler, Bursa İhtisas Deri Organize Sanayi Bölgesi'ne taşınmıştır. Deri OSB, 2006 yılında Nilüfer ilçesinin Badırga mahallesi ile Karacabey ilçesinin İkizce ve Taşpınar mahallesi sınırları içerisinde yeni yerinde faaliyete geçmiştir. Bugün Sıcaksu/Tabakhaneler bölgesinde uygulanması planlanan kentsel dönüşüm projesi ihale aşamasındadır.

6   1995 yılında yapımına başlanan ve 1998'de hizmete açılmış olan **Botanik Park**ta, 3 adet büyük gölet, 1 adet su oyunları havuzu, 2 adet çocuk oyun alanı, 4 adet wc, 2 adet büfe, bir adet büfe-bisiklet evi, bir adet pastane, bir adet idari bina bulunmaktadır. Botanik Parkının güney bölümünde; 17.,18.,19., yüzyılda Bursa'da bulunan Halıcı İzzet evi, Havuzlu Konak, Çift Bacalı ev, Abdülvahap evi, gibi tarihi yapıların birebir uygulanması ile oluşan Bursa Evleri yer almaktadır. 200 dönüm arazi üzerinde kurulmuş olan **Bursa Hayvanat Bahçesi** 1998 yılında hizmete açılmıştır. Hayvanat bahçesinde 67 farklı türde 600 hayvan barınmaktadır. Hayvanat Bahçesi içerisinde 9 gölet, yürüyüş yolu, çoğu meşelerden oluşan 3000 kadar ağaç bulunmaktadır. Su kuşları için ayrılan bölümde dev bir kafes ve gölet bulunur. Bahçenin tam ortasında Cumalıkızık köyünün bir sokağındaki yapılar kopya edilmiştir. "Çocuk Köyü" adlı bu bölümde çocuklar, çiftlik hayvanlarına temas edebilir yem verebilir. Bursa Büyükşehir Belediyesi tarafından işletilen Hayvanat Bahçesini her yıl 100-150 bin kişi ziyaret etmektedir.

bulunmaktaymış. Bunların en tanınanı Bale Manastırı'dır. 7. yy'da kurulduğu bilinen bu manastırda 100 kadar keşiş barınıyormuş (Bernardin Menthon 1935). Fakat bugün bu manastırların izleri silinmiş ancak çok dikkatli gözlemciler yerlerini tespit edebilmektedirler. Bu derenin adının Filiboz'dan geldiği düşünülüyor. Dere civarında bulunan Filiboz'un mezarı nedeniyle önceleri Filiboz olarak anılmış, zamanla da Cilimboz'a dönüşmüş olmalıdır. Phillippos/Filiboz'un Bursa'nın kuşatılmasında Türklere yardım eden bir Rum komutan olduğu söylenmektedir (URL-3).

Cilimboz deresinin hızlı bir biçimde akması, eskiden dere boyunca değirmenler kurulmasına imkân tanımıştır. Bu değirmenlerden biri bugün bir işletme olarak yaşatılmaktadır. Derenin bu su potansiyeli Bursa'nın ilk sanayi bölgesi olarak buranın seçilmesini sağlamış ve vadi boyunca fabrikalar kurulmuştur. Yani Cilimboz Bursa'nın ilk sanayi bölgesi idi. 19. yüzyılda bu vadide üç iplik fabrikası bulunuyordu. David Saban Kardeşler Fabrikası ile Muis ve Savul Kardeşler Fabrikası ve İshak İskender Fabrikaları dere yatağı çevresinde idi. Bursa'nın

en büyük ipek fabrikaları olan Fabrika-i Hümayun ile Romangal fabrikaları da bu dere kıyısında idi. Pauvlaki'nin Cilimboz Deresi'nin üzerinde açtığı fabrika da olasılıkla sudan elektrik elde ediyordu. Türkiye'nin ilk kâğıt fabrikasının da Bursa'da Cilimboz Deresi'nde kurulduğu söylenmektedir (Kaplanoğlu, 2014). Fabrikaların burada kurulmasında, ipek işçiliği için suyun gerekliliği kadar, çoğu Rum ve Ermeni olan işçilerin yaşadığı mahalle olması da etkili olmuştur. Cilimboz vadisinde dut ağaçlarının da yer alması, burada sanayinin kurulmasında işgücü, enerji ve hammaddenin bir arada bulunmasına dayandığını göstermektedir. Günümüzde Cilimboz vadisinde faal olan fabrika kalmasa da fabrikaların bazılarının binaları varlıklarını sürdürüyorlar.

Cilimboz deresi vadisinin Soğanlı köyü arazisinde yer alan kesimlerinin düzenlenerek kanala alınması ve kanal boyunca uzanan yolların kenarının yapılarla dolmasıyla Kanalboyu (2. Kanal Cad.)[7] caddesi oluşmuştur. 2007 yılında başlanan ve 2009'da tamamlanan yeni düzenleme ile de bugünkü Kanalboyu şekillenmiştir. Kanalboyu ya da 2. Kanal caddesi 1750 m.
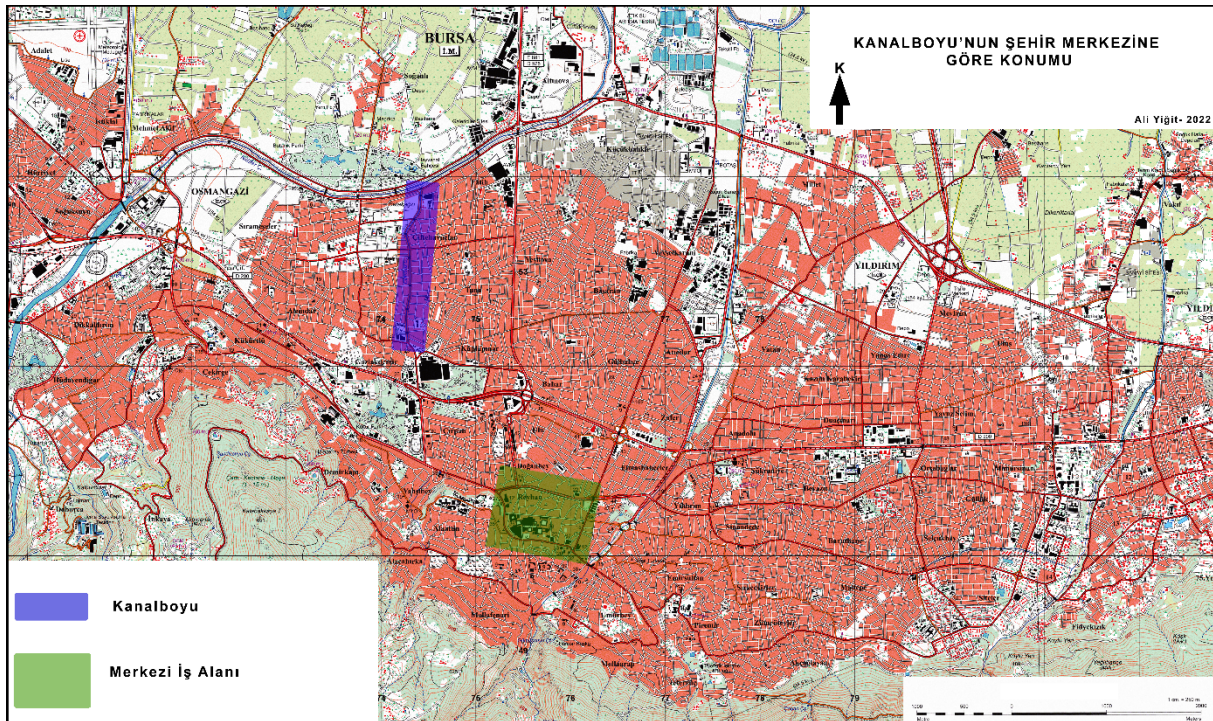
Şekil 1: Kanalboyu caddesinin merkezi iş alanına göre konumu
Figure 1: The location of Kanalboyu Street relative to the Central Business District

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7   Bursa'da bir kaç tane Kanal Caddesi vardır. Bunların hemen hepsine "Kanalboyu" ismi kullanılmaktadır. 1. Kanal Caddesi Çekirge'de Dikkaldırım'dadır. 2. Kanal Caddesi bizim incelediğimiz caddedir. Ayrıca Yıldırım'da ve Çalı'da da Kanal caddeleri vardır. Bursa Ovası'nda, bataklıkların kurutulması için 1934-1938 yılları arasında Alman mühendisler tarafından yapıldığı için "Alman Kanalı" olarak adlandırılan drenaj kanalı da son yıllarda düzenlenerek kenarına yol açılmıştır. Fuat Kuşçuoğlu Caddesi ya da Yunuseli Bulvarı ismi verilen bu caddeye ve devamındaki caddeye 2. Kanalboyu ismi verilmektedir. Ayrıca Bursa Ovasında çok sayıda sulama ya da kurutma kanalı boyunca uzanan yollar için de bu isim kullanılmaktadır. Ancak Bursa'da Kanalboyu dendiğinde ilk akla gelen ve en tanınanı Soğanlı-Çirişhane ve Çiftehavuzlar arasında yer alan bizim incelediğimiz caddedir. Resmi adı olmasa da pek çok adres bilgisinde caddenin adı Kanalboyu olarak yazılmaktadır.

Foto 1: Kanalboyu'nun ara sokakları dar kaldırımsız ve iç içe sıkışıktır.
Photo 1: The side streets of Kanalboyu are narrow, without pavement, nested and congested.

uzunluğundadır. Cadde boyunca kanal içine alınan derenin duvar kenarları çit bitkileri ile yeşillendirilmiş sarılgan/sarmaşık türü bitkiler duvar üzerine sardırılmış ve belli aralıklarla ağaçlar dikilmiştir. Cadde boyunca yaklaşık yüzer metre aralıklarla 12 yerde kanalın üzeri kapatılarak dairesel oturma yerleri oluşturulmuştur. Böylece cadde ortasındaki dere kenarı bir dinlenme parkı ya da eğlendinlen (rekreasyon) alanı halini almıştır (Şekil 1).

Caddenin her iki tarafındaki mahalleler, plansız düzensiz bir şekilde üst üste yığılmış binalarla dolu, çok dar (genelde 5 m'den az) kaldırımsız sokaklara dizilmiş haldedir (Foto 1). Bu dar sokaklara araçların park edilmesiyle hem yayalar hem de araçlar için adeta adım atmanın imkânsızlaştığı yerler halini almaktadır. Bu mahallelerden Çirişhane, 28 ha alana ve 10 bin nüfusa sahiptir. Yani kişi başına 28 m² alan düşmektedir. Aynı şekilde 58 ha alana sahip Çiftehavuzlar mahallesinde de, 20 bin kişi yaşamaktadır. Burada da kişi başına 29 m² alan düşmektedir. Soğanlı mahallesinde Hayvanat bahçesi, Botanik park ve Millet bahçesi alanlarından başka Avrupa Konseyi Bulvarının kuzeyi ile Yalova yolunun batısı arasında yer alan bir kısmı hobi bahçeleri ve Hilton oteli ile Özdilek AVM tarafından işgal edilen yaklaşık 220 ha'lık kırsal sahadan (Dışbudak Mevkii) dolayı

mahalle alanı 341 ha çıkmaktadır. Fakat meskûn alan yaklaşık 70 ha, nüfusu da 26 bin kişidir. Yani yine kişi başına 27 m²'lik bir alan düşmektedir. Kısacası Kanalboyu'nun her iki tarafında 1 dekar alanda 35 kişi yoğunluk bulunmaktadır (35 da/kişi). Başka bir değişle kanal boyunun 500 m doğusu ve 500 m batısı arasında toplam 55 bin kişi yaşamaktadır. Kanalboyu'nun toplam genişliği çok yerde 30 m'yi bulmamaktadır; kanal genişliği 5 m, her iki yanda 5'er metre kaldırım ve yeşil alanla 15 metredir. Caddenin ortasındaki 15 metrelik bu nefes alma alanını her iki yanda kuşatan 7,5 m'lik yol ve kaldırımlarla birlikte Kanalboyu'nun toplam genişliği 30 metredir. Yani toplam alanı 55 bin m² olan sahanın etrafında 55 bin kişinin yaşadığı bölgede insanlara 1 m² nefes alma alanı sunulmaktadır. Kanalboyu'nu şehrin sıkışmış bu bölümüne hapsolmuş insanların bir nefes alma boşluğu, bir koridor hatta bir nevi malta[8] olarak düşünebiliriz. Düzensiz ve plansız kendiliğinden gelişmiş olan şehrin bu kesiminde, yine kendiliğinden (halaza olarak) plansız ve düzensiz bir heterotopik kaçış alanı oluşmuştur.

3.1. Kanalboyu'nun İşlevsel Özellikleri

Kültür coğrafyası açısından işlev, bir kültür biriminde ekonomik yönden değerlendirilen ve birbirine karşılıklı bağımlı durabilen etkinlikler olarak tanımlanmaktadır. Birçok etkinliğin merkezi olan şehirsel yerleşmeler sadece mesken ve mesken topluluklarından meydana gelmemekte, aynı zamanda ticari, idari, sosyal ve kültürel işlevleriyle birlikte bir bölgedeki gelişmişlik düzeyinin göstergesi ve o sahadaki yaşayış biçiminin ve ekonomik yaşantının da bir görüntüsüdür. Bu açıdan Kanalboyu'nun en önemli işlevi bir ulaşım koridoru olmasıdır. Kanalboyu'nun üzerinde karşılıklı 6 çift otobüs durağı yer almaktadır. Bu duraklardan 15 dakika aralıklarla sürekli çalışan, Bursaray'ın Merinos ve Kültürpark istasyonlarından mahalle içine yolcu taşıyan B/2, B/2-A ve B/2-C minibüsleri geçmektedir. Yani Kanalboyu çevresinde oturanların Bursa içinde tren ile ulaşabilecekleri her yere taşınmaları sağlanmaktadır. Yine caddeyi boydan boya tüm duraklara uğrayarak geçen Çiftehavuzlar-Uludağ Üniversitesi arasında çalışan B/44-B otobüsü kullanmaktadır. Alemdar-Teferrüç (Teleferik) arasında çalışan 15-A ve Çiftehavuzlar-Akçağlayan arasında çalışan 15-B otobüsleri Kanalboyu'ndan geçmektedir. Bu her iki hat da şehir merkezinden (Atatürk Caddesinden) geçmektedir. Ayrıca Etibank Caddesi-Çekirge Devlet Hastanesi arasında çalışan 19/D ile Fatih-Çekirge Devlet Hastanesi arasında çalışan 5/A ve Siteler-Şehirlerarası Otobüs Terminali arasında çalışan 99 no.lu otobüs hatları da Kanalboyu'ndan geçmektedir. Bu belediye

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8   "**Malta**; Taşla kaplı hapishane avlusu" Kamus-ı Türki (1899)

Foto 2: Kanalboyu bir yürüyüş mekânıdır.
Photo 2: Kanalboyu Street is a walking space.

Foto 3: Kanalboyu bir dinlenme mekânıdır.
Photo 3: Kanalboyu Street is a to relax space.

otobüslerinden başka Ulucami-Kanalboyu arasında dolmuş taksiler çalışmakta ve Çiftehavuzlar-Kentmeydanı-Heykel arası çalışan dolmuş minibüsler Kanalboyu'ndan geçmektedirler. Kısacası Kanalboyu çevresinde oturanların şehrin hemen her yerine ulaşmasını sağlayan otobüsler, dolmuşlar minibüsler ve dolmuş taksiler Kanalboyu'nu kullanmaktadırlar. Ayrıca okul ve fabrikaların servis araçlarının güzergâhında da Kanalboyu mutlaka yer almaktadır. Böylece Kanalboyu sadece bir nefes alma dinlenme ve vakit geçirme yeri değil aynı zamanda bu çevrede oturanların dünyayla bağlantı noktasıdır.

Foto 4: Kanalboyu bir dinlenme yürüyüş ve sohbet mekânıdır.
Photo 4: Kanalboyu Street is a space for walking, resting and chatting.
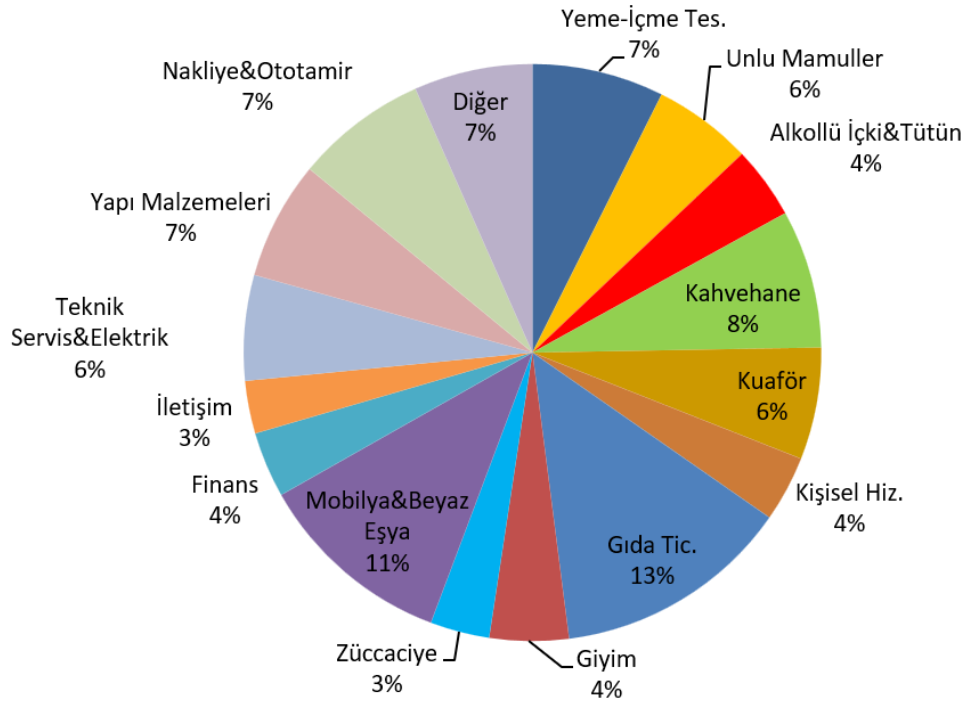
Şekil 2: Kanalboyu caddesinde dükkânların etkinlik alanına göre dağılımı
Figure 2: Distribution of shops on Kanalboyu Street based on activity area

Kanalboyu'nun ikinci önemli işlevi ise boş vakitlerini çeşitli etkinlikler ile değerlendirmek isteyenler için bir eğlendinlen (rekreasyon) alanı olmasıdır. 2009 yılında tamamlanan yeni düzenleme ile Kanalboyu'nun ortasındaki Cilimboz dere yatağı taş duvarlarla örülmüş, dere üzerine insanların dinlenebileceği ve karşıya geçmesini sağlayacak 12 adet betonarme köprü yapılmıştır. Bu köprüler üzerine su havuzları ve oturma grupları inşa edilmiştir. Ayrıca taşla örülen kanal duvarları boyunca çok sayıda ağaç dikilmiş ve yaya yürüyüş yolları yapılmıştır (Foto 2,

3 ve 4). Böylece Soğanlı, Çirişhane ve Çiftehavuzlar mahallelerinin ortasında insanların dinlenebileceği bir park alanı oluşmuştur. Buradaki banklar üzerine hatta duvarlar üzerindeki betonlar üzerine oturmuş çekirdek çitleyen, sohbet eden her yaştan insanları günün her saatinde ve özellikle de akşam saatlerinde görmek mümkündür. Özellikle yaz aylarında gecenin geç saatlerine kadar Kanalboyu canlılığını korumaktadır. Yaz gecelerinde Kanalboyu'nda dondurma yemek artık geleneksel bir etkinliktir. Cadde boyunca sıralanan kahvehanelerin pek çoğu kanal duvarı kenarındaki yeşillikler üzerine tabure, küçük

AÇIKLAMALAR

Lokanta, Dönerci, Lahmacuncu, Kokoreççi, Çiğköfteci, Tostçu ...

Pastane, Baklavacı ...

Dondurmacı, Tatlıcı

Ekmek-Simit Fırını, unlu mamüller

Kuruyemişçi

Alkollü içecekler ve Tütün mamülleri (Tekel Bayii)

Kahvehane, Kıraathane, Çay Ocağı, Lokal...

Market, Bakkal, Büfe...

Manav

Kasap, Tavuk eti, Balık, Süt ürünleri (Şarküteri)

Bakliyatçı

Baharatçı

Giyim (Konfeksiyon, Tuafiye, Bujiteri...)

Zücaciye, Mutfak eşyaları...

Beyaz Eşya

Mobilya, Halı-Perde-Çeyiz...

Kuyumcu

Kırtasiye, Fotokopi, Fotoğrafçı

İletişim Bayii

Sigortacı

Emlakçı

Yapı Dekorasyon, Boya-Tadilat, Sıhhi Tesisat, Cam, Pen...

Nalburiye, Hırdavatçı...

Elektrikçi

Teknik Servis, Tamiratçı...

Oto Bakım-Tamirat, Aksesuar, Lastikçi...

Nakliyeci, Taşımacılık, Servis araçları ofisi

Bisikletçi (Tamirat-Kiralama)

Eczane

Dişçi

Sağlık Kabini

Gözlükçü (optik)

Terzi

Erkek Kuaförü, Berber

Kadın Kuaförü, Güzellik Salonu

Petshop, Akvaryum, Kuş Yemi, Veteriner

Temizlik Ürünleri

Dikimevi (Atölye)

Döşemeci, Koltuk tamiri

Depo

Armaları bilinen tanınmış market ve kurumların açıklaması ayrıca yapılmamıştır.

Şekil 3: Şekil 3a, 3b, 3c ve 3d'deki haritaların Yer Bulduru ve Açıklamalar kısmı
Figure 3: Locating and Legend part of the maps in Figures 3a, 3b, 3c and 3d

masa (sehpa) ve hatta taş duvar üzerine minder koyarak buralara çay servisi yapmaktadırlar. Kanalboyu'nda 20 tane çay ocağı, kahvehane ve dernek lokali bulunmaktadır. Yine cadde boyunca dondurmacı, pastane, baklavacı, lokanta, dönerci, lahmacuncu, çiğköfteci, kokoreççi, kuruyemişçi gibi anlık-yerinde tüketilen yiyecek-içecek satışı yapan 60'dan fazla dükkân vardır (Şekil 2, 3, 4, 5). Yani cadde boyunca sıralanan iş ve ticarethanelerin 1/4'ü bu tür dükkânlardan oluşmaktadır.

Kanalboyu'nun diğer bir önemli işlevi de alışveriş imkânı sunan bir ticaret alanı olmasıdır. Cadde üzerinde yer alan dükkân ve işyerlerinin sayısı sürekli değişmektedir. Bizim 2022 yılında tespit ettiğimiz sayı 261'dir. Bu 261 işyerinden 144 tanesi yani % 50'si ticari faaliyetlerle uğraşmaktadır. Bunların 47 tanesi bakkal, manav, kasap, fırın gibi günlük ihtiyaçlara yönelik, 21 tanesi konfeksiyon, manifatura, tuhafiye, kavafiye, zücaciye gibi periyodik ihtiyaçlara yönelik, 61 tanesi de dayanıklı tüketim malzemeleri, mobilya, beyaz eşya, hırdavatçı ve inşaat malzemeleri… vs satan uzun vadeli ihtiyaçlara yönelik ticarethanelerdir. Böylece 130 kadar ticarethanede perakende ticaretle uğraşılmaktadır. Buna karşın büyük ticaret grubuna sokabileceğimiz sadece 8 ticarethane mevcuttur ki, bunların
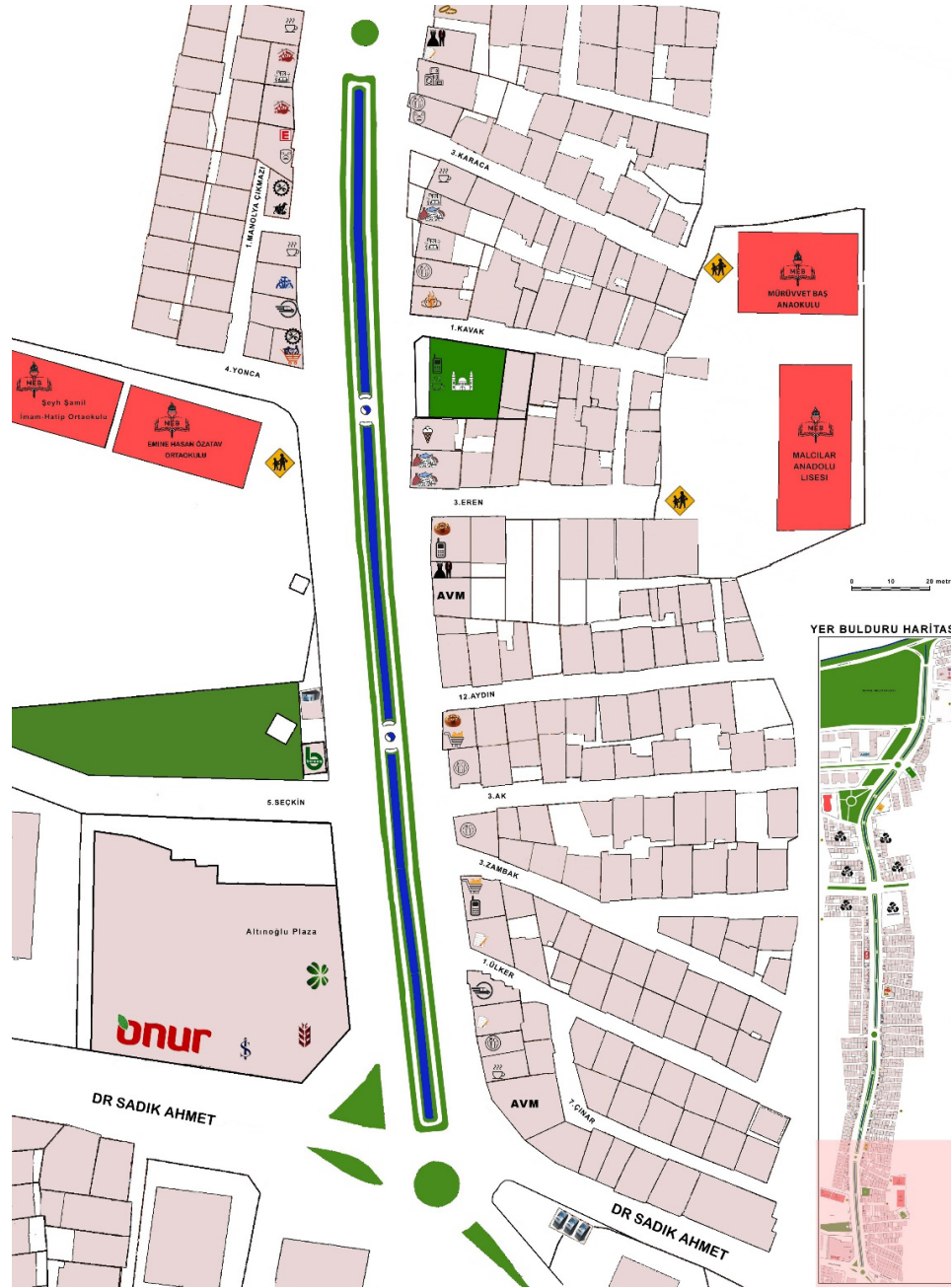
Şekil 3a: Kanalboyu caddesinde iş ve ticaret alanlarının işlevlerine göre dağılımı.
(güney kesimi)
Figure 3a: Distribution of business and commercial areas based on their functions in Kanalboyu Street. (Southern part)

büyük bir kısmı AVM ve çeşitli malları toptan satan ticarethanelerdir. Ayrıca Kanalboyu'nda dört banka şubesi bulunmaktadır. Bunlar Ziraat, İş, Garanti ve Kuveyt Türk bankalarıdır. Bu bankaların ve diğer hemen tüm bankaların caddenin dört farklı yerine konumlanmış bankamatikleri de bulunmaktadır. Yine burada yer alan 6 adet kuyumcu dükkânı, altın ve değerli taş ticareti yanında döviz bürosu işlevi de görmektedir. Yani bunlar da finans kurumu özelliği göstermektedir. Son olarak belirtmek istediğimiz bir diğer husus da, buradaki sabit iş ve ticaret yerlerinden başka cadde üzerinde seyyar satıcıların da yer almasıdır. Özellikle yaz aylarında köylerinden getirdikleri çeşitli tarım ürünlerini pazarlayan üreticileri görmek mümkündür.

Kanalboyu'nda çeşitli yiyecek ve içecekleri üreten ve/veya satan 82 tane işyerinden başka, kahvehane, kıraathane, çay ocağı

Şekil 3b: Kanalboyu caddesinde iş ve ticaret alanlarının işlevlerine göre dağılımı.
(güney orta kesimi)
Figure 3b: Distribution of business and commercial areas based on their functions in Kanalboyu Street. (South central part)

Şekil 3c: Kanalboyu caddesinde iş ve ticaret alanlarının işlevlerine göre dağılımı.
(kuzey orta kesimi)
*Figure 3c: Distribution of business and commercial areas based on their functions in
Kanalboyu Street. (North central part)*

Şekil 3d: Kanalboyu caddesinde iş ve ticaret alanlarının işlevlerine göre dağılımı. (kuzey kesimi)

Figure 3d: Distribution of business and commercial areas based on their functions in Kanalboyu Street. (Northern part)

ve aynı işlevi gören dernek lokallerinin sayısı 24'tür. 4 tane PetShop, akvaryum ve kuşyemi satan iş yeri, 7 tane oto tamir-bakım ve aksesuarları satan dükkândan başka, çeşitli ev aletlerini tamir eden teknik servisler ve çilingir-bıçakçı vs. işler yapan işyerlerinin sayısı da 16'dır. 4'ü bayan olmak üzere 17 tane kuaför, 3 tane terzi, 2 fotoğrafçı, 1 matbaa, 3 şans oyunlar bayii ve bir temizlik ürünleri satıcısından başka imalathane olarak 1 dikimevi ve 2 döşemeci atölyesi yer almaktadır. Görüldüğü gibi orta büyüklükte bir şehrin hemen tüm ihtiyaçlarını karşılayabilecek, hemen her türden ticaret ve işyeri Kanalboyu etrafına konumlanmış bulunmaktadır.

Kanalboyu'nun kültürel işlevlerinden bahsederken, eğitim-öğretim kurumları ve dini yapılardan başka caddenin Dr. Sadık Ahmet Caddesi ile kesiştiği güney başlangıcında yer alan Soğanlı Kültür Merkezi'nden söz edebiliriz. Osmangazi Belediyesi'nin önemli kültür merkezlerinden olan Soğanlı Kültür Merkezi'nde atölye salonları, idari ofisler, sosyal yardım birimi, spor salonu, ArGe ofisleri, dinlenme alanı ve kafeteryalar bulunmaktadır. Kültür merkezi şehrin bu kesiminin kültür-sanat etkinlikleri ile ilgili birçok ihtiyacını karşılamaktadır. Kanalboyu üzerinde ve yakınında Malcılar Anadolu Lisesi, Emine-Hasan Özatav Ortaokulu, Şeyh Şamil İmam Hatip Ortaokulu, Dr. Necla Yazıcıoğlu İlkokulu ve Remzi Zümrüt İlkokulu ile Mürüvvet Baş Anaokulu ve Özel Soğanlı Ortaöğrenim Erkek Öğrenci Yurdu yer almaktadır. Ayrıca Soğanlı Mahallesi içerisinde yer alan, ara sokaklarla caddeye bağlanan Şehit Komando Er Samet Saraç Anadolu Lisesi ve Yusuf Köstem İlkokulu ile Sabiha Köstem Ortaokulu da Kanalboyu ile yakın ilişki içindedir. Cadde boyunca Erenler ve Meşeli camileri de yer almaktadır. Kanalboyu'nun sağlık işlevleri olarak cadde boyundaki Çiftehavuzlar Aile Sağlığı Merkezi ile 2 tane Sağlık kabininden başka 3 tane diş muayenehanesi, 4 tane eczane ile 2 tane gözlükçüden de söz etmek gerekir.

Kısacası Kanalboyu'nun işlevsel özelliklerini değerlendirdiğimizde Bursa gibi büyük bir şehrin kenarında yer almasına rağmen sanki müstakil bir yerleşmenin merkezi gibi çevresindeki nüfusun hemen tüm temel ihtiyaçlarını karşılayabilecek bir nitelikte merkezi iş sahasına sahip olduğunu görüyoruz. Bu durum şehrin ana merkezi dışında onun işlevlerinin önemli bir kısmını üstlenen heterotopik bir yapılanmayı göstermektedir. Bir plan-program çerçevesinde düşünülüp geliştirilmemiş, kendiliğinden halaza bir şekilde oluşmuş bir mekân, şehrin bu kesiminin önemli bir merkezi işlevini yürütmektedir.

Kanalboyu'nun gün içerisinde kullanım şekli ve kullanıcı tutumları arasında önemli farklılıklar vardır. Şöyle ki: Sabah saatlerinde Kanalboyu'nun müdavimleri, işe gitmek için otobüs-minibüs veya işyeri okul servislerini bekleyen çalışanlar ya da öğrencilerden oluşur. Bunlar kahvaltılarını yolda ya da duraklarda beklerken yaptıkları için, bu saatlerde en aktif dükkânlar da simit poğaça gibi yiyecekler satan pastane ve fırınlardır. Genelde işe ya da okula yetişme telaşesi ile koşuşturmaların yaşandığı, hızlı zaman akışının yaşandığı bir süreçtir. Bu insanlar akşamüstü işlerinden evlerine dönerken, bu sefer akşam yemekleri için malzeme tedariki amacıyla manav ya da marketlere yönelmekte ya da kızarmış tavuk, döner gibi paketlenen yiyecekler satın almaktadır. Dolayısıyla bu saatlerde bu tür dükkânların aktivitelerinin arttığı zamanlardır.

Gündüz saatlerinde, özellikle öğleden sonra akşamüstü arası zaman diliminde caddenin müdavimleri, genelde yaşlı bayanlar ve baylardır. Bunlar guruplar halinde banklara oturmakta ve koyu bir sohbete dalmaktadırlar. Bu kesimin en önemli tüketim maddesi kuruyemişlerdir. Akşam saatlerinde, özellikle de yaz gecelerinde çocuk ve bebek arabaları ile gezintiye çıkmış aileler Kanalboyu'nun genel görünümünü oluşturur. Gecenin ilerleyen saatlerinde daha çok gençler caddeye hâkim hale gelmekte, bunlara hizmet eden kokoreçci, pilavcı gibi seyyar satıcılar kanal kenarlarına konumlanmaktadır. Yani Kanalboyu günün farklı saatlerinde farklı yaş ve cinsiyetteki insanların belli sürelerle baskın hale geldikleri ve günün hemen her saatinde etkin olan bir mekândır.

3.2. Kanalboyu'nda Heterotopik Topofilya

Kanalboyu üzerinde yer alan dükkânların bazılarının taşıdığı isimler bize buraların sahiplerinin nerelerden geldiğini ya da hangi mekânlara özlem duyduğunu da göstermektedir. Kültürel görünümlerin okunup yorumlanmasında birer sembol işlevi gören yer adları, toplulukların geleneksel yapıları ile kültürel bağları için bir yol haritası olarak görülmektedir. Yerel halkın özne olabildiği mekân isimlerinde yerlerin kimliği, kültürleri ve bağları hakkında önemli çıkarımlar yapmak mümkündür (Alderman 2008). Nitekim Tuan'ın topos (yer) ve philia (sevgi) kavramlarından türeterek kullandığı topophilia (topofilya) yer kavramına aktarılan imge ve anlamlardan doğar. Belirli bir yerin, bölgenin övülmesi, yüceltilmesi insanların o yer ile kurduğu duygusal bağı yansıtır. Topofili olarak anacağımız bu bağlanma şekilleri o yere dair bir duyarlılığı değil bizzat o yeri anlamlandırarak üretme halini imler. Literatürde yer kavramının önemine dikkat çeken araştırmacılar toplulukların belirli bölgeleri kutsallaştırarak yer-insan-mekân bağını olumlu ya da olumsuz anlamda inşa ettiğini belirtir (Johnson, 1995). Bu bakımdan; Kanalboyu gibi çeşitli yerlerden gelmiş insanların

inşa ettikleri mekânların isimlerine bakarken, bu insanların geldikleri yerlerin kimliği, kültürleri ve bağları hakkında önemli çıkarımlar yapmak mümkündür. Bu düşünceden hareketle Kanalboyu'ndaki iş yerleri incelendiğinde oldukça anlamlı sonuçlar elde edilmektedir.

Buradaki insanların önemli bir bölümü, Bursa'da "dağlılar" olarak ifade edilen, Uludağ'ın güneybatısındaki Bursa'nın dağ ilçelerinden gelmiştir. Mekân isimlerinde; Dağlı Kuruyemiş, Dağlı Oto Lastikçi, Dağkar Otomotiv, Dağlı Telekom Teknik Servis, Orhaneli Söğütlü Süt ve Süt Ürünleri, Öz Harmancık Kahvehanesi, Göynükbelen Kıraathanesi, Göynükbelen Dönercisi, Orhaneli Yeşiller Köyü Kıraathanesi gibi pek çok mekân isminde kökenlerini yansıtmakla kalmamış ayrıca, Çiv-Der Orhaneli Çivili Köyü Kültür Merkezi ve Bursa Ertuğrulgazi Karakeçili Yörük ve Türkmen Derneği gibi hemşeri dernekleri oluşturmuşlardır. Kanalboyu'nda bir diğer baskın grup da Mustafakemalpaşalılardır. Mustafakemalpaşa Kıraathanesi, Meşhur M.Kemalpaşa Tostçusu, Kemalpaşa Ciğercisi, M. Kemalpaşa Barutet entegre et satış mağazası, Kirmasti Çay ocağı gibi işyerleri isimleri yanında Mustafakemalpaşalılar Eğitim Kültür ve Yardımlaşma Derneği ve Sincan Sarnıç Kültür ve Yardımlaşma Derneği binaları da Kanalboyu çevresinde yer almaktadır. Kanalboyu, sadece Bursa ilçelerinden gelenlerin isim yarıştırmasına sahne olmaz, Doğu ve Güneydoğu Anadolu'dan gelenler ve Balkan göçmenleri de kültürel kimliklerini iş yerlerine yansıtmaktadırlar. Bunlara örnek olarak da şu işyeri isimlerini sayabiliriz. Balıklıgöl Lahmacuncusu, Adıyaman Çiğ Köftecisi, Dağıstanlı Kuruyemişçi, Karadağlı Kuyumcu, Kumanova Lokantası gibi... Kısacası Kanalboyu'nun heterotopyası sadece oluşum şekliyle değil, bu çevrede yaşayan insanların kökenlerinin, kültürlerinin çeşitliliğini mekâna her yönüyle yansımasıyla görülmektedir.

3.SONUÇ

Bursa şehrinin ovaya doğru yayılmaya başlaması ile, Nilüfer çayına karışan Cilimboz deresi boyunca, 1970'li yıllarda yapılaşmaya başlayan Kanalboyu'nun, 2009'da bugünkü şeklini almıştır. Kenarları taş duvarlarla çevrilen dere kanal içine alınmış etrafı ağaç ve süs bitkileri ile donatılmış ve oturma yerleri yapılarak bir dinlenme parkı halini almıştır. Ortasında dere, etrafında oluşturulmuş bir park yer alan caddenin her iki yanında sıralanan dükkânlarda da, bir şehir merkezinin sahip olduğu hemen tüm işlevleri üstlenen merkezi iş alanı gelişmiştir. Bursa şehir merkezine sadece 4-5 km mesafede oluşan bu farklı yer, merkezi iş alanının işlevlerini paylaşmaktadır. Ayrıca çok etkin bir ulaşım koridoru ve bu çevrede oturanlar için önemli bir

dinlenme parkı, bir eğlendinlen alanı işlevine de sahiptir. Şehrin plansız-düzensiz gelişim gösterdiği sokakların düzensiz ve çok dar olduğu iç içe binaların birbiri üzerine bindiği, insanların sokaklarda yürümekte bile zorlandığı bir bölgede, bu cadde bir nefes alma, bu sıkışık ortamdan bunalan insanlar için bir rahatlama alanı olmuştur. Tüm bu özellikleri ile heterotopik bir kaçış alanı olarak şekillenmiş bir mekân halini almıştır. Yakın zamanda yapılan ve henüz tam olarak bitirilmemiş olan ve Kanalboyu'nu kuzey tarafından kesen Soğanlı Bulvarının devamı olarak inşa edilen 30 m genişliğinde ve 1200 metre uzunluğundaki Çelebi Mehmet Bulvarı ile onun devamı olan, Yalova yolundan Gökdere'ye kadar 2,5 km uzunluğundaki Hüdavendigar Bulvarları, benzer şekilde plansız-düzensiz olarak oluşmuş çok dar sokaklar etrafına dizilmiş iç içe binalardan oluşan bir bölgede toplam 431 tane binanın yıkılmasıyla açılmıştır. Kısa sürede bu caddeler üzerinde de pek çok iş ve ticaret alanları oluşarak bu mahallelere bir fark katmıştır. Tüm bunlar şehrin düzensiz-plansız gelişim gösteren kesimlerinde açılacak geniş bir caddenin o mahallelere nefes aldıracak, onları hayata döndürecek bir rolü üstleneceğini göstermektedir.

Araştırmamıza konu olan Kanalboyu'nun Michel Foucault'nun heterotopik mekânları tanımlayarak örneklendirildiği altı ilkeden özellikle ikisine karşılık gelebilecek ögeler barındırdığı belirlenmiştir. Foucault'nun belirlediği bu altı ilkeden üçüncü ilkede yapılmış olan tanımdaki "birbiriyle bağdaşmayan çok çeşitli alan ve mekânların örtüştürülmesiyle bir şekilde düzenleri değiştiren tek ve gerçek mekân oluşturma" ile tam olarak örtüştüğü, yine, "işlevsel olarak toplumdaki diğer alanlarla yakından ilişkili olmak" olan altıncı ilkenin özelliklerini de taşıdığı görülmüştür. Bu iki ilkede ifade edilen nitelikler ışığında Kanalboyu'nun heterotopik mekân olarak tanımlanabileceği sonucuna varılmıştır. Ancak, Lefebvre'in mekân üçlemesinin araştırma sahamız açısından daha anlamlı sonuçlar verdiği açıktır. Ayrıca Soja'nın üçüncü mekân anlayışı da bu alana uyarlanabilir. Fakat asıl olarak Hetherington'un yeni sosyal düzen biçimleri, alternatif düzen alanları ve işleri farklı bir şekilde yapma alanları olarak tanımladığı heterotopya anlayışına daha uygundur. Hetherington'un anlayışına göre, heterotopik mekân, karışıklıklar ve iç içe geçmişlikler, birbirinden ayrılamayan üst üste binmiş çeşitlilikleri içerdiğinden tanımlanması çok zor olan bir kavramdır. Heterotopik mekânın biricikliği ve diğer gerçek mekânlarla olan bağlantısından kaynaklanan paradoksal bir özelliği de vardır. Heterotopyalar, ayrı kalmak yerine, egemen olana alternatif bir düzen üretirler, ama aynı zamanda egemen düzenin alanlarını da içerirler. Bu bakış açısı ile Kanalboyu değerlendirildiğinde hemen her özelliği ile heterotopik bir mekândır.

Türkiye'deki heterotopya çalışmaları çoğunlukla siyasal iktidarın hegemonik pratikleri karşısındaki mekânları incelenmiştir. Kanalboyu, heterotopya literatüründeki yönelimin aksine daha büyük bir iktidar olan neoliberal kentleşmenin karşısında yer alan bir kamusal mekân özelliği barındırmaktadır. Yani neoliberal tüketim mekânlarının üretimiyle birlikte şehirlerin, merkezi iş sahaları, önce hane halkını yerinden ederek sermayeyi önceleyen ve antikapitalist yaşam biçimlerini şehrin kenarlarına (periferiye) iten bir karaktere büründürüldü. Bir insanın para harcamadan Kapalıçarşı, Hanlar bölgesi, Ulucami, Tophane gibi ana kamusal mekânlarında var olması güçleşmiştir. Bu yönelim, şehrin çeperlerindeki küçük kamusal mekânların işlevini daha önemli hale getirmiştir. İşte Kanalboyu'ndaki hikâye söz konusu dönüşümün önemli bir çıktısını göstermektedir. Dolayısıyla, çalışmanın literatüre getireceği bu farklılık ve katkıları da vurgulamak gerekir.

Ayrıca heterotopya literatüründe coğrafyacıların yanında özellikle mimarlık ve planlama alanlarının uzmanları tarafından yapılmış pek çok önemli çalışma vardır. Bu çalışmalar heterotopyayı genellikle mekânın mimari boyut ve şekillerini dönüştürücü gücüyle ele almıştır. Ancak burada üzerinde durduğumuz heterotopyanın "biçimsizlik" karakteri ile Lefebvre'in sosyal mekânın (temsilin mekânı) iktidar olmadan kendi kendisine oluşan karakteri arasında bir yakınlık bulunmasıdır. Dolayısıyla Kanalboyu heterotopisi aynı zamanda kentsel planlamanın insan deneyimini göz ardı eden anlayışına karşı durabilecek bir dinamiğe sahip olduğunu vurgulamaktır. Planlamacı ve mimarların oluşturduğu heterotopya literatüründeki açığı kapatmak bakımından önemli bir katkı sunduğu da açıktır.

Son olarak bu çalışmada heterojenlik ve merkezi iş sahası potansiyeli özellikle şehir içi arazi kullanım haritalarıyla detaylı bir şekilde irdelenmiştir. Burada yerinde yapılan gözlem ve tespitlerin yanında görüşmeler ve etnografik bulgulardan da yararlanılmıştır. Fakat Kanalboyu sakinlerinin heterotopik deneyimlerini sosyal boyutlarıyla ortaya koymak için vaka sunumları yapılmamıştır. Çalışmanın ileriki aşamalarında, özellikle etnografi/otoetnografi açısından özdüşünümsel tespitler de heterotopyaya dâhil edilebilir. Yine sosyal açıdan Kanalboyu'nun sınıfsal bir boyutu bulunmaktadır. İç göçle meydana gelmiş olması ve çevresel yükünün ağırlığı sınıfsal bir Harveyci heterotopyanın varlığına dair önemli bir göstergedir. Son dönemlerde coğrafyacılar, ele aldıkları yerin çok boyutlu incelemesi yönünde bir takım hassasiyetler geliştirmiştir. Bunlardan birisi mekâna kesişimsel yaklaşmaktır. Özellikle postyapısalcılar, sınıfsal okumanın hegemonyasına karşılık bir yerin sınıfsal açıdan değerlendirmesi toplum dışına itilen dezavantajlı grupları anlamada yetersiz kaldığını öne sürmektedir. Bir fenomen ya da mekanı sınıfsal okumanın yanına artık cinsiyet, ırk ve yaş gibi kategorilerin kesişiminde okumanın daha gerçekçi olduğu savunulmaktadır. Dolayısıyla Kanalboyu'ndaki heterotopyanın özellikle cinsiyet açısından çıktılarının da sunulması kavramın öne sürdüğü heterojenlik ve özgürlük gibi değerleriyle olan ilişkisini gösterebilir. Özellikle kadınların bireysel olarak Kanalboyu'ndaki varlıkları ve mekândaki failliklerinin seviyesi ayrı bir araştırma ile sorgulanabilir.

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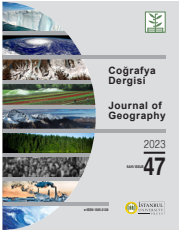
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Akçay Havzası Aşağı Çığırının (Antalya/Finike) Kuraklık Özelliği ve Su Hasadı Yapılabilecek Potansiyel Alanların Belirlenmesi

Drought Features of the Akçay Lower Catchment Area (Antalya/Finike) and Identifying Potential Areas for Water Harvesting in the Basin

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ÖZ

Akçay havzası aşağı çığırının (Finike/Antalya) kuraklık özelliği ve bu alanda su hasadı yapılabilecek potansiyel alanların belirlenmesi başlıklı bu çalışmada, kuraklık ve su hasadı konuları üzerinde durulmuştur. Bölgenin kuraklık özelliğini belirlerken kuraklık indeksleri arasında yaygın olarak kullanılan standartlaştırılmış yağış indeksi (SYİ) kullanılmıştır. Ardından su toplama sistemlerinden bahsedilmiştir. Çok Kriterli Karar Verme (ÇKKV) yöntemlerinden analitik hiyerarşi prosesleri (AHP) ve mekansal analizlerde kullanılan Coğrafi Bilgi Sistemleri (CBS), su hasadı yapılabilecek potansiyel alanların belirlenmesinde kullanılan yöntemlerdir. Finike Meteoroloji İstasyonu 1973-2021 yılları arası verileri ile yapılmış standartlaştırılmış yağış indisinin yıllık ortalama kuraklık analizi sonuçlarına göre son 3 yıldır kurak dönemlerin, daha önceki kurak dönemlere göre daha şiddetli olmasıdır. İnceleme alanının coğrafi ve meteorolojik özellikleri dikkate alınarak 6 kriter belirlenmiştir. Bunlar: Arazi kullanımı, nehir mesafesi durumu, jeoloji, eğim, yağış ve sıcaklıktır. Kriterlerin ağırlıkları AHP ile belirlenmiş ve en fazla önemin yağış olduğu, bunu sırasıyla eğim, nehir mesafesi, jeoloji, sıcaklık ve arazi kullanımının takip ettiği görülmüştür. Kriterlere ağırlıklı çakıştırma analizi yapılarak su hasadı için %23 kuvvetle uygun alan bulunduğu tespit edilmiştir.

Anahtar kelimeler: Kuraklık, Yağmur Suyu Hasadı, AHP, SPİ, Finike, Akçay

ABSTRACT

This study focuses on drought and water harvesting issues. The standardized precipitation index (SPI) was used to determine the drought characteristics of the region. To identify potential areas for water harvesting, this study employed analytical hierarchy processes (AHP) from multicriteria decision-making methods and geographic information systems. The results of the drought analysis of SPI made with the data of the Finike Meteorology Station from 1973 to 2021 showed that the dry periods for the last 3 years have been more severe than the previous ones. The study determined six criteria based on the geographical and meteorological characteristics of the area: land use, river distance, geology, slope, precipitation, and temperature. The AHP was used to determine the weights of the criteria, and the results showed that precipitation was the most important criterion, followed by slope, river distance, geology, temperature, and land use. Weighted overlay analysis was performed on the criteria, and it was found that there was a suitable area with 23% strength for water harvesting.

Keywords: Drought, Rainwater Harvesting, Analytical Hierarchy Processes, Standardized Precipitation Index, Finike, Akçay

EXTENDED ABSTRACT

Drought is a natural disaster that develops slowly but has a huge impact. The distribution of water resources and precipitation is uneven worldwide, and water is a cycle. Turkey is located in a semiarid/semihumid climatic region, and if a drought disaster occurs, different regions can be affected in various ways. Taking measures before a crisis occurs can delay or reduce the severity of disasters. Therefore, it is essential to harvest rainwater in suitable areas. Water harvesting techniques reduce the effects of water scarcity and drought by collecting rainwater in arid regions (Kuzucu, 2019: 577). The process of accumulating or storing rainwater falling on the surface in arid and semiarid areas with little or no precipitation is known as "water harvesting" (Oweis, et al., 2001: 3; Kuzucu 2013: 6). Water harvesting is a method that has been in use for 40–50 years in many arid regions worldwide. This method is particularly useful in deserts and dry areas with annual precipitation of 50–80 mm (Köksal, 2000; Kuzucu 2013: 3).

To ensure maximum efficiency in water harvesting projects, suitable areas are identified using multicriteria decision methods, remote sensing, and geographic information systems. By conserving water, it is possible to achieve positive effects such as reducing the severity of drought or delaying its onset.

Long-range meteorology bulletin, monthly, annual, and average data of precipitation and temperature parameters of Finike Meteorology Station, located in the lower part of the Akçay basin, were obtained from the   GDM in 4 region.

A location map that denotes the study area's boundaries and location along with topography, slope, hydrology, soil, and land use maps was obtained from General Directorate of Maps (GDM). A temperature distribution map was created using the Lapse rate formula in the ArcGIS 10.5 program, and precipitation distribution maps were created using Kriging analysis.

The standardized precipitation index (SPI) is the most used index to determine drought conditions in any region (Türkeş, 2012: 15). Using the method developed by Mckee et al., (1993), the SPI value is calculated by converting the precipitation value into a numerical value (Arslan et al., 2016: 190). This index can be calculated for different periods, such as 1, 3, 6, 9, 12, and 48 months. To accurately calculate SPI values, at least 30 years of data are necessary (Mckee et al., 1993; Arslan et al., 2016: 191). To ensure accuracy, 51 years of data (1970–2021) were used in this study, and the "SPI SL 6.exe" program was used for calculation.

The analytical hierarchy process (AHP) method is the most used method for eligibility analysis (Güler and Yomralıoğlu, 2017; Uyan, 2017; Gürkan et al., 2021; Ödeker and Bayar, 2021; Akıncı et al., 2015; Ertunç and Çay, 2020; Akıncı et al., 2012; Yalçın and Yüce, 2018). Herein, six criteria were first determined using the AHP method: slope, land use, geology, stream distance, rainfall, and temperature. To evaluate the importance of these criteria, 15 comparative matrices were created, and 10 experts were asked to complete a questionnaire using Saaty's 1–9 scale. The geometric averages of the completed questionnaires were used to calculate consistency and weight ratios. The "Super Decisions" program was utilized to determine the weights of each criterion. These weights were then used in the reclassification process of the maps using the ArcGIS 10.5 program. The resulting "Reclassified" maps were overlapped with the "Weighted Overlay" analysis to identify suitable potential areas using spatial analysis.

This study utilized various methods and techniques. The standardized precipitation index was used to examine drought, and an annual average drought analysis was conducted for the basin. Suitability analysis methods were employed to identify potential areas for water harvesting. The analytical hierarchy process, a multicriteria decision-making method, played a crucial role in this study. This method helped determine the criteria and their weights, creating a vector of priorities. Criteria classification was done using the obtained weight values and geographic information systems, and a map showing suitable areas was generated using the weighted overlay method.

Based on data from the Finike Meteorology Station, the annual average drought analysis of the standardized precipitation index between 1973 and 2021 showed that the area was neither completely dry nor completely humid. However, the last three years had more severe dry periods compared to previous years.

Geographic information systems were used to determine potential areas for water harvesting and conduct spatial analysis. However, it is important to note that these systems require additional methods, such as analytical hierarchy, to support them. Herein, criteria were determined, expert opinions were used to determine their weights, classification was performed, and then weighted overlapping analysis was applied. This led to the identification of strong suitable areas, moderately suitable areas, low-level suitable areas, and unsuitable areas in the Akçay basin for water harvesting.

1. GİRİŞ

Yerkürenin yapısı ve canlıların yaşamlarını devam ettirebilmesi için suyun önemi büyüktür. Kuraklık, yağışların uzunca yıllar boyunca gözlemlenen oranından daha da az yeryüzüne düşmesi olarak bilinmektedir. Su kaynakları su ihtiyacını karşılayamaz hale geldiğinde kuraklık ortaya çıkmaktadır. Bazen yalnızca bir mevsim sürüp, sadece az bir alanı etkilerken, iklim kayıtları kuraklığın bazı durumlarda uzunca yıllar devam edebileceğini ve çok geniş alanları etkileyebileceğini göstermektedir (Turan, 2018: 64). Kuraklık yavaş gelişen fakat etkisi çok büyük olan bir doğal afettir. Su kaynakları ve yağışların, Dünya'nın her yerine eşit oranda dağılmamış olduğu ve suyun bir döngü halinde olduğu bilinmektedir. Dünya'daki toplam su miktarı 1,4 milyar km^3'tür. Bu suların %97,5'i okyanuslarda ve denizlerde tuzlu su olarak, %2,5'i ise nehir ve göllerde tatlı su olarak bulunmaktadır (Korkmaz vd., 2018: 52). Türkiye, yarı kurak/ yarı nemli iklim bölgesinde yer almaktadır. Herhangi bir kuraklık afeti yaşanacak olursa her bölge farklı boyutlarda etkilenecek potansiyele sahiptir.

İnsanlığın her geçen gün suya duyduğu ihtiyaçla, su kaynakları arasındaki fark büyük oranda açılmaktadır. İmalatta, sağlıkta, tarımda, tüketimde ve temizlikte olduğu gibi birçok alanda su kullanılmaktadır. Nüfusun artmasıyla birlikte suya duyulan ihtiyaç sürekli artmakta ancak kaynaklar ise azalmaktadır. Küresel iklim değişikliği nedeniyle yağışların azalmasına bağlı olarak yer altı sularının azalması, göllerin kuruması ve akarsuların denize ulaşmadan kaybolması gelecekte ciddi oranda su kıtlığı yaşanacağının göstergeleridir.

Yağış olmayan veya çok az olan kurak ve yarı kurak alanlarda yeryüzüne düşen yağmur sularının yerinde biriktirilmesi veya depolanması işlemi "su hasadı" olarak tanımlanır (Oweis, vd., 2001:3; Kuzucu 2013:6). Su hasadı 4500 yıl kadar önceki Akdeniz medeniyetleri zamanında kullanılan ve 40–50 yıldan beri de dünyanın birçok kurak bölgesinde uygulanmakta olan bir yöntemdir. Bu yöntem özellikle yıllık yağışı 50–80 mm olan çöllerde ve çok kurak alanlarda kullanılmaktadır (Köksal, 2000; Kuzucu 2013:3). Su hasadı, genel anlamda tanımlanacak olursa çatılardan, toprak yüzeylerinden veya havzalardan basit teknikler ile yağmur sularının tutulması, depolanması olarak açıklanmaktadır (Örs, vd., 2011:66). Su hasadı, yeryüzü ve yeraltı su kaynaklarının bulunmadığı alanlarda güvenilir, sağlıklı, temiz su avantajını sunmaktadır. Bu doğrultuda, yağışın yetersiz olduğu çayır alanlarında ve ekilebilir tarım arazilerinde verimliliği yükseltmek, ekolojik düzenin bozulmamasını

sağlamak, ağaçlandırma ile çölleşmeyle mücadele etmek, meyve ve diğer ağaçların yetiştirilmesi; hayvanlar için içme suyu ihtiyacı ve evsel su ihtiyacının giderilmesi konuları da su hasadı yönteminin uygulanma nedeni olarak sayılabilir. Su hasadı tekniğinde su depolama alanları çatı, bahçe, meydanlar ve caddeler, küçük toprak yüzeyleri, az eğimli bölgeler ve mevsimlik akarsuları besleyen büyük havzalardır. Su depolama ortamı ise yeraltında su tutma ve toprak yüzeyinde su tutma olarak iki kategoriye ayrılır. Yeraltında yapılan su hasadında sediment, toprak ve sarnıçlar kullanılırken, yeryüzünde yapılan su hasadında yine sarnıçlar, rezervuarlar, su tankları ve havuz kullanılmaktadır (Pamuk Mengü ve Akkuzu, 2008:79). Su hasadı, H.J.Geddes (1965) tarafından tarım sektöründe kullanılmıştır. Nehirlerde, derelerde veya akış halinde olan herhangi bir suyun ikinci kez kullanılabildiğini göstermek için uygulanan bir teknik olarak gelişmiştir. Bu yöntem su hasadı terimiyle kullanılmamış olsa da çok eski tarihlerden beri kullanılan bir yöntem olarak bilinmektedir (Pekin Timur vd., 2012: 170; Suresh, 2000: 951).

Su hasadı konusunda çok kriterli karar verme yöntemleri, uzaktan algılama ve coğrafi bilgi sistemleri analizleri gibi farklı araştırma yöntemleri kullanılmaktadır. Su hasadı araştırmalarında ana hedef daha fazla oranda su tasarrufu yapılarak, birçok alanda bu suyun kullanımının sağlanması ve kuraklık şiddetinin azaltılıp afetin etkisini azaltmaktır. Mevcut çalışmada da Akçay havzası aşağı çığırının kuraklık özelliğinin açıklanması ve o bölgede yağmur suyunun depolanması (su hasadı) için potansiyel alanların belirlenmesi amaçlanmaktadır.

1.1. Araştırma Alanının Yeri ve Sınırları

Araştırma sahası olan Akçay havzası aşağı çığırı, Batı Akdeniz Bölümü'nün Akdeniz Bölgesinde, idari olarak Antalya ili sınırları içerisinde 36°18ı Kuzey enlemi ve 30°09ı Doğu boylamında yer alan Finike ilçesinde bulunmaktadır. Havza, il merkezinin 83 km batısında yer almaktadır. Akçay havzası aşağı çığırının doğusunda Kumluca, batısında Demre ve Kaş, kuzeyinde Elmalı ilçeleri, güneyinde ise Akdeniz yer almaktadır. (**Şekil 1**).

Uzunluğu 33 km olan ve Finike'nin Başgöz Köyü'nden doğan Akçay, Yazır Köyü'nden bir kol ile beslendikten sonra Gökçe ve Tocak dağlarından gelen çayı kendi bünyesine alarak Finike ovasını sulamaktadır. Akçay Çayı doğduğu köyün de adını aldığı Başgöz Çayı olarak da tanınmaktadır ve Turunçova çevresinde bulunan Tekke Pınarlarının da dahil olmasıyla genişleyip Finike Ovasını geçerek Finike'den Akdeniz'e ulaşır (**Şekil 1**). Finike Ovası içerisinde geniş bir yatağa sahiptir ve ova

içinde genellikle çakıllı ve kumlu bir yapı gösterir (TC. Tarım ve Orman Bakanlığı, 2019).

Yoğun yağış alan, Batı Akdeniz'de bulunan Alakır ve Akçay akarsularının hem akış özellikleri hem de akış gösterdikleri alanda yerleşim ve tarım alanlarının bulunması dolayısıyla su hasadı gibi önemli bir konunun bu alanda çalışılmasının daha etkili ve doğru olacağı düşünülmüştür. Çalışma alanının "Akçay havzasının aşağı çığırı" olarak sınırlandırılmasının nedeni ise aşağı çığırının Finike ilçe sınırları içerisinde kalmasıdır. Bu durum ile araştırmanın daha spesifik ve detaylı olması amaçlanmıştır. Böylece daha hassas verilerin üretileceği kanısına varılmıştır.

Şekil 1: Akçay havzası aşağı çığırı lokasyon haritası
Figure 11: Akçay basin downstream location map

2. MATERYAL VE YÖNTEM

Çalışma alanının iklim özellikleri incelenirken Akçay havzasının aşağı çığırında bulunan Finike Meteoroloji İstasyonunun uzun yıllık meteoroloji bülteni, yağış ve sıcaklık

gibi parametrelerin aylık, yıllık, ortalama verileri elde edilmiştir. Elde edilen veriler ile "MS Excel programı" üzerinden meteorolojik verilerin tablo ve grafikleri oluşturulmuştur.

HGM (Harita Genel Müdürlüğü)'den elde edilen 1/25.000'lik haritalar ile "ArcGIS 10.5 programı" üzerinden lokasyon, eğim, hidrografya, toprak ve arazi kullanım haritaları yapılmıştır. Alanın iklimi hakkında bilgi veren sıcaklık dağılış haritası için aynı program üzerinden Lapse rate formülü ile Kriging analiz yöntemi, yağış dağılış haritası için Schreiber formülü ile Kriging analiz yöntemi kullanılarak sıcaklık ve yağış dağılış haritaları oluşturulmuştur.

Tablo 1: Çalışmada kullanılan materyal ve yöntem adımları tablosu.
Table 1: Table of materials and method steps used in the study.

Çalışamada Kullanılan Materyal ve Yöntem Adımları		
Standartlaştırılmış Yağış İndisi (SYİ)	**Analitik Hiyerarşi Prosesi (AHP)**	**Coğrafi Bilgi Sistemleri (CBS)**
"SPI SL 6.exe" programı kullanılarak çalışma alanının kuraklık analizi yapılmıştır.	"Super Decisions" programı kullanılarak belirlenen kriterlerin ağırlık oranları hesaplanmıştır.	"ArcGIS 10.5" programı kullanılarak haritaların reclassify işlemi yapılmıştır. Daha sonra yine aynı program üzerinden mekansal analiz için Ağırlık Bindirme (Weighted Overlay) işlemi uygulanmıştır.

Akçay havzasının aşağı çığırının kuraklık özelliğinin belirlenmesinde Standartlaştırılmış Yağış İndisi (SYİ) yöntemi kullanılmıştır. Herhangi bir bölgenin kuraklık özelliğinin belirlenmesinde kullanılan en yaygın indisin SYİ olduğu bilinmektedir (Türkeş, 2012: 15). Mckee vd., (1993) tarafından geliştirilen yöntemde SYİ değeri yağış değerinin sayısal bir değere dönüştürülmesi ile hesaplanmaktadır (Arslan vd., 2016: 190).

Burada; Xi, belli bir periyot için toplam yağışı (mm),
Xort, aynı periyot için ortalama toplam yağışı (mm),
σ ise standart sapmayı göstermektedir.

$$SY\dot{I} = \frac{X_i - X_{ort}}{\sigma}$$

Standartlaştırılmış yağış indisi değerleri farklı periyotlar (1, 3, 6, 9, 12, 48 gibi) için hesaplanabilirler. Ancak yağış verileri 12 ay ve daha kısa dilimlerde normal dağılıma uymayabilirler. Bu nedenle çalışılan konuda 48 aylık dilim dikkate alınmıştır ve her bir veri seti Gamma fonksiyonuna uydurulmuştur. Standartlaştırılmış yağış indisi değerlerinin doğru bir şekilde hesaplanabilmesi için en az 30 yıllık veriye ihtiyaç duyulduğu belirtilmiştir (Mckee vd., 1993; Arslan vd., 2016: 191).
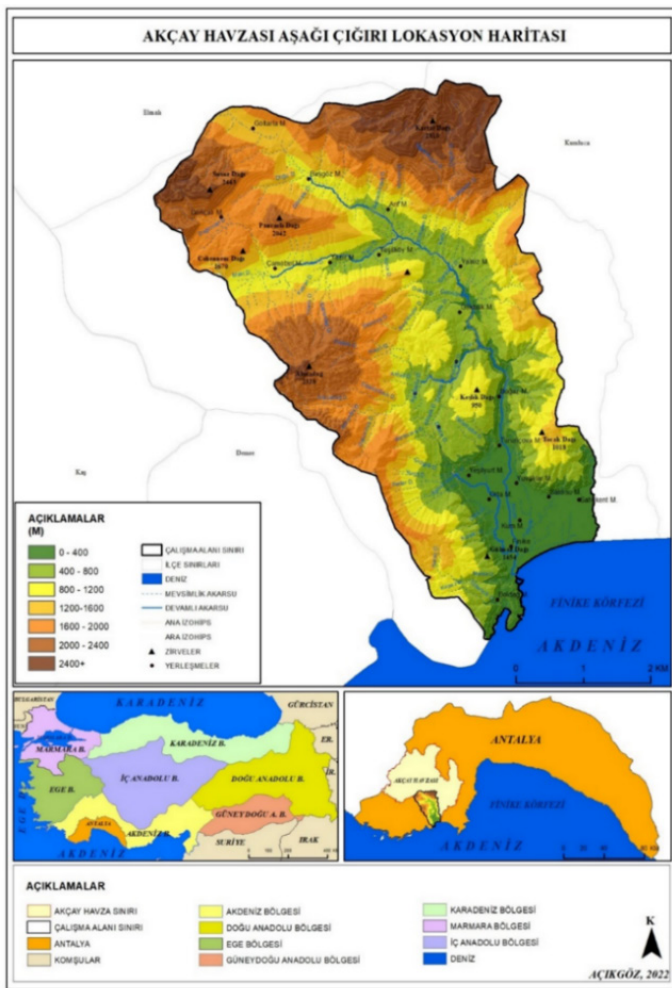
Bu nedenle bu çalışmada 51 yıllık veri (1970-2021) kullanılmış ve hesaplamalar da "SPI SL 6.exe" programı kullanılarak yapılmıştır. Elde edilen değerler "MS Excel" programı ile grafik haline getirilmiştir.

Yer uygunluk analizi çalışmalarında ise literatür taraması sonucunda en fazla Analitik Hiyerarşi Prosesi (AHP) yönteminin kullanıldığı tespit edilmiştir (Güler ve Yomralıoğlu, 2017; Uyan, 2017; Gürkan vd., 2021; Ödeker ve Bayar, 2021; Akıncı vd., 2015; Ertunç ve Çay, 2020; Akıncı vd., 2012; Yalçın ve Yüce, 2018). Bu yöntemle öncelikle amaç veya hedefler belirlenir sonrasında kriterler belirlenir ve daha sonra gerekirse alternatifler belirlenir ve hiyerarşik yapı oluşturulur (Tablo 3.2). Oluşturulan her bir kriter ile ilgili değişen önem derecelerinin belirlenmesinde karar vericiye ihtiyaç duyan bir teknik olmasından kaynaklı olarak önceden belirlenen kriterlerinin karar verici (uzman) tarafından göreceli önemlerinin belirlenmesine ve daha sonra her bir kritere göre karar alternatiflerinin belirlenmesini sağlamaktadır. Her bir kriter uzman görüşü tarafından değerlendirildikten sonra kriterlerin göreceli önem derecelerini gösteren ikili karşılaştırma matrisi üstünlüklerin belirlenmesi amacıyla uygulanır, tutarlılık oranları hesaplanır ve o anketin kullanılabilir olup olmadığı tespit edilir. Tutarlılık oranı kabul edilebilir düzeyde ise kriterlerin öncelik sıralaması belirlenmektedir. Böylece en yüksek değeri elde eden kriterden, en düşük değeri elde eden kritere doğru bir sıralama oluşturulmaktadır (Esen, 2008:499; Önder ve Önder, 2013:198; Yılmaz, 2010: 210; Ömürbek ve Şimşek, 2014: 308).

Bu yöntem ile yapılacak analiz için çalışma alanına uygun 6 kriter belirlenmiştir. Belirlenen kriterler; "eğim, arazi kullanımı, jeoloji, akarsu mesafe, yağış miktarı ve sıcaklık" olmuştur. Kriterlerin 15 adet karşılaştırmalı matrisi oluşturulmuş ve 10 uzman görüşten Saaty'nin 1 ve 9 ölçeğinde önem derecesine göre anketi doldurmaları istenmiştir. Doldurulan anketin geometrik ortalamaları alınmıştır (Tablo 1).

Ağırlıkların hesaplanmasının ardından anketin tutarlılık oranı hesaplanmıştır. Tutarlılık 0.10 dan küçük bir değer çıkarsa geçerli anket olduğu anlaşılmaktadır (Saaty, 1977). Yapılan çalışmanın da tutarlılık oranı 0.09 şeklinde hesaplanmış ve geçerli olduğu tespit edilmiştir. Tutarlılık formülü aşağıdaki gibidir.

$$Tutarlılık\ Oranı(CR) = \frac{Tutarlılık\ Göstergesi\left(CI = \frac{\lambda max - n}{n-1}\right)}{Rassallık\ Göstergesi\ (RI)}$$

Tutarlılık oranı, tutarlılık oranının (CI) rassal indis değerine (RI) bölünmesiyle hesaplanır. Rassal indis (RI) değeri 1'den 9'a ölçeklendirilmiş rastlantısal ters matris ile yapılmaktadır (Saaty, 1980; Alkay, 2014: 141). Matris geneline bakıldığında her satırı için, sütunlardaki kriterler, toplam sütun ağırlığına bölünmüş ve normalize edilmiştir. Oluşturulan bu matrisin her satırının ortalaması alınarak ağırlıklara göre öncelikler vektörü oluşturulmuştur. Öncelikler vektörü ikili karşılaştırma matrisi ile çarpılarak öncelikler matrisi elde edilmiştir. Öncelikler matrisinde her satır toplamı öncelikler vektörüne bölünerek "λmax" değerine ulaşılmıştır.

Tablo 2: Geometrik ortalaması alınmış kriter tablosu.
Table 2: Geometric averaged criteria table.

Kriterler																		
Arazi Kullanımı	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Akarsu Mesafe
Arazi Kullanımı	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Eğim
Arazi Kullanımı	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Jeoloji
Arazi Kullanımı	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Sıcaklık
Arazi Kullanımı	9	8	7	6	5	4	3	2	1	2	3	4	5	6	**7**	8	9	Yağış Miktarı
Akarsu Mesafe	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Eğim
Akarsu Mesafe	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Jeoloji
Akarsu Mesafe	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Sıcaklık
Akarsu Mesafe	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Yağış Miktarı
Eğim	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Jeoloji
Eğim	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Sıcaklık
Eğim	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Yağış Miktarı
Jeoloji	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Sıcaklık
Jeoloji	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Yağış Miktarı
Sıcaklık	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Yağış Miktarı

Formülde bulunan "n" değeri kriter sayısına karşılık gelirken, rastgele değer indeksi kriter sayısına göre oluşturulmaktadır (Ödeker ve Bakar, 2021: 128).

Anketin kriter ağırlıkları ve öncelik vektörü **tablo 2**'teki gibidir.

Tablo 3: Kriter ağırlıkları tablosu.
Table 3: Table of criterion weights.

Kriter Ağırlıkları	
1. Yağış Miktarı	0.45
2. Eğim	0.18
3. Akarsu Mesafe	0.17
4. Jeoloji	0.10
5. Sıcaklık	0.06
6. Arazi Kullanımı	0.04

Çalışmanın ağırlık ve tutarlılık hesaplamalarında "Super Decisions" programı kullanılmıştır. Elde edilen kriter ağırlıkları, ArcGIS 10.5 programı aracılığı ile haritaların yeniden sınıflandırılması işleminde kullanılmıştır. Yeniden sınıflandırılmış (Reclassify)" haritalar daha sonra Ağırlıklı Bindirme (Weighted Overlay) analizi ile çakıştırılarak uygun potansiyel alanların mekânsal analizinin yapılması için altlık oluşturulmuştur. AHP analizi için izlenen tüm adımlar sırasıyla **tablo 3**'teki gibidir.

3. BULGULAR

3.1. Akçay Çayı Havzası Aşağı Çığırının Standartlaştırılmış Yağış İndisine Göre Kuraklık Analizi

Standartlaştırılmış yağış indisi, bir bölgedeki yağışın belirli bir zamanda ortalamadan çıkarılıp standart sapmaya bölünmesi ile analiz edilmesidir. En az 30 yıllık yağışlar ele alınarak, bu yağışların 1, 3, 6, 12, 24, 48 aylık vb. zaman periyodlarında toplam yağışlar üzerinden yapılan işlemlerle veriye ulaşılması amaçlanır (McKee vd., 1993; İrcan ve Duman, 2021:7).

Standartlaştırılmış yağış indisi değerleri, yağış ile düzenli olarak artan veya azalan bir eğilim sergiler. Seçilen zaman dilimi içerisinde SYİ değerlerinin sonucuna bakılarak, kurak dönemler ve nemli dönemler mevcuttur. SYİ değerleri göz önüne alınarak yapılan kuraklık analizinde indeksin devamlı olarak negatif değerde olduğu dönem kurak dönem olarak açıklanmaktadır. Yapılan analizlerde değerlerin sıfırın altına ilk düştüğü dönem kuraklığın başlangıcı olarak belirlenirken, analizin pozitif değere ulaştığı ay kuraklığın sonu olarak açıklanmaktadır (**Tablo 4**) (Özgün, vd., 2020: 878).

1973-2021 yılları arasında Finike istasyonu verilerine göre standartlaştırılmış yağış indisi analizi yapılmıştır (**Şekil 2**). Elde

Tablo 4: Çalışmada uygulanan AHP ve uygunluk analizi adımlarının tablosu.
Table 4: Table of AHP and fitness analysis steps applied in the study.

Akçay Havzası Aşağı Çığırında Su Hasadı Yapılabilecek Potansiyel Alanların Belirlenmesi					
Kriterler					
1. Eğim	2. Arazi Kullanımı	3. Jeoloji	4. Akarsu Mesafe	5. Yağış Miktarı	6. Sıcaklık
Alternatifler					
1.1. Tam Düzlük	2.1. Tarım Alanı	3.1. Alüvyon	4.1. 0-50m	5.1. 741-1000mm	6.1. 6-10 °C
1.2. Dalgalı Düzlük	2.2. Bağ ve Meyvelik Alan	3.2. Kiltaşı	4.2. 50-100m	5.2. 1000-1250mm	6.2. 10-12 °C
1.3. Az Eğimli Yamaç	2.3. Yerleşim Alanı	3.3. Konglomera, Kum ve Kiltaşı	4.3. 100-200m	5.3. 1250-1500mm	6.3. 12-14 °C
1.4. Eğimli ve Dik Yamaç	2.4. Çayır ve Meralık Alan	3.4. Kireçtaşı	4.4. 200-300m	5.4. 1500-1750mm	6.4. 14-16 °C
1.5. Çok Dik Yamaç	2.5. Ormanlık Alan	3.5. Talus	4.5. 300m ve üzeri	5.5. 1750mm ve üzeri	6.5. 16 °C ve üzeri

1. İkili karşılaştırma matrislerinin oluşturulması, uzman görüş tarafından doldurulması, hesaplamalarının yapılması

2. Analitik hiyerarşi süreci ve kriter ağırlıklarının hesaplanması

3. CBS ile yeniden sınıflandırma (Reclassify) ve Çakıştırma analizi (Weighted Overlay)

4. Akçay Havzası Aşağı Çığırında Su Hasadı Yapılabilecek Potansiyel Alanlar Haritası

edilen verilerde 1973 yılından 2021 yılına kadar kurak dönemler ve nemli dönemler yaşanmış olup, dönem dönem dalgalanmalar görülmüştür. 1973 de -1,55 değerinde şiddetli kurak dönem yaşanmışken, 1976-1977 yılına kadar giderek azalan kurak dönemler yaşanmıştır.

1978'de 0,35 ile 1979'da -0,0 değeri ile normal civarı dönemler yaşanmıştır. Kurak dönemlerden sonra 1978 ile normal civarı dönemler 1986 yılına kadar sürmüştür. 1983'te 1,18 değer ile orta nemli dönem yaşanmıştır.

Daha sonra 1987 yılı itibariyle 1998 yılına kadar negatif değerde dönemler yaşanmış olup 1992 yılında -2,03 değeri ile olağanüstü kurak dönem yaşanmıştır. Bu tarihler aralığında en az negatif değere sahip yıl ise 1998 yılı olarak belirlenerek -0,18 ile normal civarı dönem olarak açıklanmaktadır.

Tablo 5: SYİ metoduna göre indeks değerleri ve sınıflandırma tablosu.
Table 5: Index values and classification table by SPI method.

SYİ Değeri	Sınıflandırma
2.0 ve fazla	Olağanüstü Nemli
1.60 ile 1.99	Aşırı Nemli
1.30 ile 1.59	Çok Nemli
0.80 ile 1.29	Orta Nemli
0.51 ile 0.79	Hafif Nemli
0.50 ile -0.50	Normal Civarı Nemli
-0.51 ile -0.79	Hafif Kurak
-0.80 ile -1.29	Orta Kurak
-1.30 ile -1.59	Şiddetli Kurak
-1.60 ile -1.99	Çok Şiddetli Kurak
-2 ve düşük	Olağanüstü Kurak

1999 yılı 0,10, 2000 yılı -0,11, 2001 yılı 0,07, 2002 yılı 0,49 değerler ile normal civarı dönem yaşanmıştır. 2003-2008 yılları arasında pozitif değerler gözlemlenerek, en yüksek değer 2005 yılında 2,46 ile olağanüstü nemli dönem olarak tespit edilmiştir. 2009 yılında tekrar negatif döneme dönse de -0,06 değeri ile normal civarı dönem yaşanmıştır.

Daha sonra 2010- 2016 yılları arası yine pozitif dönem olarak ilerlemiştir. Bu dönem içerisinde en yüksek nemlilik oranına sahip yıl ise 2013 yılıdır. 1,06 değeri ile orta nemli dönem olarak değerlendirilmektedir. En düşük nemlilik oranına sahip yıl ise 0,06 değeri ile 2016 yılı, normal civarı olarak belirlenmiştir. 2017 yılından 2021 yılına kadar ise negatif değerler görülmüştür. En yüksek negatif değer -0,94 ile 2019 yılı, orta kurak dönem olarak adlandırılır. En az negatif değere sahip yıl ise 2017 yılında gözlemlenmiş olup, -0,51 ile hafif kurak olarak adlandırılmaktadır. Ölçülen ve değerlendirilen son yıl ise 2021'de -0,80 ile negatif değer görülmüş olup orta kurak dönem olarak değerlendirilmiştir.

Şekil 3'te 2005-2021 yılları arasında standartlaştırılmış yağış indisi analizinin kış mevsimi ortalamaları verilmiştir. Bu tabloya göre verilen değerlerde eksiye inilerek kurak dönemler görülmemiştir.

2005 yılında 0,08; 2006 yılında 0,25; 2007 yılında; 0,18; 2008 yılında 0,19; 2009 yılında 0,43 değerler ile normal civarı kuraklık durumu var iken, 2010 yılında 0,75 ile hafif nemli bir yıl olduğu analiz edilmiştir. 2011 yılında 0,90; 2012 yılında 1,22 ile orta nemli; 2013 yılında 1,39; 2014 yılında 1,40; 2015 yılında
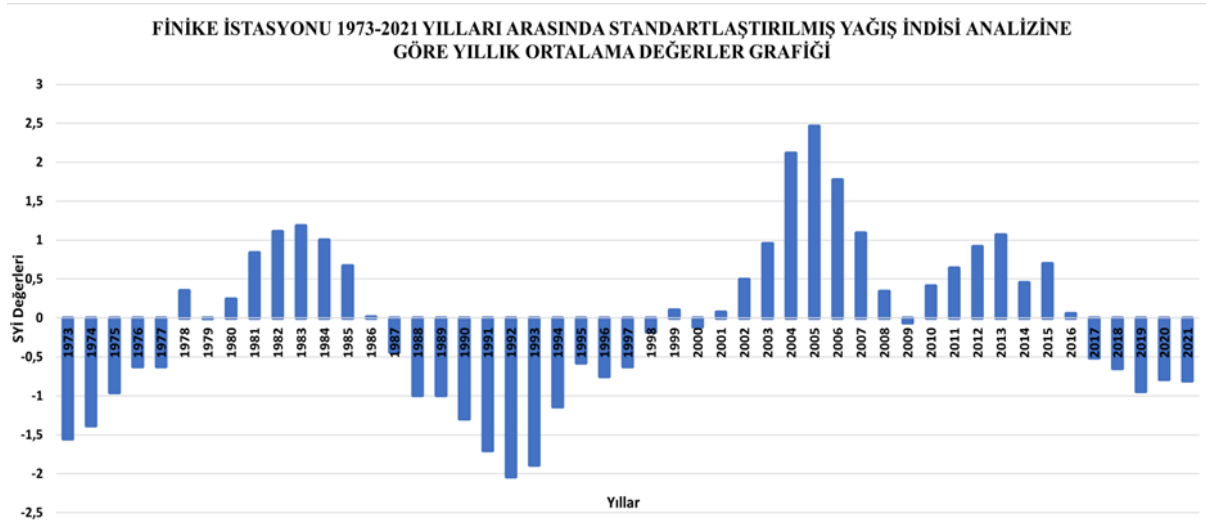
Şekil 2: Finike Meteoroloji İstasyonu 1973-2021 yılları arası standartlaştırılmış yağış indisi analizine göre yıllık ortalama kuraklık durumu grafiği

Figure 2: Annual average drought situation graph according to standardized precipitation index analysis of Finike Meteorology Station between 1973-2021.
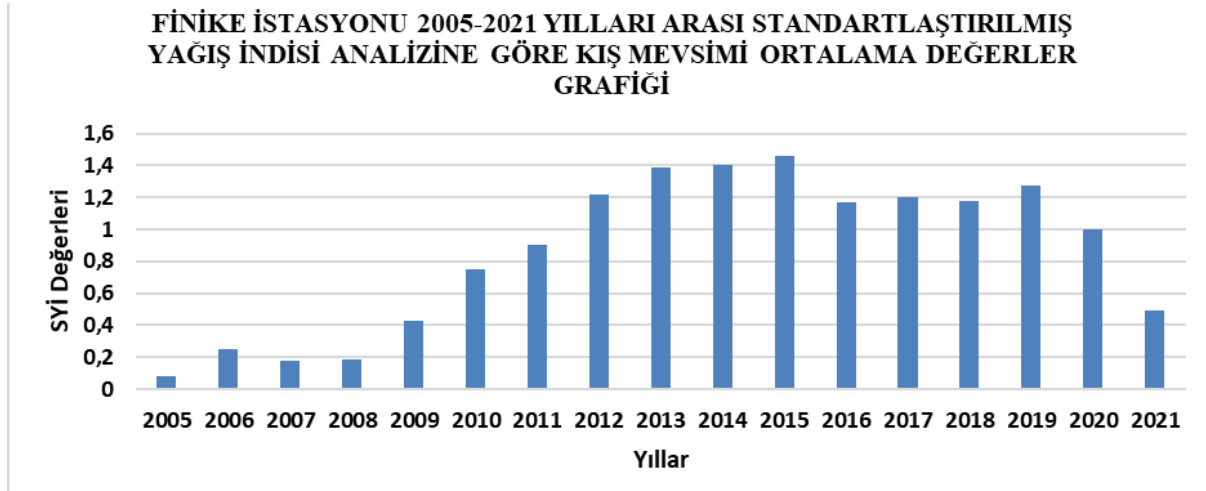
Şekil 3: Finike Meteoroloji İstasyonu 2005-2021 yılları arası standartlaştırılmış yağış indisi
analizine göre kış mevsimi ortalama kuraklık durumu grafiği
*Figure 3: Winter season average drought situation graph according to the standardized precipitation
index analysis of Finike Meteorology Station between 2005-2021*

1,46 ile çok nemli; 2016 yılında 1,17; 2017 yılında 1,20; 2018 yılında 1,18; 2019 yılında 1,27; 2020 yılında 1 kuraklık değeri ile orta nemli dönemler yaşanmışken 2021 yılında ise 0,49 ile normal civarı kuraklık durumu saptanmıştır.

Şekil 4'te 1985- 2021 yılları arasındaki standartlaştırılmış yağış indisi analizinin yaz mevsimi ortalamaları verilmiştir. Tabloya bakıldığında eksi değerler ve artı değerler, iniş çıkış durumu söz konusudur. 1985 yılında -0,65; 1986 yılında -0,59 ile hafif kurak dönemler yaşanmıştır. 1987 yılında -0,16; 1988 yılında -0,31; 1989 yılında -0,39; 1990 yılında -0,46; 1991 yılında -0,17 ile normal civarı dönemler yaşanmıştır. 1992 yılında 0,70; 1993 yılında 0,54 ile hafif nemli bir dönem, 1994

yılında 0,26; 1995 yılında 0,27; 1996 yılında 0,37 ile normal civarı dönemler yaşanmıştır.

1997 yılında 0,66 ile hafif nemli; 1998 yılında 0,24; 1999 yılında -0,21; 2000 yılında -0,19; 2001 yılında -0,18; 2002 yılında 0,14 kuraklık değerleri ile normal civarı kuraklık durumu analiz edilmiştir. 2003 yılında 1,28 ile hafif nemli bir dönem, 2004 yılında ise 1,08 ile orta nemli dönem yaşanmıştır. 2005 yılında 1,76; 2006 yılında 1,74 değer ile aşırı nemli bir dönem yaşanmıştır. 2007 yılında 1,44 ile çok nemli; 2008 yılında 0,42; 2009 yılında 0,34; 2010 yılında 0,29; 2011 yılında 0,10; 2012 yılında 0,07; 2013 yılında -0,19; 2014 yılında 0,20; 2015 yılında 0,20; 2016 yılında -0,22; 2017 yılında -0,19; 2018 yılında -0,05
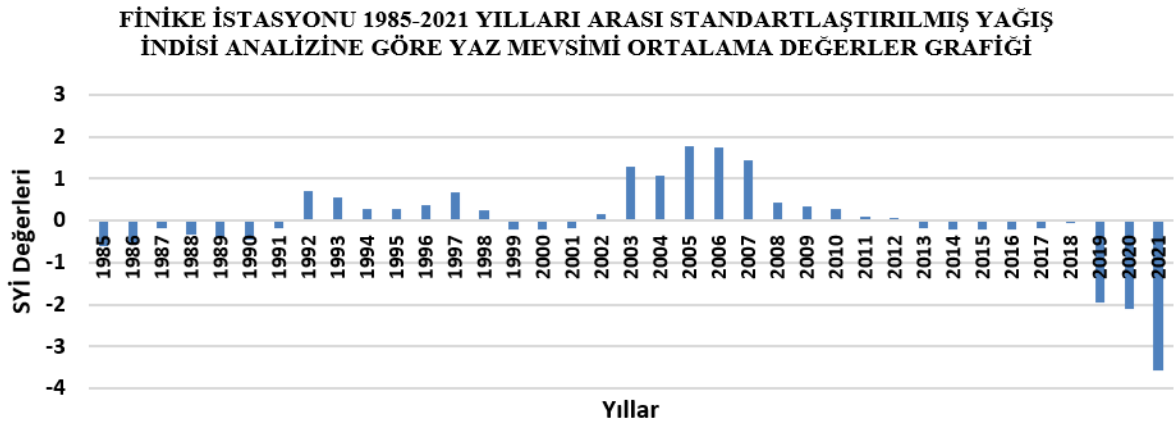
Şekil 4: Finike Meteoroloji İstasyonu 1985- 2021 yılları arası standartlaştırılmış yağış indisi
analizine göre yaz mevsimi ortalama kuraklık durumu grafiği
*Figure 4: Summer season average drought situation graph according to the standardized precipitation
index analysis of Finike Meteorology Station between 1985 and 2021*

ile normal civarı durum seyrederken, 2019 -1,95 ile çok şiddetli kurak dönem yaşanmıştır. 2020 yılında -2,10; 2021 yılında ise -3,57 ile olağanüstü kurak dönemler yaşanmıştır.

3.2. Akçay Çayı Havzası Aşağı Çığırında Su Hasadı Yapılacak Alanları Belirleme Analizi

3.2.1. Analitik Hiyerarşi Süreci (AHP)

Analitik Hiyerarşi Prosesi (AHP), çok kriterli karar verme yöntemlerinden biridir ve birden fazla nicel veya nitel kriterin karmaşık problemlerine çözüm sunmak amacıyla oluşturulmuştur. İlk olarak 1970'li yılların başında, Thomas L. Saaty tarafından Wharton School of Business'da karmaşık çok kriterli karar verme problemlerinin çözümü için geliştirilmiştir. Uygulaması kolay olan analitik hiyerarşi tekniğinin kritik öneme sahip noktası, sayısal olarak belirlenebilecek objektif yargılar ile sübjektif nitelikli yargıları bir arada bulundurabilmesidir (Önder ve Önder, 2013: 198; Ömürbek ve Şimşek, 2014: 308).

Mevcut çalışmada da öncelikli olarak amaç belirlenmiştir. Temel amaç Akçay havzası aşağı çığırının (Finike/ Antalya) su hasadı yapılabilecek potansiyel alanlarının belirlenmesidir. Amaç belirlendikten sonra problemin çözümü odaklı olarak hiyerarşik tablo oluşturulmuştur (**Tablo 5**).

Oluşturulan hiyerarşik tabloya amaç ve alt kriterler eklenir. Birçok literatürden de elde edilen bilgiler dahilinde havzalarda yapılan su hasadı çalışmalarında en fazla tercih edilen coğrafi

faktörlerin eğim, arazi kullanımı, jeoloji, akarsuyun su hasadı yapılacak olan alana mesafesi, yağış miktarı ve sıcaklık faktörü olduğu belirlenmiştir (Michael Ward, vd., 2021; Ammar Adham, vd., 2016; Şanlısoy, 2002; Imzahim A. Alwan, vd., 2020; Shaho Khorsheed NOORI, 2021; Centre for Development and Environment, 2013).

İnceleme alanı için 6 kriter belirlenmiş olup, 15 tane ikili karşılaştırma matrisi oluşturulmuştur (**Şekil 5**).

Oluşturulan karşılaştırma matrisi 2 Profesör, 2 Doçent, 2 Doktor Öğretim Üyesi, 1 Öğretim Görevlisi, 2 Araştırma görevlisi ve 1 konuyu çalışan yüksek lisans öğrencisi tarafından cevaplanarak toplamda 10 uzman görüş yardımıyla 1 ve 9 arasında ölçeklendirilerek önem dereceleri karşılaştırılmış olup, uzman görüşlerin geometrik ortalamaları alınmıştır (**Tablo 6**) (**Şekil 5**).

Akçay havzasının aşağı çığırında su hasadı yapılabilecek potansiyel alanların belirlenmesi amacıyla oluşturulan karşılaştırma matrisi ile akarsu mesafe faktörünün 5 ölçeğinde arazi kullanım faktörüne göre daha önemli, eğim faktörünün 6 ölçeğinde arazi kullanım faktörüne göre daha önemli, jeoloji faktörünün 3 ölçeğinde arazi kullanım faktörüne göre daha önemli, sıcaklık faktörünün 4 ölçeğinde arazi kullanım faktörüne göre daha önemli, yağış miktarı faktörünün 7 ölçeğinde arazi kullanım faktörüne göre daha önemli, eğim faktörünün ve akarsu mesafe faktörünün 1 ölçeğinde eşit olduğu, akarsu mesafe faktörünün 3 ölçeğinde jeolojiye göre daha önemli olduğu, akarsu mesafe

Tablo 6: AHP analizi için kullanılan kriterler.
Table 6: Criteria used for AHP analysis.
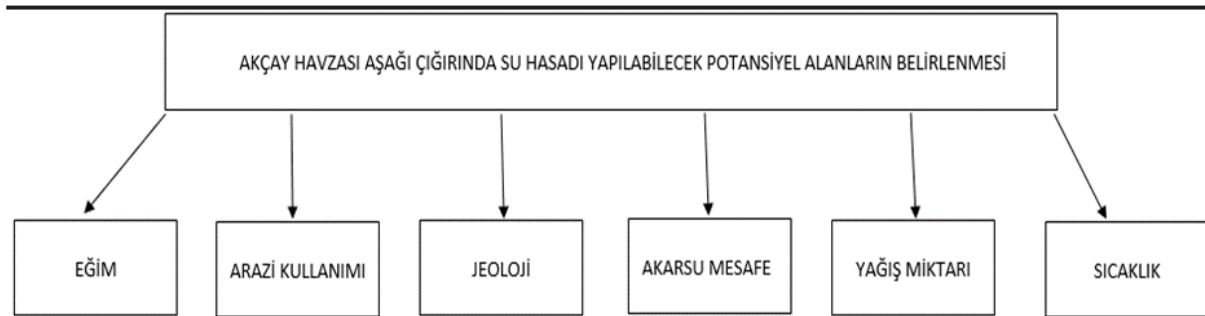
Tablo 7. Saaty'nin Ölçek Açıklama Tablosu (Saaty, 1990; Altunay, 2018: 26).
Table 7. Saaty's scale explanation table (Saaty, 1990; Altunay, 2018: 26).

Sayısal Değerler	Tanım	Açıklama
1	Eşit	Hedef için her iki kriterin de eşit önemde olması durumu.
3	Kısmen Önemli	Tecrübe ve yargılara göre bir kriterin diğerine göre güçlü şekilde desteklenmesi durumu.
5	Önemli	Tecrübe yargılara göre bir kriterin diğerine göre güçlü şekilde desteklenmesi durumu.
7	Çok Önemli	Kriterlerden birisinin güçlü bir şekilde tercih edilmesi ve bu durumun pratikte kanıtlanmış olması.
9	Kuvvetli Derecede Önemli	Bir kriterin diğerine göre güçlü olduğuna ilişkin güçlü kanıtlar olması durumu.
2, 4, 6, 8	İki bitişik yargı arasındaki ara değerler (uzlaşma değeri)	Tercih değerlerinin birbirine yakın olduğu uzlaşma gerektiren durumlarda kullanılır.

Şekil 5: Kriterlerin karşılaştırma matrisi ve geometrik ortalamaları
Figure 5: Comparison matrix and geometric mean of criteria

faktörünün 4 ölçeğinde sıcaklık faktöründen daha önemli olduğu, yağış miktarı faktörünün 5 ölçeğinde akarsu mesafe faktörüne göre daha önemli olduğu, eğim faktörünün 4 ölçeğinde jeoloji faktörüne göre daha önemli olduğu, eğim faktörünün 3 ölçeğinde sıcaklık faktörüne göre daha önemli olduğu, yağış miktarı faktörünün 4 ölçeğinde eğim faktörüne göre daha önemli olduğu, jeoloji faktörünün 4 ölçeğinde sıcaklık faktörüne karşı daha önemli olduğu, yağış miktarı faktörünün 4 ölçeğinde jeoloji faktörüne karşı daha önemli olduğu, yağış miktarının 6 ölçeğinde sıcaklık faktörüne karşı daha önemli olduğu uzman görüşlerinin geometrik ortalaması alınarak tespit edilmiştir.

Oluşturulan karşılaştırmalı matris sonucunda ise kriterlerin ağırlıkları "Super Desicions" programı ile hesaplanmıştır.

Şekil 6: Kriter ağırlıkları
Figure 6: Criterion weights

Hesaplanan kriter ağırlıkları ise 0.45 ağırlığı ile yağış miktarı faktörü en fazla değeri alan kriterdir. Yağış miktarı faktörünü takiben 0.18 ağırlık ile eğim faktörü gelmekte ve daha sonra 0.17 ağırlık değeri ile akarsu mesafe faktörü, daha sonra 0.10 ağırlığı ile jeoloji faktörü, daha sonra 0.06 ağırlığı ile sıcaklık faktörü, en az ağırlığa sahip faktör ise 0.04 ağırlığı ile arazi kullanım faktörü olduğu saptanmıştır (**Şekil 6**).

3.2.2. Ağırlıklı Çakıştırma Analizi

Ağırlıklı çakıştırma analizi (Weighted Overlay) herhangi bir projenin uygun yer seçiminde öncelikli olarak kullanılan analiz çeşitlerinden bir tanesidir. Bu analiz yöntemi kullanılırken coğrafi bilgi sistemlerinin, mekânsal uygunluğunu tespit etmemizi sağlayan araçlarından birisi olan ArcGIS-Arc Map 10.5 programından yararlanılmıştır. İlk olarak kriterlerin her birinin altlık haritaları olan; arazi kullanım haritası, eğim haritası, jeoloji haritası, drenaj yoğunluğu haritası, yağış dağılış haritası ve sıcaklık dağılış haritası oluşturulmuştur. Oluşturulan bu haritalar vektör haritalara dönüştürülmek için **3D Analyst Tools'undan, Raster Reclass Tool**'una ulaşarak reclassify ile sınıflandırılmıştır (**Şekil 7-12**). Sınıflandırılırken her bir kriterin alternatifleri 1-5 arasında puanlanmışlardır. Uygun olan alternatif değerleri için 5, ara değerler de uygunluk durumuna göre 4,3,2

Tablo 8: Ağırlıklı çakıştırma yönteminde kullanılan kriterlerin alternatifleri ve ağırlık dereceleri.
Table 8: Alternatives and weight grades of the criteria used in the weighted overlay method.

Temel Parametreler	Parametre Faktörleri	Ağırlık Sınıfları	Ağırlık Değerleri
Litoloji	Alüvyon (KUVATERNER)	Kuvvetli Önemli	5
	Kiltaşı (TRİAS)	Çok Önemli	4
	Konglomera-Kum-Ki-reçtaşı (MİOSEN)	Biraz Önemli	3
	Kireçtaşı (MESOZOİK)	Önemli	2
	Talus (KUVATERNER)	Önemsiz	1
Eğim (%)	0-20 (Tam Düzlük Alan)	Kuvvetli Önemli	5
	20-40 (Dalgalı Düzlük Alan)	Çok Önemli	4
	40-60 (Az Eğimli Yamaç)	Biraz Önemli	3
	60-80 (Eğimli ve Dik Yamaç)	Önemli	2
	80+ (Çok Dik Yamaç)	Önemsiz	1
Yağış (mm)	741-1000 mm	Kuvvetli Önemli	5
	1000-1250 mm	Çok Önemli	4
	1250-1500 mm	Biraz Önemli	3
	1500-1750 mm	Önemli	2
	1750+ mm	Önemsiz	1
Sıcaklık	6-10 °C	Kuvvetli Önemli	5
	10-12 °C	Çok Önemli	4
	12-14 °C	Biraz Önemli	3
	14-16 °C	Önemli	2
	16 + °C	Önemsiz	1
Arazi Kullanım	Tarım Alanı	Kuvvetli Önemli	5
	Bağcılık ve Meyvecilik	Çok Önemli	4
	Yerleşim Alanı	Biraz Önemli	3
	Çayır ve Meralık Alanlar	Önemli	2
	Orman	Önemsiz	1
	Kayalık Alanlar	Derecelendirilmedi	0
Akarsu Mesafe	0-50 m	Kuvvetli Önemli	5
	50-100 m	Çok Önemli	4
	100-200 m	Biraz Önemli	3
	200-300m	Önemli	2
	300+ m	Önemsiz	1

şeklinde puanlanmış ve uygun olmayan alternatif değerleri için 1 puanlaması yapılmıştır (**Tablo 7**).

5: Kuvvetli derecede önemli
4: Çok önemli
3: Biraz önemli
2: Önemli
1: Önemsiz

Sınıflandırılmış yağış haritasında;

Finike ovasından itibaren Yalnız Mahallesine kadar ortalama 741-1000 mm arası yağış görülmektedir. Asarönü Mahallesi, Alacadağ Mahallesi, Gökçeyaka Mahallesi, Gökbük Mahallesi, Yeşilköy Mahallesi, Arif Mahallesi ve Yazır Mahallesi ortalama 1000-1250
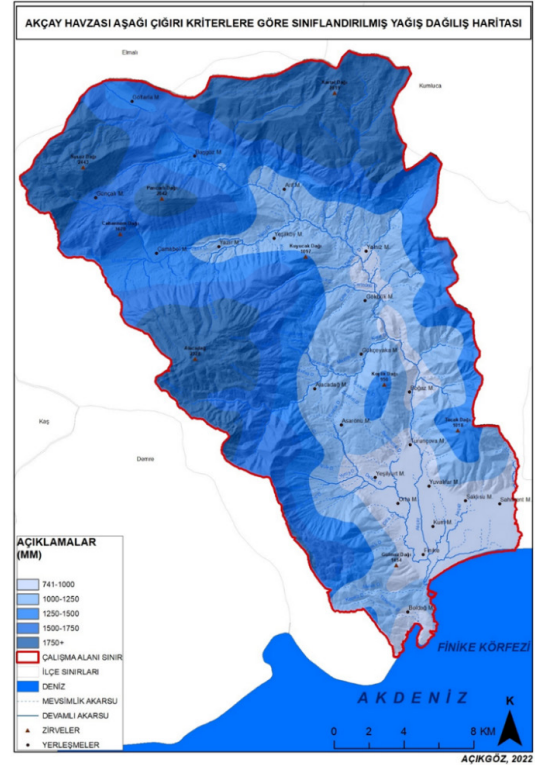
Şekil 7: Çalışma alanı yağış dağılış haritası
Figure 7: Study area precipitation distribution map
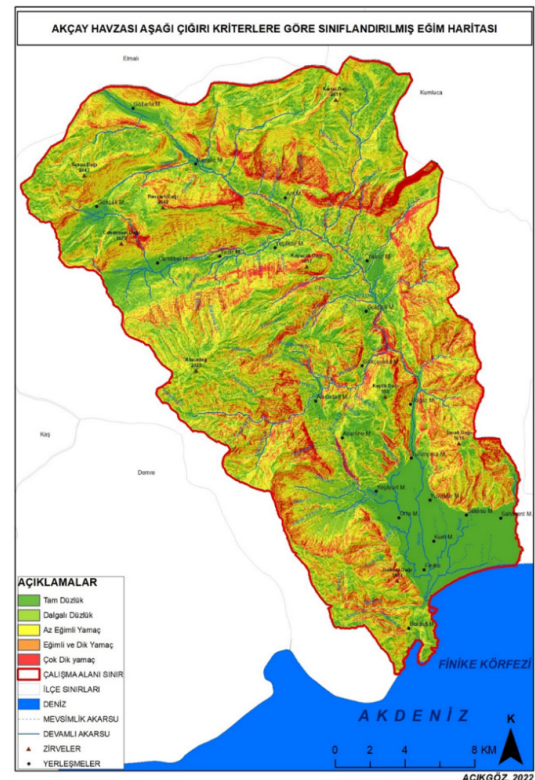
Şekil 8: Çalışma alanı eğim haritası
Figure 8: Study area slope map
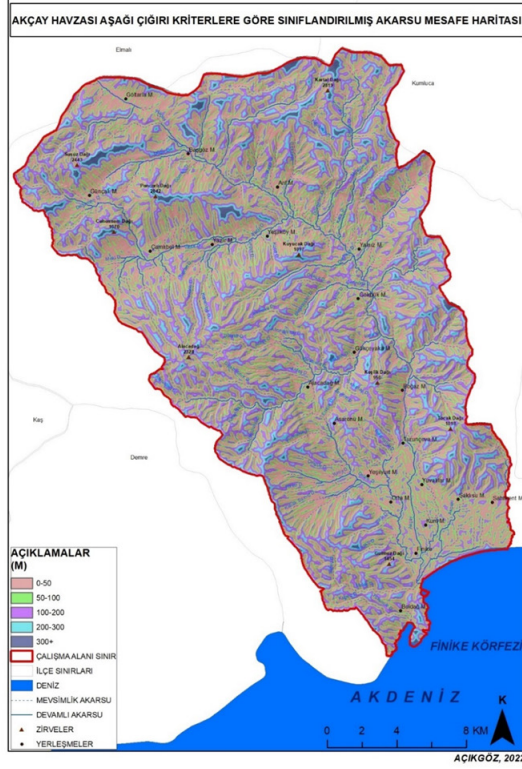
Şekil 9: Çalışma alanı akarsu mesafe haritası
Figure 9: Study area stream distance map
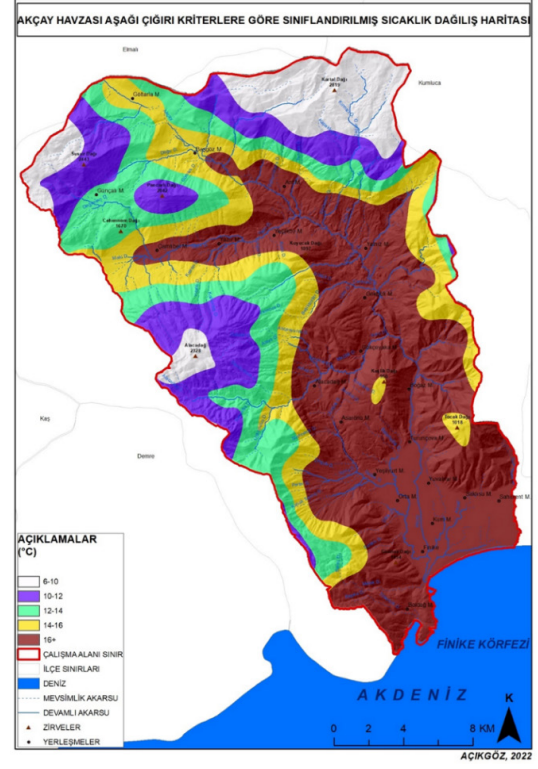
Şekil 11: Çalışma alanı sıcaklık dağılış haritası
Figure 11: Study area temperature distribution map
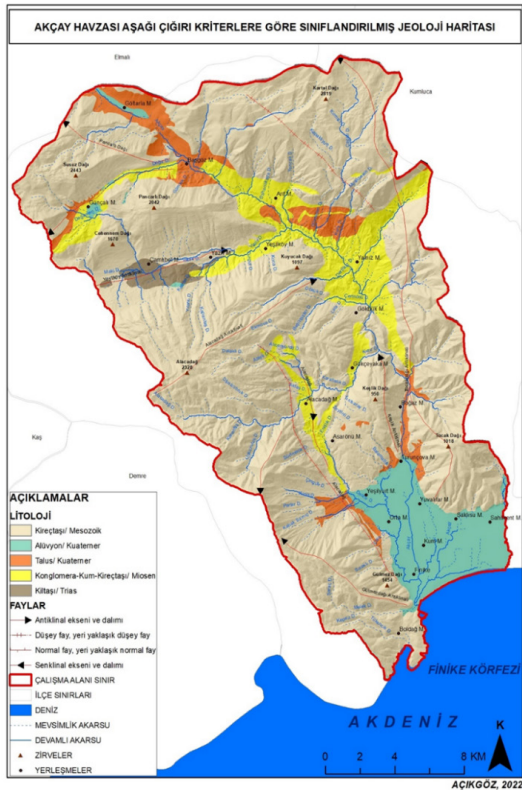
Şekil 10: Çalışma alanı jeoloji haritası
Figure 10: Study area geology map
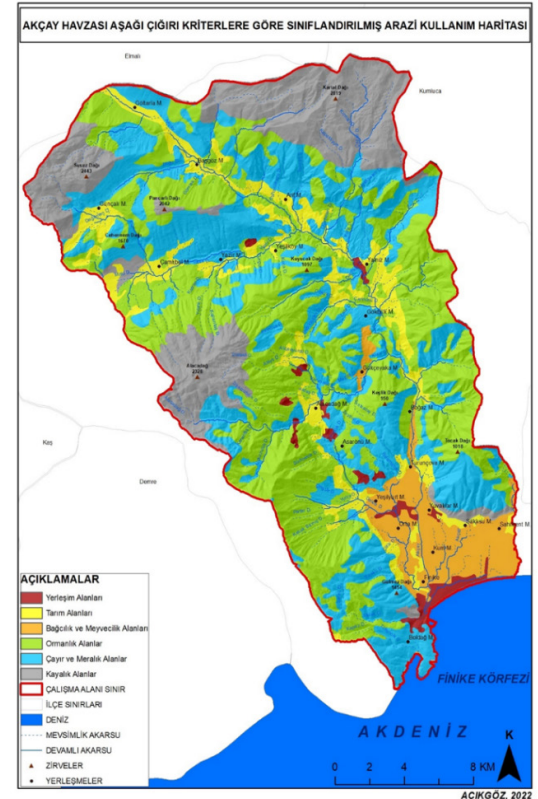
Şekil 12: Çalışma alanı arazi kullanım haritası
Figure 12: Study area land use map

mm yağış alan bölgelerdir. Tocak Dağı, Çamlıbel Mahallesi, Göltarla Mahallesi ve Başgöz Mahallesi 1250-1500 mm yağış alan bölgelerdir. Cehennem Dağı ve Günçalı Mahallesi 1500-1750 mm yağış alan bölgelerdir. Son olarak da Alacadağ, Susuz Dağı ve Kartal Dağı 1750 mm ve üzeri yağış alan bölgelerdir (**Şekil 7**).

Sınıflandırılmış eğim haritasında;

Finike ovasının bulunduğu alan, Yalnız Mahallesinin güneyi, Çamlıbel Mahallesi, Günçalı Mahallesi, Başgöz Mahallesi ve Göltarla Mahallesi tam düzlük olarak sınıflandırılan alanlardır. Boldağın bir kısmı, Yeşilyurt Mahallesinin batısı, Asarönü Mahallesi, Gökçeyaka Mahallesinin bir kısmı, Gökbük, Yeşilköy, Yazır ve Arif Mahalleleri dalgalı düzlük ve az eğimli yamaç olarak sınıflandırılan alanlardandır. Tocak Dağı, Gülmez Dağı, Keşlik Dağı, Alacadağ, Kuyucak Dağı, Cehennem Dağı, Susuz Dağı ve Kartal Dağı tam düzlük, dalgalı düzlük, az eğimli yamaç, eğimli ve dik yamaç, çok dik yamaç sınıflarının hepsinin de yer yer görüldüğü alanlardır (**Şekil 8**).

Sınıflandırılmış akarsu mesafe haritasında;

Finike ovası ve çevresinde, akarsu vadisi ve çevresinde, eğimin az olduğu alanlarda 0-50 m, 50-100 m ve yer yer de 100-200 metre uzaklıkta alanlar görülmektedir. Eğimin fazla olduğu engebeli ve yüksek alanlarda ise 200-300 m uzaklıkta, 300 m ve üzeri uzaklıkta alanlar görülmektedir (**Şekil 9**).

Sınıflandırılmış jeoloji haritasında;

Finike ovasının Kuvaterner yaşlı alüvyonlarla kaplı olduğu, Günçalı Mahallesinde ve Göltarla Mahallesinde yer yer Kuvaterner yaşlı alüvyonların görüldüğü tespit edilmiştir. Çamlıbel Mahallesi Trias yaşlı kil taşlarından oluşmaktadır. Asarönü Mahallesinin batısı, Alacadağ Mahallesi, Gökçeyaka Mahallesi, Yalnız Mahallesi, Yeşilköy Mahallesi, Arif Mahallesi ve Günçalı Mahallesinde Miyosen yaşlı konglomera, kum ve kireçtaşları mevcuttur. Çalışma alanının büyük çoğunluğu Mesozoik yaşlı kireçtaşlarından oluşmaktadır. Göltarla, Başgöz, Günçalı Mahallelerinde, Yeşilyurt Mahallesinin batısında, Turunçova ve Arif Mahallelerinin güney doğusunda yer yer Kuvaterner yaşlı Talus'lar görülmektedir (**Şekil 10**).

Sınıflandırılmış sıcaklık haritasında;

Akçay havzası aşağı çığırında bulunan yerleşim alanlarının büyük çoğunluğunda sıcaklıklar 16 °C ve üzeri sıcaklığa sahip, Keşlik Dağı ve Tocak Dağı 14-16 °C, Cehennem Dağı 12-14 °C, Pancarlı Dağı ve Susuz Dağı 10-12 °C, Alacadağ ve Kartal Dağı ise 6-10 °C sıcaklıklara sahiptir (**Şekil 11**).

Sınıflandırılmış arazi kullanım haritasında;

Çalışma alanının büyük çoğunluğu alan olarak ormanlık ile kaplıdır, daha sonraki büyük çoğunluğu çayır ve meralık alan kaplamaktadır. Finike ovası bağcılık, meyvecilik ve yer yer de tarım alanlarıyla kaplıdır. Alanın kuzeyi tarım alanlarıyla yoğunlaşmış olarak bulunmakta güneyi ise hem bağcılık, meyvecilik hem de tarım alanlarıyla yoğunlaşmış durumdadır. Elbette bağcılık, meyvecilik ve tarım alanlarının bulunduğu bölgelerde yoğunlaşan su hasadının pozitif etkileri fazladır. Elde edilen yağmur suları tarım arazilerinde kullanılarak tekrar dönüştürülür ve aslında amaçlanmak istenen tasarruf elde edilmiş olur (**Şekil 12**).

SONUÇ VE ÖNERİLER

Tüm yapılan analizler sonucunda Akçay havzası aşağı çığırı su hasadı yapılabilecek potansiyel alanlar haritası oluşmuştur (**Şekil 14**). Bunun yanı sıra Çalışma alanında su hasadı yapılabilecek potansiyel alanların yüzde (%) ve hektar (hm2) cinsinden kapladığı yüzeyler hesaplanmıştır (**Tablo 8**), (**Tablo 9**), (**Şekil 13**). Elde edilen sonuçlara göre kuvvetli derecede uygun alanlar % 23, orta derecede uygun alanlar %51, düşük derecede uygun alanlar %11 ve uygun olmayan alanlar %15 olarak 4 sınıfta incelenmektedir (**Tablo 8**).

Tablo 9: Su hasadı yapılacak alanların % cinsinden kapladığı hektar alan tablosu.
Table 9: Table of hectare area occupied by water harvesting areas in %.

Akçay Havzası Aşağı Çığırı Su Hasadı Yapılabilecek Potansiyel Alanların % Cinsinden Kapladığı Hektar Alan	
Alanlar	**Kapladığı Alanlar (%)**
0 (Uygun Olmayan Alan)	15
1-2 (Düşük Derecede Uygun Alan)	11
3-4 (Orta Derecede Uygun Alan)	51
5 (Kuvvetli Derecede Uygun Alan)	23

Tablo 10: Akçay havzası aşağı çığırı su hasadı yapılacak alanların hektar (hm**2**) cinsinden değerlendirilmesi.
Table 10: Evaluation of the areas to be harvested in Akçay basin lower pile water harvest in hectares (hm2).

Akçay Havzası Aşağı Çığırı Su Hasadı Yapılabilecek Potansiyel Alanların Hektar (Hm²) Cinsinden Değerlendirilmesi						
	Yerleşim Alanları	**Tarım Alanları**	**Bağcılık ve Meyvecilik Alanları**	**Ormanlık Alanlar**	**Çayır ve Meralık Alanlar**	**Kayalık Alanlar**
0 (Uygun Değil)	0	0	0	0	0	9191,63
1-2 (Düşük Derecede Uygun)	3,83	23,66	0	4887,25	3158,65	0
3-4 (Orta Derecede Uygun)	560,84	4425,13	848,6	15071,08	12502,8	0
5 (Kuvvetli Derecede Uygun)	308,67	386	2490,12	0,09	0,04	0
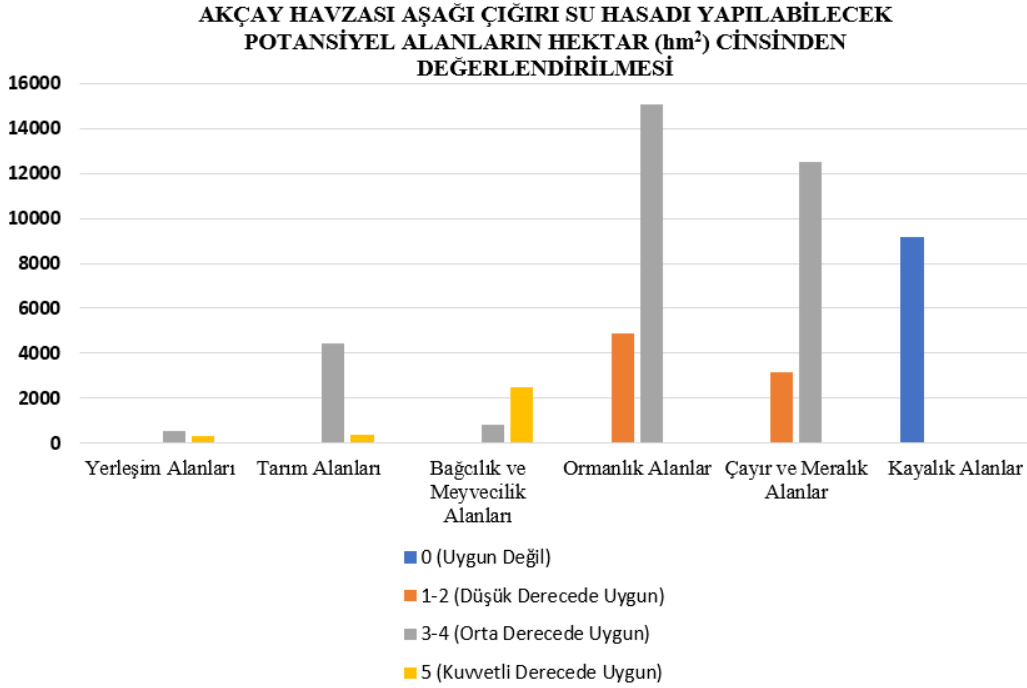
Şekil 13: Akçay havzası aşağı çığırı su hasadı yapılabilecek potansiyel alanların hektar (hm2) cinsinden değerlendirildiği grafik

Figure 13: Graph where the potential areas where water can be harvested from the lower part of the Akçay basin are evaluated in terms of hectares (hm2)
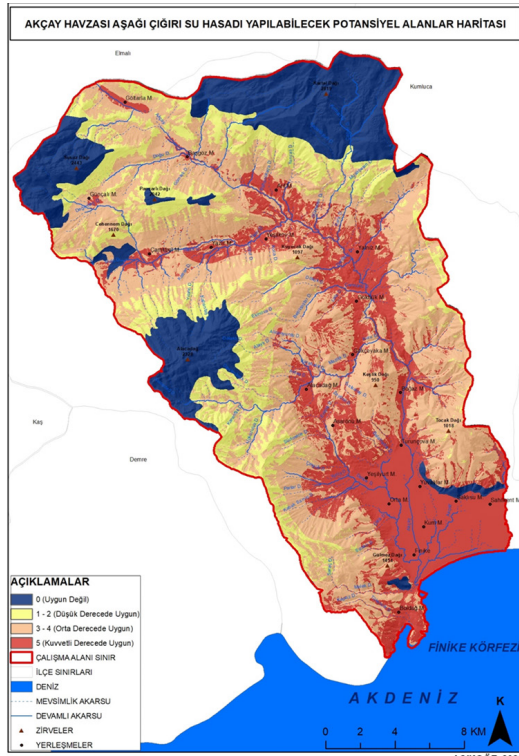
Şekil 14: Akçay havzası aşağı çığırı su hasadı yapılabilecek potansiyel alanlar haritası

Figure 14: Map of potential areas where water harvesting can be done downstream of the Akçay basin

Sahilkent, Saklısu, Yuvalılar, Turunçova, Yeşilyurt, Kum, Finike merkez, Boldağ ve Orta mahalle Finike ovasında bulunan mahallelerdir. Bu yerleşmeler su hasadı yapmak için kuvvetli derecede uygun potansiyel alanlar olarak belirlenmiştir. Bunun yanı sıra Finike ovasında bulunmayan Asarönü, Gökçeyaka, Gökbük, Boğaz, Yalnız, Yeşilköy, Yazır, Arif, Başgöz, Göltarla, Günçalı ve Alacadağ Mahalleleri de su hasadı yapılabilecek potansiyel alanlardan kuvvetli derecede uygun alanlar sınıfında yer almaktadır. Az eğimin bulunduğu dalgalı düzlük olan, vadi yamaçları ise orta derecede su hasadı potansiyel alanlarını oluşturmaktadır. Susuz Dağı, Kartal Dağı, Pancarlı Dağı, Alacadağ su hasadı yapılmasının mümkün olmadığı alanlar sınıfında yer almaktadır. Saklısu'nun kuzeyinde bulunan alan ve Gülmez Dağının güneyinde bulunan alan da su hasadı yapılmasının mümkün olmadığı alanlar sınıfında yer almaktadır. Kayalık alanlar ve çok dik yamaçlar su hasadının yapılmasının mümkün olmadığı alanlar sınıfına girmektedir. Az eğimli ve dik yamaç olarak sınıflandırılan alanlar ise düşük derecede su hasadı yapılması mümkün olan alanlar sınıfında yer almaktadır.

Finike Meteoroloji İstasyonu verilerine göre 1973-2021 yılları arası standartlaştırılmış yağış indisinin yıllık ortalama kuraklık analizi sonuçlarında da görüldüğü gibi ne tamamen kurak ne de tamamen nemlilikten söz edilmesi mümkün değildir.

Fark edilen bir şey vardır ki o da son 3 yıldır kurak dönemlerin, daha önceki kurak dönemlere göre daha şiddetli olmasıdır.

Çalışmada kullanılan coğrafi bilgi sistemleri, su hasadı için potansiyel alanların belirlenmesi ve mekânsal analizinin yapılması noktasında inanılmaz büyük bir öneme sahiptir fakat tek başına değil de onu destekleyici analitik hiyerarşi gibi yöntemlere de ihtiyaç duyulmaktadır. Kriterler belirlenmiş ve uzman görüşünden faydalanılmıştır. Sonrasında kriter ağırlıkları belirlenerek, sınıflandırma işleminin yapılması ve daha sonra ağırlıklı çakıştırma analizinin uygulanması sonucunda da Akçay havzasında su hasadı yapılabilecek kuvvetli derecede uygun alanların, orta derecede uygun alanların, düşük derecede uygun alanların ve uygun olmayan alanlarının mevcut olduğu anlaşılmıştır.

Sahilkent Mahallesi, Saklısu Mahallesi, Yuvalılar Mahallesi, Turunçova Mahallesi, Yeşilyurt Mahallesi, Kum Mahallesi, Finike merkez, Boldağ Mahallesi, Orta Mahalle, Asarönü Mahallesi, Gökçeyaka Mahallesi, Gökbük Mahallesi, Boğaz Mahallesi, Yalnız Mahallesi, Yeşilköy Mahallesi, Yazır Mahallesi, Arif Mahallesi, Başgöz Mahallesi, Göltarla Mahallesi, Günçalı Mahallesi ve Alacadağ Mahallesi su hasadı yapmak için kuvvetli derecede uygun potansiyel alanlar olarak belirlenmiş, yer yer de orta derecede su hasadı yapılabilir potansiyel alanlar olarak belirlenmiştir. Kayalık alanlar ve dik yamaçlar ise su hasadı yapılmasının mümkün olmadığı alanlar olarak belirlenmiştir.

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Evolution of Autumn Leaf Coloration of *Torminalis glaberrima* Grown in Isparta, Türkiye

Isparta-Türkiye'de Yetişen Torminalis glaberrima'nın Sonbahar Yaprak Renklenmesinin İncelenmesi

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ABSTRACT

The fall coloration of temperate tree leaves is a phenomenon of nature that ranges in color from pale yellows, oranges, and purples to dark reds. Although some evolutionary forces and weathered mechanisms (e.g., light and frost protection) cause variations in leaf color within and among species, no full explanation is found regarding fall coloration. This study phonologically monitored Torminalis glaberrima leaves from May until at the end of November in terms of fall coloration and senescence properties. The study presents the average color coordinate values of Torminalis glaberrima leaves, starting from May and continuing through November. Torminalis glaberrima leaves show an intense green color from May to June. We have used CIE L*a*b (1976) color space to determine discoloration intensity. As the seasons change, however, the leaves become darker into November (L = 25.67), with leaf discolorations becoming clearly distinguishable. We selected color values of leaves of Torminalis glaberrima at May as control, and as vegetation continues, compared to color changes throughout study (end of November). Accordingly, we measured total color differences (ΔE). The highest change in coloration was found in November (ΔE = 56.86) followed by October (ΔE = 44.71), September (ΔE = 42.32), August (ΔE = 15.37), July (ΔE = 5.86), and June (ΔE = 2.14). Notably, the highest color difference ΔE = 44.56 was found from August to September, and the lowest from May to June (ΔE = 2.14). Except for the leaves' GE brightness values, which show very low correlations over time, all other color coordinate values for CIE L*a*b* and hue values show some color level correlations over time.

Keywords: CIE L*a*b*, *Torminalis glaberrima leaves*, autumn coloration, leaf senescence

ÖZ

Ilıman iklim bölgelerinde yetişen ağaçların yaprakları, sonbaharda bir olgu olarak parlak sarı renkten turuncu, pembe ve koyu kırmızı renge kadar karmaşık renklenme göstermektedir. Hernekadar bazı evrimsel güçler ve dış atmosferik şartlar (ışık ve don koruması) yapraklarda renk değişimine sebep olmakla birlikte, bu durum türler arasında farklılık göstermekte ve hala tam olarak açıklanabilmiş değildir. Bu çalışamda, torminalis glaberrima yapraklarının sonbahar renklenmesi ve yaşlanma durumu, fenolojik olarak Mayıs ayından Kasım sonuna kadar izlenmiştir. Torminalis glaberrima yapraklarının renk değerleri, Mayıs ayından başlayarak Kasım ayı sonuna kadar karşılaştırmalı olarak sunulmuştur. Torminalis glaberrima'nın yaprakları Mayıstan Haziran sonuna kadar koyu Yeşil renk tonunda gözlemlenmiş ve zaman ilerledikçe Kasımda daha koyu renge dönüşmüştür (L: 25.67 nümerik). Zamana bağlı olarak oluşan yapraklardaki renk değişimi kolaylıkla gözlemlenebilmiştir. En yüksek renk değişimi, Kasımda (ΔE: 56.86), devamında Ekimde (ΔE: 44.71), Eylülde (ΔE: 42.32), Ağustosta (ΔE: 15.37), Temmuzda (ΔE: 5.86) ve Haziranda (ΔE: 2.14) ölçülmüştür. Fakat en yüksek renk farklılığı ise ΔE: 44.56 numerik olarak, Ağustostan Eylüle kadar olan periyotta en düşük ise Mayıstan Hazirana kadar (ΔE: 2.14) olan periyotta oluşmuştur. GE parlaklık değeri zamana bağlı olarak çok düşük korelasyon göstermekte ve istisna oluşturmakta, fakat diğer tüm renk koordinasyon değerleri olan CIE L*a*b*C* ve h nin, zamana bağlı olarak bir şekilde korelasyon gösterdiği anlaşılmıştır.

Anahtar kelimeler: CIE L*a*b*, torminalis glaberrima, sonbahar renklenmesi

INTRODUCTION

Many variables besides maturity, geographic location, and atmospheric conditions have impacts on the physicochemical properties of plants, even those in the same species. However, seasonal factors have been reported as one of the most effective on plant species' growing conditions (Archetti et al., 2009; Chiba et al., 1996; Junker & Ensminger 2016; Lee et al., 2003). Therefore, determining such changes such as chemical content and color variations plays an important role in plant species' properties and constituents. While numerous studies are found to have investigated the constituents and contents of pigments, evaluating certain physical parameters (i.e., color) may be necessary to determine the aesthetic value of a plant species (Archetti et al., 2009; Bozdoğan, 2016; Chiba et al., 1996; Field et al., 2001; Junker & Ensminger 2016; Lee et al., 2003; Lehrer & Brand 2010). Certain color pigments, particularly those that appear in autumn, have already been well presented for user who is too impersonal for aesthetics (Archetti et al., 2009; Chiba et al., 1996; Junker & Ensminger 2016; Lehrer & Brand 2010).

According to more recent study on International Plant Names Index (IPNI) 2022, *Sorbus torminalis* have called to be called *Torminalis glaberrima* (Gand.) Sennikov & Kurtto (Akyıldırım Beğen and Eminağaoğlu, 2022). *Sorbus torminalis*, commonly known as the wild service tree, is a deciduous tree widely distributed throughout the lower elevation temperate and Mediterranean zones of Europe, extending eastwards into the Caucasus Mountains and northern Iran (Jeran et al., 2017; Bednorz & Urbaniak 2005). The species is tolerant to direct sunlight and short periods of drought and therefore suitable for afforestation in warm arid sites. However, the species is particularly noted for its attractive form, shaggy bark, white spring flowers, edible berry-like fruits, and lobed maple-like leaves (Jeran et al., 2017; Bednorz & Urbaniak, 2005; Bekçi et al., 2010). The leaves are glossy green on top and light green underneath, often turning vivid yellow, orange, and red in the fall. The leaves are reported to show autumn coloration in mid-September to October, with leaf fall occurring from early October to mid-November (Bednorz & Urbaniak, 2005). Moreover, several phenolic compounds have been isolated from the leaves of *Sorbus torminalis*, including caffeic acid, p-coumaric acid, flavonoids (i.e., vitexin, apigenin, luteolin, quercetin, and torminaloside), sterols (i.e., cholesterol, campesterol, stigmasterol, and sitosterol), and fatty acids (i.e. myristic, palmitic, palmitoleic, stearic, oleic, linoleic, and linolenic acids; Olszewska & Roj 2011; Hasbal et al., 2015). A recent report proposed that *Sorbus torminalis* has a smooth trunk shape, white flowers, light brown berries, and autumn coloration properties, which makes it a useful plant in landscape design practices as an allée, wind curtain, and erosion control (Bekçi et al., 2010) Regarding the expected changes in global climate, the wild service tree should substitute well for some tender woody plants with higher sensitivity to drought in landscape practices. The *Sorbus* species has also been proposed for its decorative attributes, as well as its therapeutic value that is well-known in folk tradition (Jeran et al., 2017; Bednorz & Urbaniak 2005; Bekçi et al., 2010).

Many investigators have reported on the variations in the leaf senescence properties of plant species in terms of quantity and quality (Archetti et al., 2009; Bozdoğan, 2016; Chiba et al., 1996; Field et al., 2001; Lehrer & Brand, 2010). Recent studies have presented evidence for *Sorbus torminalis* leaf color changes to occur in autumn (Hasbal et al., 2015; Jeran et al., 2017; Bednorz & Urbaniak 2005), but no work is yet found to have investigated its autumn coloration properties in Türkiye. Therefore, the present study aims to study and discuss the autumn senescence of *Torminalis glaberrima* leaves based on experimental findings to determine their color properties.

The purpose of this paper is to give an overview of *Torminalis glaberrima*, the autumn coloration properties of the species' leaves, and their value in landscaping. The paper assumes native *Sorbus* species to present itself as a quality multifunctional species applicable for use in landscaping.

MATERIALS AND METHODS

The study has selected to evaluate the autumn leaf coloration characteristics of *Torminalis glaberrima* which is in the *Rosaceae* family, and to represent its ornamental value in the field of landscaping. The study conducted phonological observations at different stages of coloration from May 2022 through end of November 2022 in in-situ growing conditions. The *Torminalis glaberrima* leaves were collected from stands in the Egirdir region of Türkiye's Isparta Province in the last weeks of each month. However, healthy mature trees were randomly selected, from which approximately 10 representative leaf samples were collected from all sides of the crown. The region in which the samples were collected is a forestland managed by the Regional Directorate of Forestry authorities. Figure 1 shows the general maps of the geographic regions from which the samples were collected. The supplied leaves were manually cleaned of contaminants then stored in standard containers at 4°C until analyzed. The experimental procedures were conducted in the
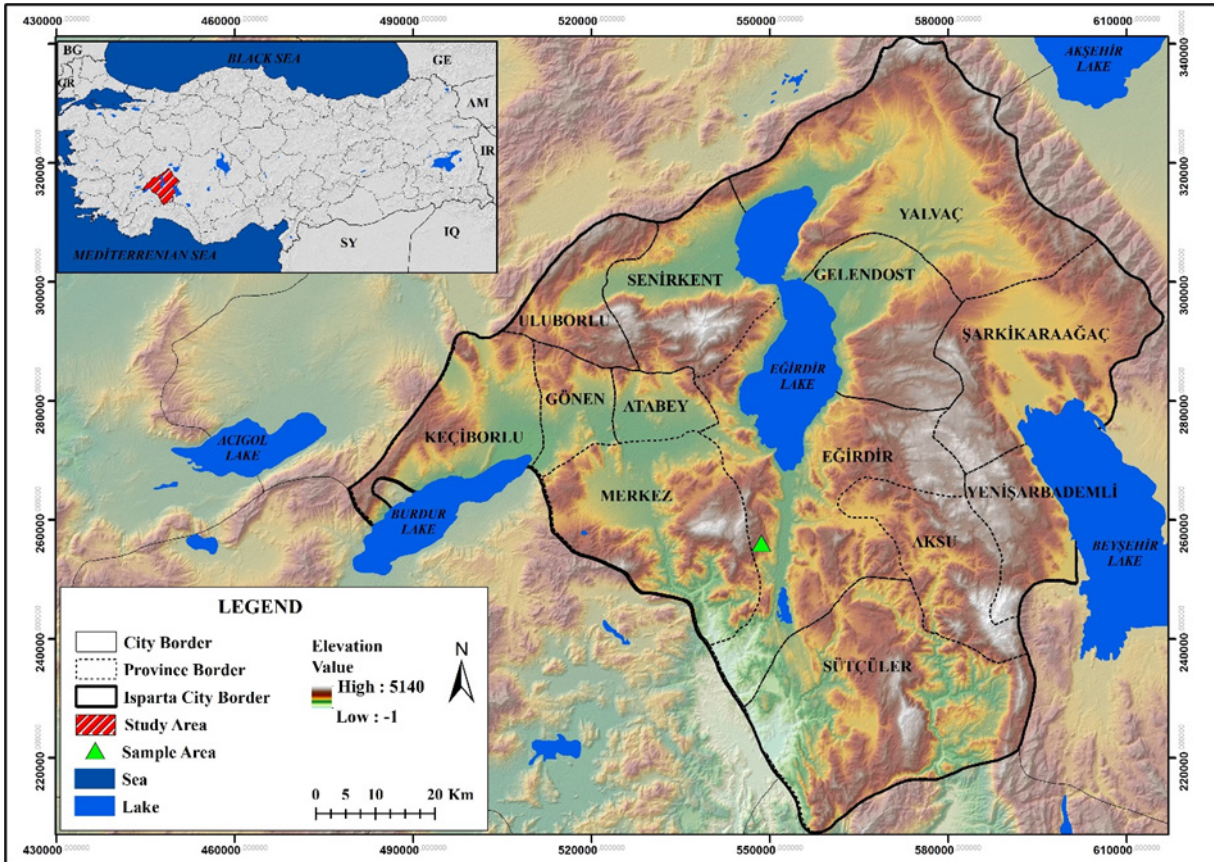
Figure 1: The geographic location of Torminalis glaberrima trees.

botanic laboratory of the Forest Engineering Department of Isparta University of Applied Sciences Faculty of Forestry in Türkiye.

The leaves of *Torminalis glaberrima* were found to be initially green in spring; the color then senesces to yellows, oranges, and reds in the fall. The study assumed that mid-to-late May to the end of November would be an appropriate observation period. The selected trees' in-situ and collected leaf samples were carefully monitored at different stages of discoloration by photographing to conduct a visual evaluation. The study obtained numerous photos that effectively reflect the leaf coloration of the *Torminalis glaberrima* species, some of which are presented in Figure 2.

To track and photograph fall discoloration, the observation was divided into five coloration periods:
· the pre-coloration period (late May to mid-July),
· early coloration period (late July to mid-September),
· middle coloration period (late September to mid-October),
· late coloration period (late October to mid-November),
· final coloration period (late November to mid-December).

Technical Association of the Pulp and Paper Industry (TAPPI) standard (i.e., GE brightness) measurements require a special instrument that employs a 45° illumination and 0° viewing geometry so that translucent materials are evaluated on an arbitrary but specific scale. This method is considered to be useful for determining *Torminalis glaberrima* leaf brightness. The GE brightness measurements were made according to TAPPI brightness (T452 om-98) and the *Commission Internationale de l'Eclairage* (CIE) L*a*b* and CIE L*C*h color coordinate measurements were made according to CIE L*a*b* (1976) using the X-Rite 938 handheld spectrodensitometer (X-Rite, Grand Rapids, MI).

The spectrodensitometer was calibrated with a standard white calibration plate, and color was measured as L*, a*, b* coordinate values. A single measurement was recorded for each sample, and 10 replicate leaves were measured for each sampling. The value of L* describes the degree of darkness/lightness with L = 0 being black and L = 100 being white. Before analysis, the a* and b* coordinates were transformed into chroma ($C*$) and hue angle ($h°$) using the equations: $C* = (a*^2 + B*^2)^{1/2}$ and $h° = \tan^{-1}(b*/a*)$. Richness of color is represented by $C*$, and $h°$ represents the dominant color wavelength where 0° =

Figure 2: The general appearance of Torminalis glaberrima trees and their collected leaves.

red–purple, 90° = yellow, 180° = bluish green, and 270° = blue. The data were evaluated statistically using the program SPSS 19.0 and the one-way analysis of variance (ANOVA) method.

FINDINGS AND RESULTS

The variation in leaf color during autumn may serve an ornamental appearance. A vast literature of reports has already been suggested for using the CIE L*a*b* color measurement method, which is based on the mathematical quantification of color, for evaluating the impact of environmental factors on leaves and fruit (Bahreini, 2022; Post & Schlautman 2020; Tan et al., 2021; Ochmian et al., 2012; Nowakowska et al., 2017).

In this regard, the average color coordinate values of *Torminalis glaberrima* leaves, starting in May a continuing through November, are presented comparatively in Table 1. The individual months appear to have a considerable influence on all color coordinates. Initially, the lightness value of L = 36.56 was found for May and to go as high as L = 45.20 in September, before decreasing to L = 25.67 in November. As expected, the leaves still show a deep greenish shade initially (May to June), with the hue ranging from h = 124.91º to h = 119.54º which is in the green (-a values) and yellow (+b values) of the color chart. The darkest leaves were found in November (L = 25.67). Timely atmospheric changes (i.e., temperature, light) were able to be determined to have had a clear impact on leaf coloration and color intensity. The highest greenish value of a = -16.37 was found in August, but the highest reddish value of a = 43.32 was found in November. After August, the leaves were shown to turn to a deep reddish-to-brown color (+a values), while the chromaticity and hue increased.

To simply quantify all color values is a very complicated process that includes many phenomenological variations. Therefore, the total color difference (ΔE), which in this study may be useful for determining leaf coloration properties, can be used to provide an estimation of how time (i.e., the month) affects the natural color of *Torminalis glaberrima* leaves.

As for the deep green color in May, the assumption is to use these values as the control and then monitor coloration changes throughout the end of the study in November. The total difference in the leaves measured color values (ΔE) compared to the control (i.e., May) are given in Figure 3. Leaf coloration clearly continues as maturation and senescence throughout the dormant period of November. Meanwhile, the highest change in coloration was found in November (ΔE = 56.86), followed by October (ΔE = 44.71), September (ΔE = 42.32), August (ΔE = 15.37), July (ΔE = 5.86), and June (ΔE = 2.14). In the literature, ΔE values between 2.0-3.0 are thought to present an observable color difference to observers (Muller et al., 2003; Sahin & Mantanis, 2011).

The method chosen in this study involves the visual (Figure 2) and mathematical (Table 1, Figure 3) evaluations of *Torminalis glaberrima* leaves starting in May and continuing through to November and has clearly confirmed the information in the literature (Archetti et al., 2009; Bozdoğan, 2016; Chiba et al., 1996; Field et al., 2001; Junker & Ensminger 2016; Lee et al., 2003; Lehrer & Brand, 2010) in terms leaf coloration changes.

Table 1. The Monthly Color Properties of Torminalis glaberrima Leaves

	L	a	b	c	h	Brightness (GE)
May	36.56 (1.39) B	-11.35 (0.98) B	16.32 (2.26) B	19.93 (2.22) A	124.91 (2.56) F	5.05 (0.26) B
June	35.36 (1.51) B	-9.80 (1.58) B	15.45 (1.53) B	18.37 (1.80) A	122.64 (4.29) EF	4.83 (0.30) B
July	39.14 (1.94) C	-9.53 (1.76) B	21.26 (2.18) C	23.35 (2.32) B	114.14 (3.95) D	4.99 (0.38) B
August	42.94 (3.36) D	-16.37 (1.43) A	29.38 (4.80) D	33.72 (4.29) C	119.54 (4.49) E	4.60 (0.25) B
September	45.20 (3.37) D	28.13 (3.13) C	28.88 (4.06) D	40.58 (1.69) E	45.65 (6.82) C	5.60 (0.87) C
October	39.85 (2.04) C	33.18 (4.20) D	18.62 (5.11) BC	37.80 (3.71) D	28.23 (5.94) B	6.19 (0.49) D
November	25.67 (3.52) A	43.32 (2.53) E	4.92 (3.44) A	43.72 (2.58) F	6.44 (4.49) A	3.91 (0.52) A
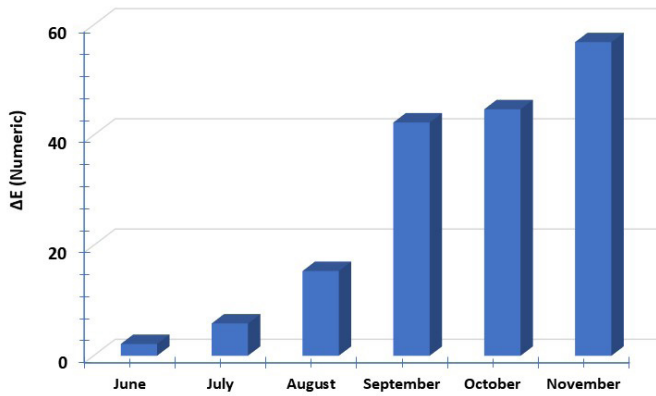
Figure 3: Monthly change in coloration properties of *Torminalis glaberrima* leaves with May as the control.
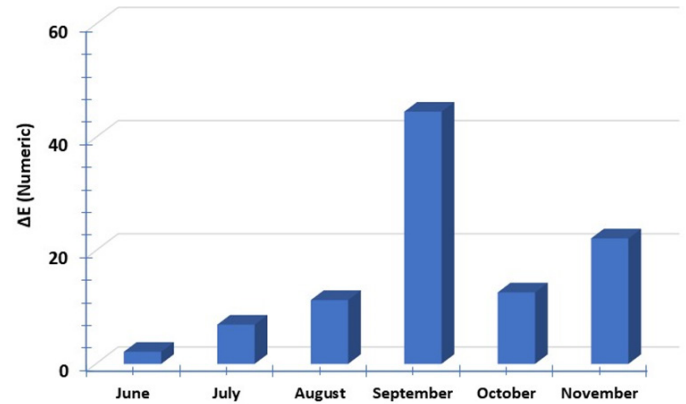
Figure 4: The monthly coloration differences of *Torminalis glaberrima* leaves beginning in May.

Another approach involved evaluating coloration changes from one month to the next starting in May, with the color difference (ΔE) values calculated and plotted in Figure 4. Just as in Figure 3, a more-or-less similar trend was also observed of maturation and senescence that continuously increased until the end of the study in November. Yet the highest change in coloration (ΔE = 44.56) occurring from August to September and the lowest occurring from May to June (ΔE = 2.14) are interesting to note. This may be an estimation time for the intense fall coloration of *Torminalis glaberrima* leaves. This approach may also be used to predict peak time for plant coloration in fall. As mentioned above and shown in Figure 2, a visual distinction in leaf color had also become apparent after July.

The measured color coordinate values were plotted against time (in months) to further evaluating the change in the coloration properties of *Torminalis glaberrima* leaves (Figure 5). Apart from the GE brightness properties' very low correlation coefficient (R^2 = 0.11), which means brightness values are practically independent when measured over time, all other measured color values appear to show some level of acceptable correlations. However, the highest correlation was found with hue angle ($R_{h^o}^2$ = 0.91), followed in order by chromaticity (R_{C*}^2 = 0.89), the greenish-reddish color space (R_{a*}^2 = 0.85), yellow-blue color space (R_{b*}^2 = 0.77), and lightness (R_{L*}^2 = 0.68).

Cold weather's impact on temperate species' leaf discolorations, usually referred to as autumn/fall colorations, have been well presented. Although the visual appearance of
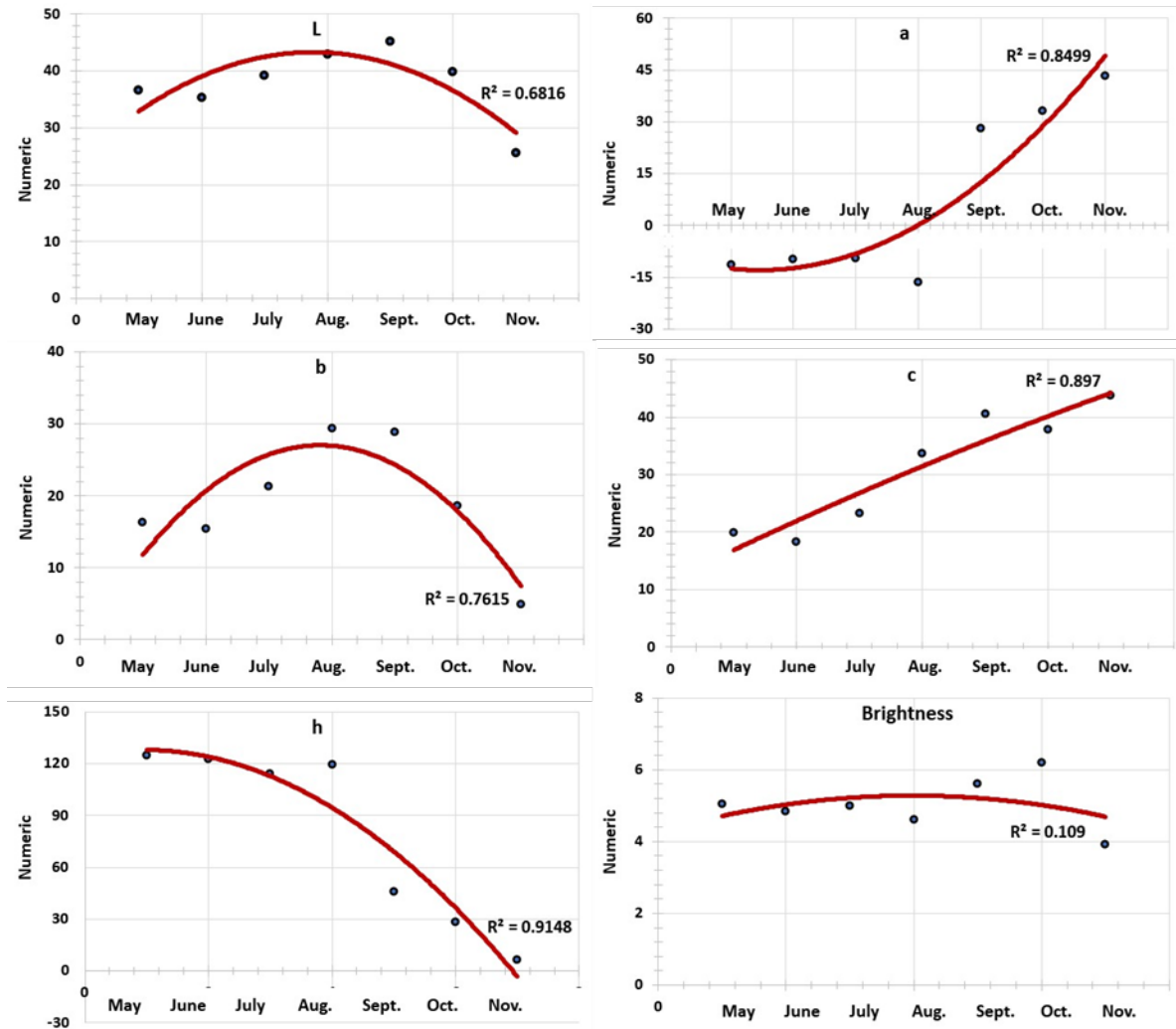
Figure 5. The relationship between color values over time for *Torminalis glaberrima* leaves.

leaves is an important criterion of acceptance in landscape design practices, the measured mathematical results may also be taken into consideration when planting species in open public spaces where aesthetic appearance is important.

Lastly, to find the combined effects of the color space regarding lightness and hue angle on *Torminalis glaberrima* leaves, the obtained values were plotted against one another and shown in Figure 6. The senescence of the leaves being clearly realizable is very apparent. Their lightness (L) was found to be 36.56 in the initial month of May and to continuously lower to 25.67 in November. A similar trend was also very visible with hue angle (hº). It measured 124.91º initially in May, which means a* had a negative (greenish) value and b* a positive (yellowish) value in the color chart (Figure 7); it then continuously lowered to 3.91º, which means a* gained a positive (reddish) and b* a positive (yellowish) value in the color chart in November (Figure 7).
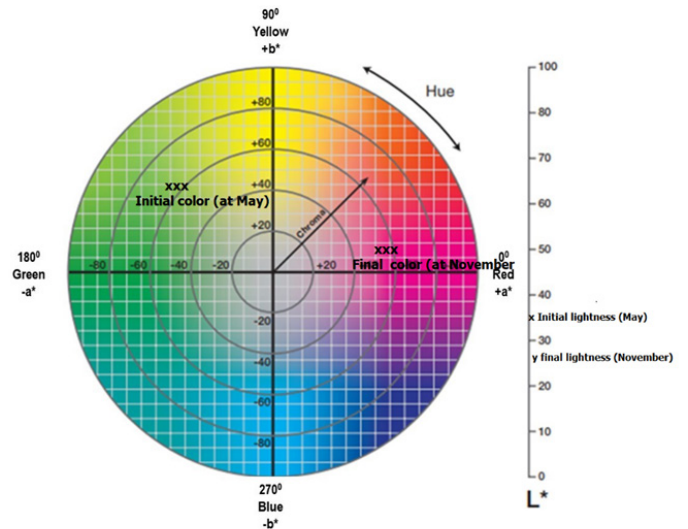
Figure 7: The initial and final color properties of *Torminalis glaberrima* leaves.
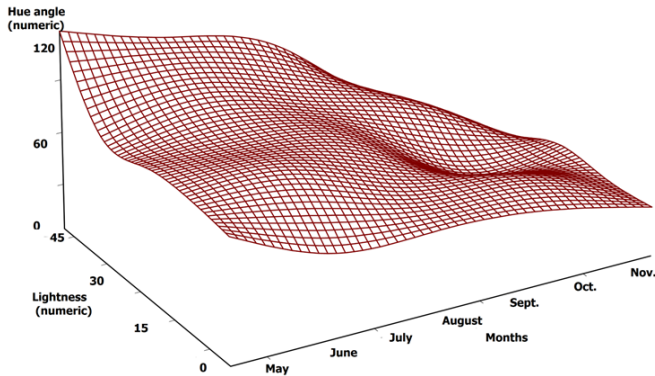
Figure 6: The relationship between lightness (L) and hue angle (hº) over time for *Torminalis glaberrima* leaves.

The plot shape in Figure 6 and color properties in Figure 7 clearly suggest that all sample monitoring times apparently affected a change in the lightness and hue angle values. This was expectable, considering the vast amount of information that has been reported in the literature on how weather conditions impact leaf senescence.

CONCLUSION

Some plants have become an important source for landscaping with cost effective ways in design practices. However, many deciduous plants have been used in combination with other elements to provide an aesthetic appearance in public spaces. The *Sorbus* species has been generally described as a very durable tree whose growth habits vary from low growing to upright and from a spreading shrub to a small tree. However, *Torminalis glaberrima* can be found over a wide range of shapes and sizes, with its leaf color varying from green to orange and reds in fall. Therefore, *Torminalis glaberrima* may be suggested for use in urban settings due to its high tolerance to heat and poor dry soils. Due to the wide variations in physical appearance, this species may be given preference in landscape plantings when used as screens, windbreaks, foundation plants, hedges, and other diverse landscape designs due to their formal appearance. The experimental results found in this study clearly suggest the fall coloration of *Torminalis glaberrima* to be measurable using spectral densitometric values. However, many phenomenological properties have been reported in detail for plant substrates, and quantifying all of these is very complicated and requires further investigation.

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Annual Mean Total Precipitation Reconstruction of the Elmacık Mountain and Its Surroundings for 1858-2015 Using Scotch Pine Tree Rings

Sarıçam Yıllık Halkaları Kullanılarak Elmacık Dağı ve Yakın Çevresinin 1858-2015 Dönemi Yıllık Toplam Yağış Rekonstrüksiyonu

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ABSTRACT

The present study aims to use dendrochronological methods to reconstruct the precipitation history of Elmacık Mountain of Northwest Türkiye and its immediate surroundings. This research is the first dendroclimatological study in Türkiye regarding total annual precipitation reconstruction in the current literature. The study created three Scotch pine (Pinus sylvestris L. ssp. hamata) site chronologies (214-, 233-, and 248-year spans) using samples from Elmacık Mountain before combining the site chronologies into one regional chronology. The study calculated relations between this regional chronology and the total annual precipitation data of the Bolu, Düzce, and Sakarya meteorological stations using Pearson's correlation coefficient. As the results are statistically suitable for reconstructing the total annual precipitation data in Bolu and Düzce, the total rainfall reconstruction of these stations was carried out over a 158 year span from 1858-2015. Low- and high-precipitation years were also revealed for 1858-1950 when the stations were not in operation. Accordingly, the years in which the annual total precipitation was at least one standard deviation unit below the average for both stations were 1860-1861, 1875, 1878, 1887, 1893, 1904-1905, 1907, 1909, 1935, 1942, 1945, and 1949. Meanwhile, 1865, 1873, 1877, 1885, 1910, 1912-1914, 1917, 1919, 1922, 1939-1940 were the years when the total annual rainfall was at least one standard deviation unit above the average. In 1901 and 1936, total annual rainfall was two standard deviations above average.

Keywords: Dendrochronology, precipitation, Scotch pine

ÖZ

Bu çalışma, Türkiye'nin kuzeybatısında yer alan Elmacık Dağı ve yakın çevresi için dendrokronolojik yöntemlerle yağışın geriye dönük yapılandırılmasını amaçlamaktadır. Bu çalışma, yapılan literatür taramasına göre yıllık toplam yağış rekonstrüksiyonu açısından Türkiye'de ilk dendroklimatolojik çalışmadır. Çalışmada Elmacık Dağı'ndan örneklerle 3 sarıçam (*Pinus sylvestris* L. ssp. *hamata*) yöre kronolojisi (214, 233 ve 248 yıllık) oluşturulmuştur. Ardından yöre kronolojileri birleştirilerek bir bölgesel kronolojiye dönüştürülmüştür. Bu bölgesel kronoloji ile Bolu, Düzce ve Sakarya meteoroloji istasyonlarının yıllık toplam yağış verileri arasındaki ilişkiler Pearson korelasyon katsayısı yöntemi kullanılarak hesaplanmıştır. Sonuçlar Bolu ve Düzce yıllık toplam yağış verileri için istatistik açıdan rekonstrüksiyon yapmaya uygun bulunduğundan, bu istasyonların yıllık toplam yağışlarının 158 yıllık (MS 1858-1915) geriye dönük tahmini yapılmış, aletsel dönem öncesi (1858-1950) az yağışlı ve yağışlı yıllar belirlenmiştir. Buna göre 1860-1861, 1875, 1878, 1887, 1893, 1904-1905, 1907, 1909, 1935, 1942, 1945 ve 1949 yılları ortalamadan en az bir standart sapma az yağışlı; 1865, 1873, 1877, 1885, 1910, 1912-1914, 1917, 1919, 1922 ve 1939-1940 yılları ortalamadan en az bir standart sapma çok yağışlı yıllar olarak belirlenmiştir. 1901 ve 1936 yıllarında yıllık toplam yağış, ortalamanın en az 2 standart sapma üzerindedir.

Anahtar kelimeler: Dendrokronoloji, yağış, sarıçam

1. INTRODUCTION

Recent climate change-related events have shifted the scientific community's focus toward reconstructing past climate to explore climate dynamics in detail (Kostakova et al., 2018; Tamkevičiūtė et al., 2018). The climate parameters of temperature and precipitation show distinct characteristics at the global level. A temperature rise has been observed in almost every part of the globe, while precipitation shows heterogenic behavior due to differences in relief patterns. Therefore, precipitation analysis is considered more important at the regional level (Belokopytova et al., 2018).

Rainfall cycles are critical to understanding precipitation systems and predicting the future (Yılmaz et al., 2021). Tree-ring chronologies built from living and dead trees offer valuable information for understanding different aspects of natural and human history, ranging from archeological dating to past climate conditions (Ljungqvist et al., 2020). The instrumental recording of meteorological data in Türkiye does not cover an extensive period. Even the oldest meteorological stations have no records over 100 years. According to the literature review, dendroclimatological precipitation reconstructions in Türkiye cover certain months or periods of the year (D'arrigo & Cullen, 2001; Touchan et al., 2003; Akkemik & Aras, 2005; Akkemik et al., 2005, Köse et al., 2011; Köse et al., 2013; Martin-Benito et al., 2016).

Some studies are found to have revealed the relationships between temperature and precipitation conditions through the annual ring development of Scotch pines in Türkiye (Yaman & Sarıbaş 2004, Köse at al. 2017, Bozkurt et al. 2021, Özel et al. 2021, Alkan & İrdem 2023). When considering the common results of these studies, the increase in temperatures in the March-April period and in precipitation in the May-June period are seen to have positively affected the annual ring development of Scotch pines.

The present study aims to create climate-sensitive chronologies for Elmacık Mountain and its immediate surroundings using Scotch pine trees' growth rings and to reconstruct the research area's annual total rainfall data. Bolu, Sakarya, and Düzce meteorological stations are the ones with long-term data in and around Elmacık Mountain. The resulting correlation coefficients and other statistical results were unsuitable for reconstructing the Sakarya station's data. Therefore, retrospective precipitation predictions were made for the Bolu and Düzce stations. The study's results are further compared with those of other studies. According to the authors' best knowledge, no previous studies are found regarding the reconstruction of total annual precipitation in Türkiye, which makes this research very important. The number of Scotch pine chronologies created in previous research in Türkiye has also been determined to be quite limited. Therefore, reconstructions
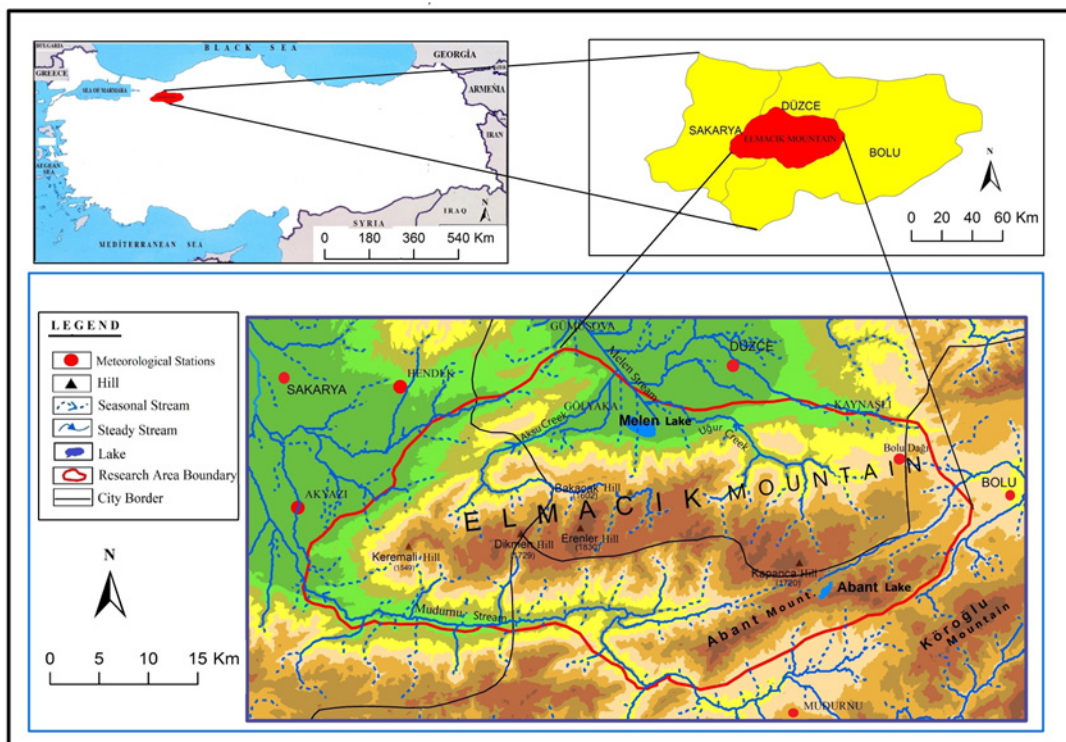
Figure 1. Location map of the research area.

Table 1: Site Information Where Samples Were Collected

Site code	Site name	Species	Core/Tree number	Slope (%)	Aspect	Elevation (m)	Latitude (N)	Longitude (E)
CIG	Çiğdem	*Pinus sylvestris*	54/27	20	SE	1430	40º 39'	30º 50
BAL	Balıklı	*Pinus sylvestris*	40/21	25	S	1366	40º 38'	31º 02
SIN	Sinekli	*Pinus sylvestris*	49/26	15	S	1358	40º 37'	31º 18

using annual ring chronologies made from old trees in the research area would be helpful for palaeoclimatological analyses.

Description of the Study Area

Elmacık Mountain is located in Northwest Türkiye, east of the Çatalca-Kocaeli section of the Marmara Region and west of the Western Black Sea section of the Black Sea Region within the borders of Sakarya, Düzce, and Bolu provinces. The mountain covers an area of 1,582 square kilometers. The approximate distance from west to east is 75 km and about 35 km from north to south (Figure 1).

The mountains span east to west in the research area, following the general span of mountains in Türkiye. This makes inhibits the humid air masses of the Black Sea from passing to the southern parts of the mountain. As a result, the northern slopes are more humid than the south, with a minor temperature difference between summer and winter. The elevation in the study area exceeds 1,800 meters, with Erenler Hill being at 1,830 meters. This situation causes temperature and precipitation conditions to change rapidly over a short distance in the area. For example, the average annual temperature of Düzce is 13.3 ºC, which decreases to 8.7 ºC at the Bolu Mountain meteorological station.

The northwestern slopes of Elmacık Mountain, which extend perpendicular to the direction of the air masses, receive more precipitation. Bolu meteorological station, located at an altitude of 740 meters on the eastern side of the mountain, has a total annual precipitation of 553.9 mm. However, the total annual precipitation of the Bolu Mountain meteorological station, which is located at an altitude of 901 meters on the northwestern slope of the mountain, is 1,057.8 mm.
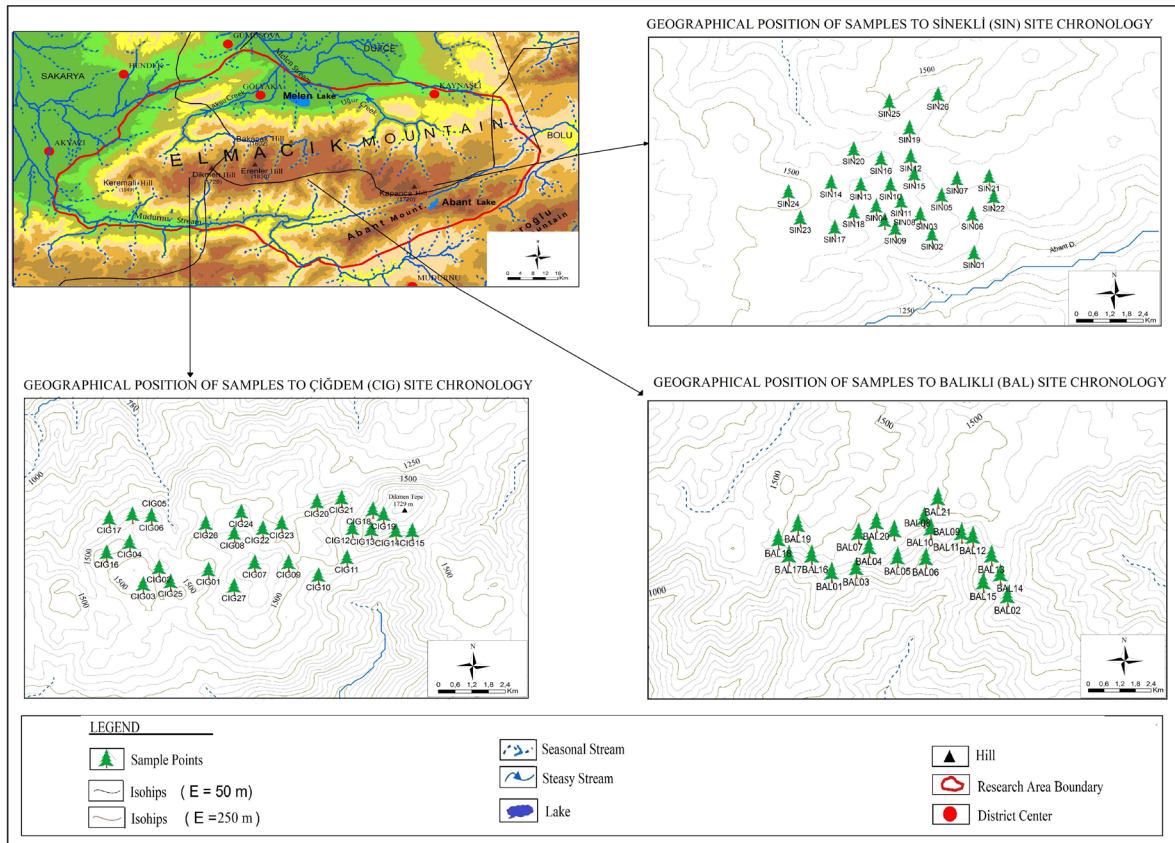
Figure 2. Map representation of sampled points.

2. METHODOLOGY

2.1. Data Collection

2.2.1. Preparing the Meteorological Data

The Sakarya, Akyazı, Düzce, Hendek, Bolu, Mudurnu, and Bolu Mountain meteorological stations have measurements on Elmacık Mountain and its immediate surroundings (Figure 1). The data from the station apart from Bolu, Düzce, and Sakarya are too short or are incomplete. The study gathered the Bolu, Sakarya, and Düzce meteorological stations' rainfall data from the Turkish State Meteorological Service. The homogeneity of the data was tested using the Kruskal-Wallis homogeneity test.

2.2.2. Annual Ring Chronologies Development

For the dendrochronological analyses, samples were taken from the appropriate places in the research area with incremental borers by identifying suitable trees. In this context, three site chronologies have been created: the Çiğdem Site Chronology (CIG), which consists of 54 cores taken from 27 trees around Çiğdem Plateau in Hendek, Sakarya, the Balıklı Site Chronology (BAL) consisting of 40 cores taken from 21 trees from the vicinity of Balıklı Plateau in Düzce, and the Sinekli Site Chronology (SIN) consisting of 49 cores taken from 26 trees from around Sinekli Plateau in Mudurnu, Bolu (Table 1, Figure 2). Afterward, these three site chronologies were combined by considering their agreement to obtain the Elmacık Regional Chronology (ELM), consisting of 143 cores taken from 74 trees. The regional chronology was created using the program CRONOL (Holmes, 1992). The biweight robust mean method was chosen for this process (Cook et al., 1990). This method is very effective and very complex to calculate, with the details explained by Cook et al. (1990; as cited in Köse, 2007).

Samples were usually taken from a height of 130 cm above the ground. Two cores were sampled from each tree. The study preferred Scotch pines (*Pinus sylvestris L.* ssp. *hamata*) due to their suitability for dendrochronological analysis and the number of aged samples in the field.

2.2.3. Method

Incremental cores were measured in the Dendrochronology Laboratory of the Istanbul University Cerrahpasa Forestry Faculty. Samples were sanded so that the ring boundary could be seen more clearly. Tree-ring widths were measured at a precision of 0.01 mm using the LINTAB™ and TSAP-Win™ measurement system, with the measurement results being recorded as files with the extension *.rwl in the TSAP-Win program (Rinntech, Germany).

The program COFECHA was used to identify missing and false rings in annual ring series and to eliminate measurement errors (Holmes, 1983; Grissino-Mayer, 2001). For cross-dating the measurement results of cores taken incrementally from the field, the data were saved in files with the *.rwl extension, converted into a single file, and then entered into COFECHA as a historically known data set, after which the program was run. Missing and false rings were resolved as a result of cross-dating, and samples whose problems could not be resolved were removed from the data set.

Four methods are used to obtain tree-ring chronologies: 1) skeleton plotting, 2) showing absolute ring widths on a graph, 3) semi-logarithmic presentation of annual ring widths, and 4) standardization of annual ring series (Trenard, 1982; Schweingruber, 1988; Akkemik, 2004). This research uses the fourth method, the standardization of annual ring series and created standard chronologies with a linear regression model using the program ARSTAN (Cook, 1985). A meaningful relationship is known to exist between the growth and development of trees and their environment. Therefore, long-term trends in annual ring widths are observed during annual ring formations according to the tree's age, soil conditions of the environment, aspect, slope, and closure. These trends need to be resolved in order to standardize chronologies. One of the simplest methods for standardizing annual ring chronologies is to construct a linear regression model. This is the preferred model when the chronology shows a linear, horizontal, decreasing, or increasing trend (Akkemik, 2004).

After obtaining individual standard graphs, two basic methods were used to determine the similarities between these graphs (Akkemik, 2004). The first is the Gleichlaufigkeit value, which determines the percentage of changes in the same direction from one year to the next (Eckstein & Bauch, 1969). The second is the correlation coefficient method. The study calculated the Gleichlaufigkeit values and correlation coefficients using TSAP-Win.

Site chronologies were created in ARSTAN by selecting the biweight robust mean method (Cook et al., 1990). Standard and residual site chronologies were then produced for each region.

To determine the changes in annual ring width from year to year, the signal-to-noise ratio (Akkemik, 2004) was calculated in

ARSTAN based on the mean sensitivities, yearly number of ring chronologies, and the mean correlation coefficients between the chronologies.

2.2.3.1. Performing precipitation reconstruction

Site chronologies were created with the samples taken from the trees in the research area. The regional chronology was made by combining the site chronologies. The study used the total annual precipitation data from the meteorological stations of Sakarya (covering the years 1956-2015), Düzce (covering the years 1956-2015), and Bolu (covering the years 1950-2015). Pearson's correlation coefficients were calculated in terms of the climate data from these stations and the regional chronology.

Pearson's correlation coefficients were obtained from the program IBM SPSS 22.0. The calculations considered the total annual precipitation data from October of the previous year to October of the ring formation year, which Fritts (1976) called the biological year, as the independent variables and the standardized regional chronologies as the dependent variables.

Pearson's correlation analysis values (r) range from -1 to +1, with a value of -1 indicating an excellent negative correlation between variables and a value of +1 indicating an excellent positive correlation between variables. A value of $r = 0$ indicates no relationship to exist between variables. If r is positive, one of the variables increases as the other increases, while a negative value for r means one variable decreases as the other increases (Sungur, 2010).

The degree of the relationship between variables is expressed by the value calculated for r, with $0.10 \leq r \leq 0.29$ indicating a small correlation, $0.30 \leq r \leq 0.49$ indicating a medium correlation, and $0.50 \leq r \leq 1.00$ indicating a high correlation (Pallant, 2017).

The results show a high correlation for annual total precipitation. Based on this, the decision was made to carry out reconstructions for the yearly total precipitation data. Firstly, the climate data set to be reconstructed was divided into two sequences, then two separate models were created. The first sequence was used for calibration and the second sequence for verification. The second sequence was then used for calibration in the second model, and the first sequence was now used for verification. Due to the similarity between the derived calibration equations and verification test results, the full calibration period was used for the reconstructions. Statistical results did not permit a reconstruction for the Sakarya station data. Thus, this research made reconstructions for the Bolu and Düzce meteorological stations.

Correlation coefficients, reduction of error ($RE > 0$), and sign tests were used to confirm the estimates. Correlations were calculated separately for the calibration, verification, and overall periods, checking their significance (Fritts, 1976; Akkemik, 2004; Köse, 2007). When determining the reconstruction period, the subsample signal strength (SSS) values were based on periods when the values exceeded 0.85 (Briffa & Jones, 1990).

2.2.3.2. Determining low and high-precipitation years.

Standard deviation (*SD*) values were used to determine the low- and high-precipitation years for the pre-instrumental period (1858-1950). Years exceeding the arithmetic mean values at one and two standard deviation levels are considered high- and very high-precipitation years, respectively; years below the one and two standard deviation levels for their average values were evaluated as low- and very low-precipitation years, respectively.

Table 2: *Statistics for Standard and Residual Site Chronologies Produced in the Research Area*

	CIG		BAL		SIN	
Chronology Type	Standart	Residual (AR1)	Standart	Residual (AR1)	Standart	Residual (AR1)
Mean	0.9810	0.9878	0.9633	0.9895	0.9687	0.9864
Median	0.9410	0.9816	0.9603	0.9805	0.9509	0.9702
Mean sensitivity	0.1432	0.1776	0.1429	0.1815	0.1540	0.1801
Standart deviation	0.2238	0.1562	0.1859	0.1498	0.2105	0.1647
Skewness coefficient	1.6173	-0.0249	0.1090	-0.0929	0.3454	0.8188
Kurtosis coefficient	6.3126	1.0973	-0.4704	-0.0929	0.3932	1.6567
Autocorrations						
t-1	0.6724	-0.0860	0.5868	-0.0762	0.5742	-0.0812
t-2	-0.0856	-0.0647	-0.0310	-0.1336	0.0323	-0.1167
t-3	-0.0617	-0.0731	0.1251	-0.0680	0.0185	0.0008

If t occurs as a superscrıpt, use: t the year the last ring was formed.

3. FINDINGS

3.1. Developing Annual Ring Chronologies

The study developed a regional chronology using three site chronologies (CIG, BAL, and SIN) created from Elmacık Mountain and its immediate surroundings. The mean sensitivity, signal-to-noise ratio, average correlations, and residual chronology with a higher variance for the first eigenvector were preferred when developing the chronologies.

The study used 45 cores from 25 trees for CIG, 40 cores from 21 trees for BAL, and 49 cores from 26 trees for SIN when developing the chronologies. Statistics for the standard and residual local chronologies are given in Table 2.

Common time interval statistics covering the years 1901–2015 (115 years) for CIG, 1917–2015 (99 years) for BAL, and 1894–2017 (124 years) for SIN are given in Table 3.
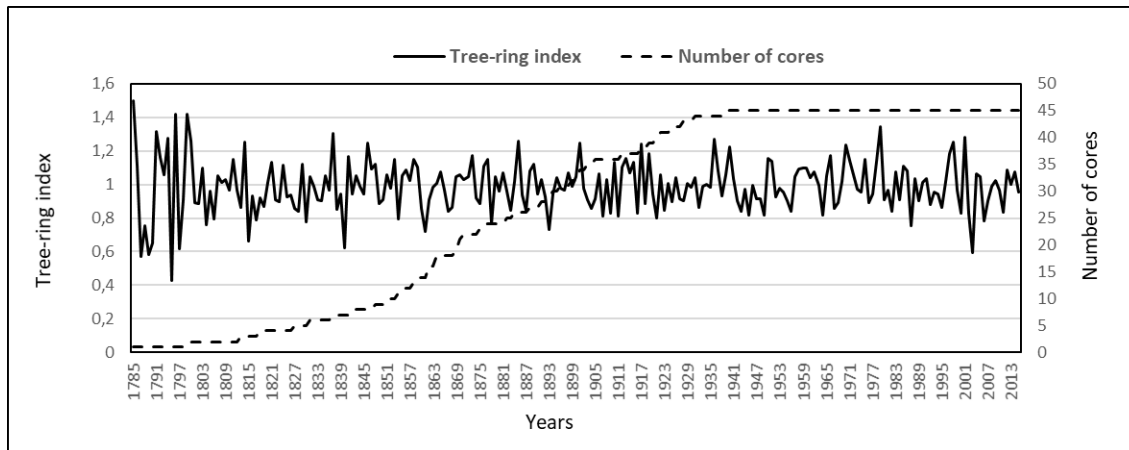
Figure 3. CIG site chronology covering 1785–2015 and the 45 cores.
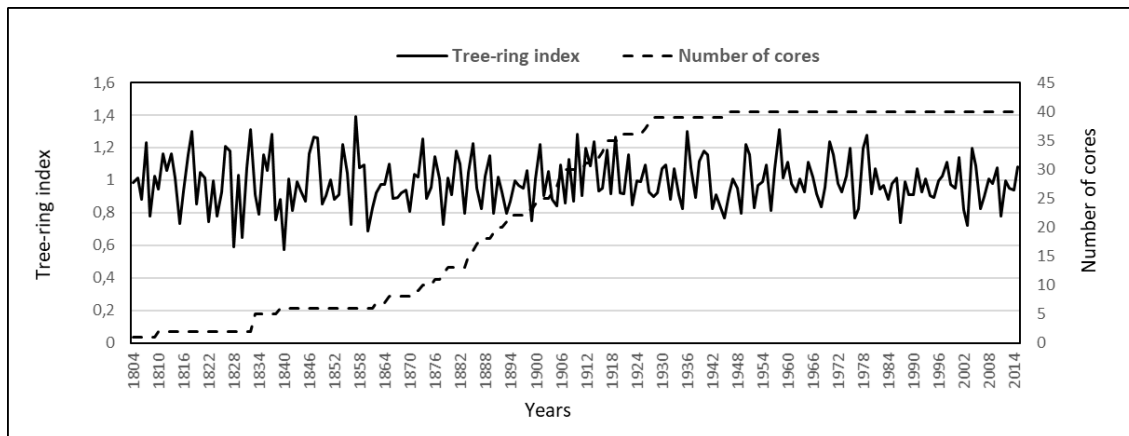
Figure 4. BAL site chronology covering 1804–2015 and the 40 cores.

Table 3: Chronology Statistics from ARSTAN for the Common Time Interval

	CIG		BAL		SIN	
	Standart	**Residual**	**Standart**	**Residual**	**Standart**	**Residual**
Mean correlations						
Correlations among all radii	0.237	0.294	0.182	0.283	0.309	0.365
Correlations between trees	0.230	0.287	0.174	0.276	0.302	0.360
Correlations within trees	0.522	0.534	0.484	0.538	0.646	0.586
Correlations radii vs mean	0.500	0.551	0.446	0.547	0.567	0.614
Signal-to-noise ratio	5.960	8.068	3.992	7.254	10.798	14.091
Agreement with population chronology	0.856	0.890	0.800	0.879	0.915	0.934
Variance in first eigenvector (%)	28.09	31.98	27.17	31.59	35.70	39.13
Chronology common range average	0.988	0.991	0.991	0.991	0.989	0.993
Chronology common range standard deviation	0.184	0.133	0.167	0.132	0.223	0.166

Figure 3 shows the 231-year CIG site chronology covering 1785–2015, Figure 4 shows the 212-year BAL site chronology covering 1804–2015, and Figure 5 shows the 246-year SIN site chronology covering 1770–2015. Figure 6 shows the 246-year ELM regional chronology covering 1770–2015. This was created by combining the site chronologies.

Correlation coefficients and Gleichläufigkeit values (*GL*) were calculated, and their significance levels were checked to determine the appropriateness with the generated site chronologies. The *GL* values and correlation coefficients of the curves between the site chronologies are seen to be statistically significant ($p \leq 0.001$; Table 4).

3.2. Precipitation Reconstruction

The total annual rainfall reconstruction of the Düzce meteorological station for 1858-2015 was made using the following formula:
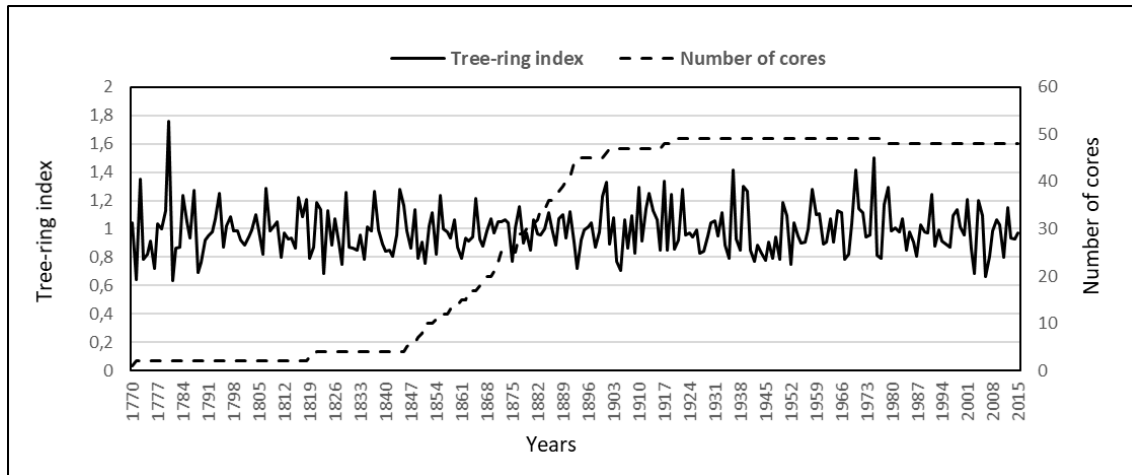
Figure 5. SIN site chronology covering 1770–2015 and the 49 cores.
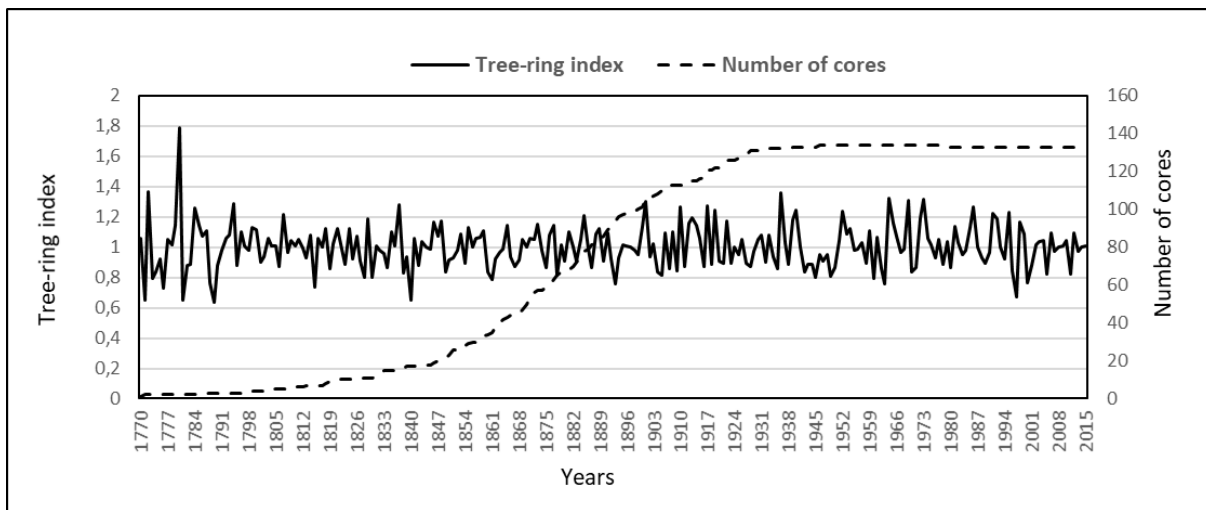
Figure 6. ELM regional chronology covering 1770–2015 and the 134 cores.

Table 4: Correlation coefficients and Gleichläufigkeit values between the Site Chronologies and the Regional Chronology

		Gleichlaufigkeit values (%)		
		SIN	CIG	BAL
Correlation coefficients	SIN	100	75	76
	CIG	0.61	100	76
	BAL	0.63	0.63	100

All values are statistically significant ($p \leq 0.001$).

Total precipitation (mm) = Annual ring width of the prediction year x 0.57 + 233.95 (1)

Total precipitation (mm) = Annual ring width of the prediction year x 0.36 + 193.84 (2)

The total annual rainfall reconstruction of the Bolu meteorological station for 1858–2015 was made using the following formula:

Figures 7 and 8 provide graphs showing the agreement between the Düzce annual total precipitation data and regional chronology, while Figures 10 and 11 provide the graphs showing

Table 5: Düzce and Bolu Meteorological Station Annual Total Precipitation Reconstruction Adjustment and Verification Statistics

	Calibration period	Verification period	Constant	Coefficients	R²	RE	Calibration	Verification
							Sign test	Sign test
	1956-1985	1986–2015	235.44	0.57	0.36	0.61	22 + / 8 - P ≤ 0.05	22 + / 8 - P ≤ 0.05
DÜZCE	1986–2015	1956–1985	240.65	0.56	0.39	0.61	22 + / 8 - P ≤ 0.05	22 + / 8 - P ≤ 0.05
	1956-2015	-	233.95	0.57	0.38	-	44 + / 16 - P ≤ 0.01	-
	1950–1982	1983–2015	222.07	0.32	0.35	0.55	24 + / 9 - P ≤ 0.05	24 + / 9 - P ≤ 0.05
BOLU	1983–2015	1950–1982	146.75	0.41	0.35	0.54	24 + / 9 - P ≤ 0.05	24 + / 9 - P ≤ 0.05
	1950-2015	-	193.84	0.36	0.34	-	48 + / 18 - P ≤ 0.01	-
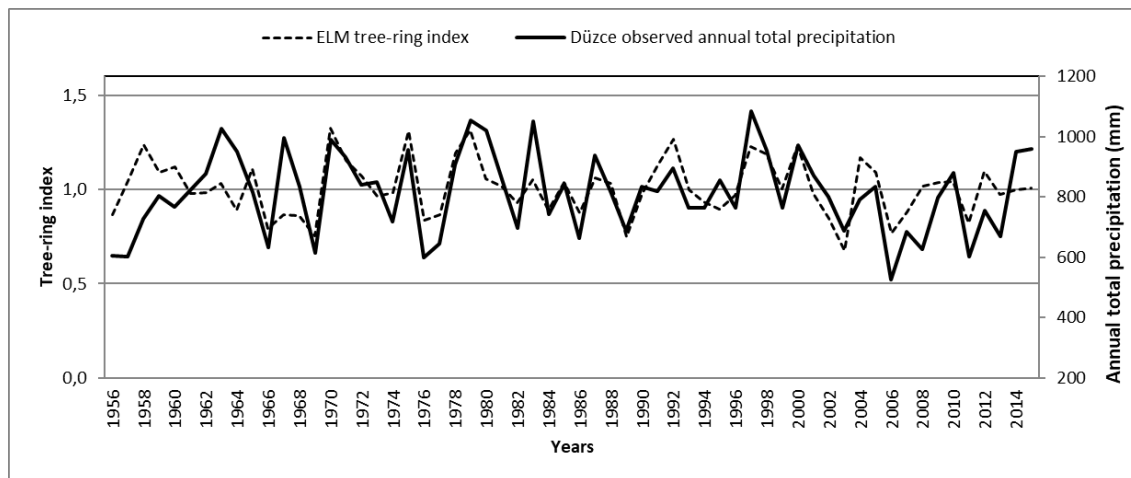
Figure 7. 1956-2015 ELM regional chronology tree-ring index and total annual precipitation at Düzce meteorological station for 1956-2015.
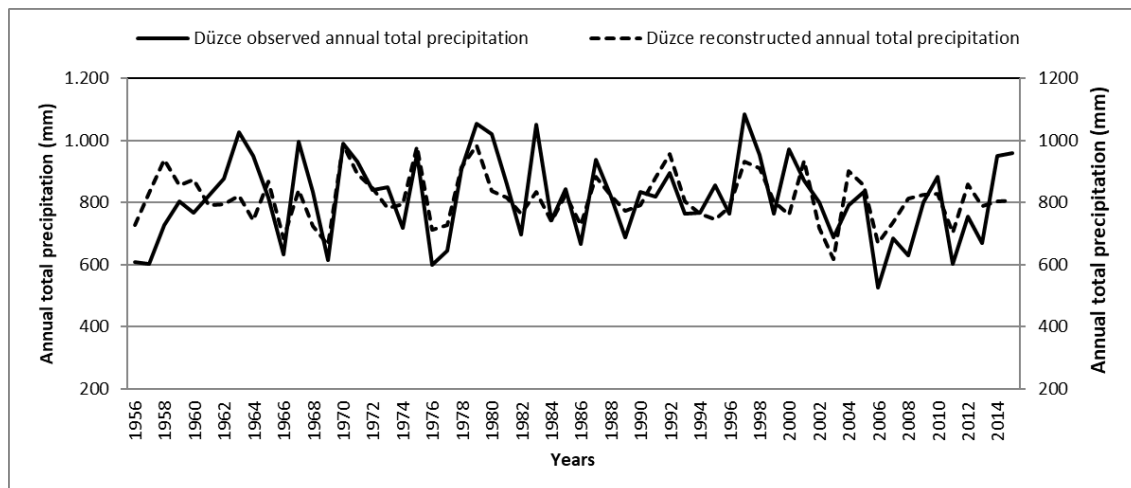
Figure 8. Total annual rainfall reconstructed and observed at the Düzce meteorological station for 1956-2015.

the agreement between the Bolu annual total precipitation data and regional chronology. Figure 9 shows the estimated annual rainfall at the Düzce meteorological station for 1858–2015. Figure 12 shows the estimated yearly rainfall at the Bolu meteorological station for 1858–2015. Table 5 provides the adjustment and validation statistics for the reconstructions.
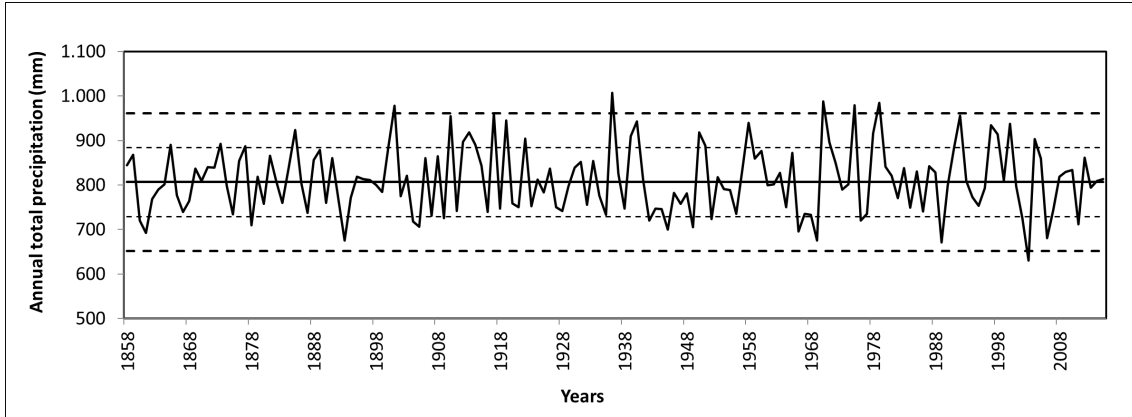
Figure 9. Reconstructed total annual rainfall at the Düzce meteorological station for 1858-2015 (Black horizontal line indicates mean, inner horizontal dashed lines indicate the limits of ±1*SD*, and outer horizontal dashed lines indicate the limits of ±2 *SD*s).
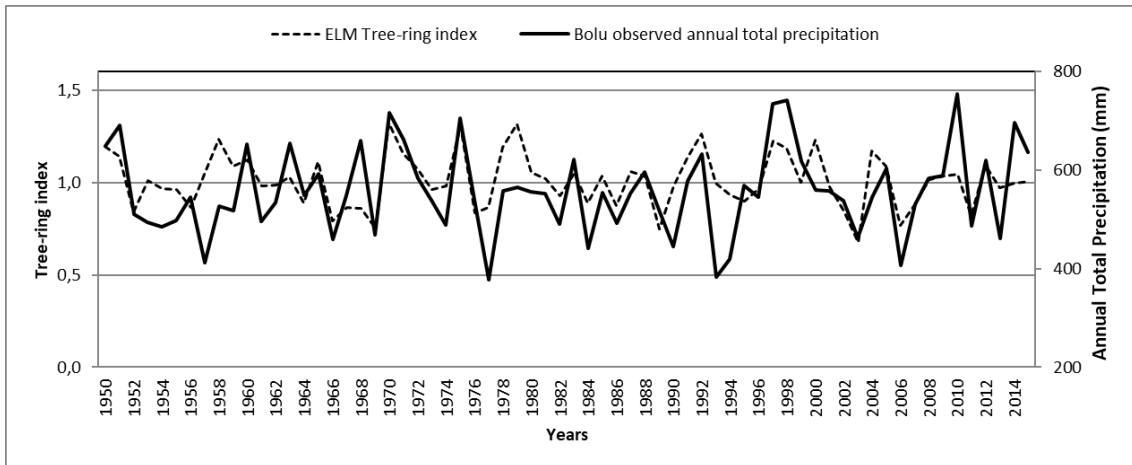
Figure 10. 1956-2015 ELM regional chronology tree-ring index and total annual precipitation at the Bolu meteorological station for 1956-2015.
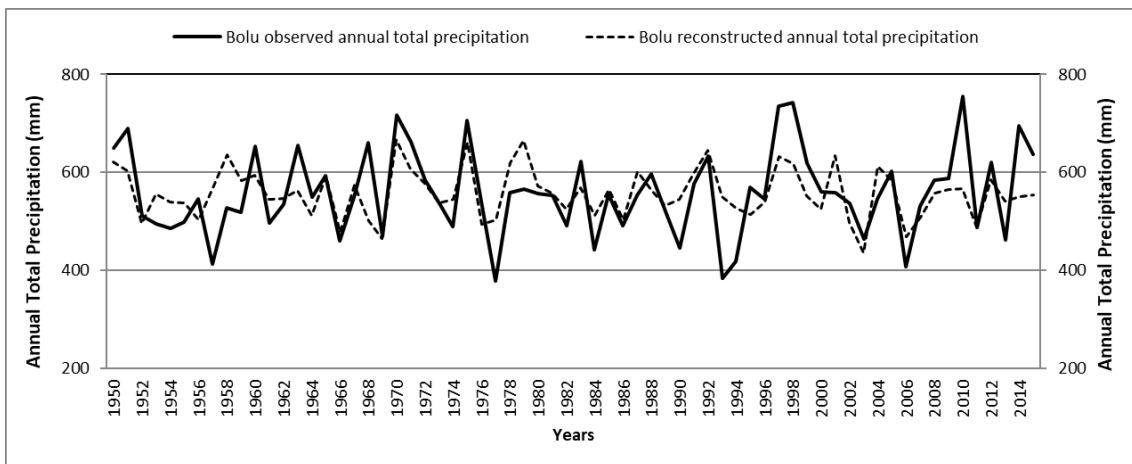
Figure 11. Total annual rainfall reconstructed and observed at the Bolu meteorological station for 1956-2015.
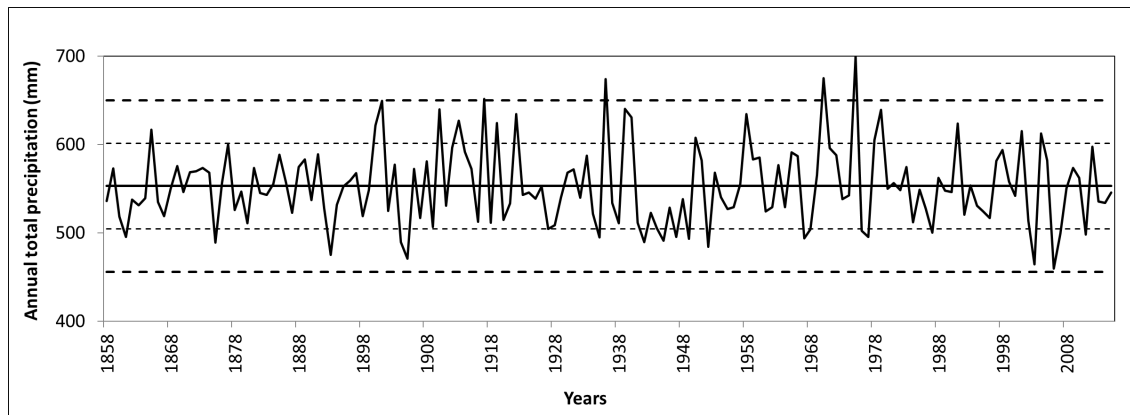
Figure 12. Reconstructed total annual rainfall at the Bolu meteorological station for 1858-2015 (Black horizontal line indicates mean, inner horizontal dashed lines indicate the limits of ±1*SD*, and outer horizontal dashed lines indicate the limits of ±2 *SD*s).

3.3. Determining Low- and High-Precipitation Years

Standard deviation (*SD*) values were used to determine low- and high-precipitation years. Years exceeding the arithmetic mean values at a level of one or 2 positive *SD*s are considered respectively as high- and very high-precipitation years, respectively. Years whose average precipitation values fall below one or two negative *SD*s are evaluated as low- or very low-precipitation years, respectively.

The results of the precipitation reconstruction at the Bolu and Düzce meteorological stations were in agreement, as expected. No very low-precipitation year could be determined in the reconstructed period. The analyses demonstrated low-precipitation events to have never lasted more than two years between 1858-1950. Of the 14 low-rainy years found in this period, 10 were lasted one year, and two lasted two years. However, 1901 and 1936 were very high precipitation years. In addition, 13 high-precipitation years were found, 8 of which lasted one year, and two of which lasted two years. Only one high precipitation period lasting 3 years occurred (1912–1914) over the reconstructed period (Table 6).

3.4 Comparing the Results with Previous Studies

Akkemik et al. (2005) defined 1887 as a very dry year for the vicinity of Kastamonu, as well as Akkemik & Aras (2005) for Konya, Hughes et al. (2001) for the Aegean basin, and Köse (2007) for Kütahya, Afyon, Eskişehir, and Isparta. Köse (2007) discusses how the Ottoman Archives mentioned Anatolia to have had a great drought and famine in 1887. According to the results of the current study, 1887 also had less precipitation than normal for the Bolu and Düzce stations, where the precipitation reconstructions were made.

Köse (2007) stated 1893-94 to have been a 2-year dry period for Western Anatolia. Akkemik & Aras (2005) found 1893 to have been extremely dry for Konya. Cook et al. (2015) determined 1893 as the dry year for the European continent in general. Tekin (2015) quoted a drought to have occurred in 1892-1893 and to have affected the Eastern Anatolia region, especially Erzurum and Bitlis. In addition, the drought affected Bayburt and its surroundings in the Black Sea region, with around 20,000 poor people from these regions having had to migrate to Trabzon. Moreover, the current paper also identified 1893 as a low-precipitation year for the research area.

Gönüllü (2010) mentioned extreme rainfall, floods, and overflows in many parts of Anatolia throughout 1901, especially in July, with these floods and overflows also causing loss of life and property. Köse (2007) reported the same year to have high precipitation for Western Anatolia. According to the May-August rainfall predictions Akkemik & Aras (2005) made for 1689-1994 at the Konya meteorological station, the three years of 1900-1902 were detected as having high precipitation.

Table 6: Reconstructed Total Annual Precipitation for Düzce and Bolu Meteorological Stations Below or Above the Long-Term Average by One or Two Standard Deviations

Very rainy years (over 2 SD)	1901, 1936
Rainy years (over 1 SD)	1865, 1873, 1877, 1885, 1910, 1912, 1913, 1914, 1917, 1919, 1922, 1939, 1940
Very low-rainy years (below -2 SD)	-
Low-rainy years (below -1 SD)	1860, 1861, 1875, 1878, 1887, 1893, 1904, 1905, 1907, 1909, 1935, 1942, 1945, 1949

Köse et al. (2013) and Cook et al. (2015) stated 1909 to have had low precipitation, as well as 1893. The Ottoman archives reported wheat exports to have been banned due to famine in these years. Likewise, this study determined 1893 and 1909 to have had low precipitation.

Hughes et al. (2001) presented 1901, 1910, 1917, 1919, and 1936 as high-precipitation years for the Aegean basin. The current research also found these years to have had high precipitation. Moreover, 1901 and 1936 were years with very high precipitation. These same two years were also expressed as having high precipitation according to the results of the May-June precipitation reconstruction by Martin-Benito et al. (2016), which included northeastern Türkiye. The years 1912-1914 were also revealed as a high precipitation period. Similarly, Martin-Benito et al. (2016) indicated 1913-1914 to have been wet years.

According to the spring precipitation reconstruction (1776-1998) Touchan et al. (2003) made for Southwest Türkiye, 1935 was the driest year, while 1936 was the wettest. This study also found 1935 to have had low precipitation and 1936 to have had very high precipitation. 1936 was also expressed as a high-precipitation year according to the results of the May-June precipitation reconstruction Griggs et al. (2007) made for the Northern Aegean.

4. CONCLUSIONS

This research has created three Scotch pine (*Pinus sylvestris* L. ssp. *hamata*) site chronologies of 214, 233, and 248 years using core samples from Elmacık Mountain in Northwest Türkiye where the Western Black Sea and the Eastern Marmara regions meet. The site chronologies were then combined into a regional chronology. With this chronology, a 158-year (1858-1915 AD) retrospective estimate was made of the total annual precipitation data from the Bolu and Düzce meteorological stations. In addition, low- and high-precipitation years were revealed for 1858-1950 before the stations started recording data.

According to the results, very low-precipitation years could not be determined between 1858-1950. Low-precipitation years were understood to have been 1860-1861, 1875, 1878, 1887, 1893, 1904-1905, 1907, 1909, 1935, 1942, 1945, and 1949. On the other hand, 1865, 1873, 1877, 1885, 1910, 1912-1914, 1917, 1919, 1922, and 1939-1940 were high-precipitation years, and 1901 and 1936 were determined as very high-precipitation years.

According to our literature review, this research is the first dendroclimatological study in Türkiye to regard a total annual precipitation reconstruction. In addition, the number of Scotch pine chronologies in Türkiye is limited. In this sense, performing longer-term studies and making comparisons by increasing the Scotch pine chronologies for different areas would be helpful in terms of precipitation data.

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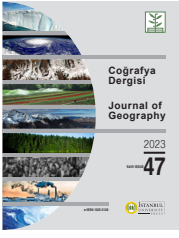
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P R E S S

Slow City and Tourism Coexistence

Sakin Şehir ve Turizm Birlikteliği

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ABSTRACT
Certain slow cities are found to host a demand for tourism well in excess of their population. This situation being experienced in destinations whose unique features entitle them to be part of the Cittaslow movement has raised debates. Within this context, this study aims to evaluate the coexistence of tourism and slow cities based on the opinions of experts on the subject who reside in slow cities for business or personal reasons. The study has consulted within its scope the opinions of 18 academicians from nine slow cities. The results show destinations that are part of the Cittaslow movement and that also appeal to mass tourism to have lost their calm. Another important conclusion of the study is that local administrators see joining the Cittaslow movement as a marketing strategy for the destination. In the face of the existence of exemplary destinations that have lost their calm and of the marketing-oriented perspective of local administrators, the interviewees stated that relevant criteria should be used as a balancing mechanism and that sustainable tourism goals can be achieved through tourism activities that are carried out by adhering to these criteria.
Keywords: Slow Cities, Cittaslow, Tourism, Sustainable Tourism

ÖZ
Bazı sakin şehirler bulunmaktadır ki nüfusunun çok üzerinde bir turizm talebine ev sahipliği yapmaktadır. Kendine özgü özellikleri ile sakin şehir unvanını almış destinasyonların böyle bir durumla karşılaşması beraberinde tartışmaları da gündeme getirmektedir. Bu bağlamda bu araştırma ile sakin şehirler ile turizm birlikteliğinin sakin şehirlerde iş ve ikamet amaçlı bulunan ve uzmanlık alanı olarak konuya hakim olan kişilerin görüşleri ile değerlendirilmesi amaçlanmıştır. Araştırma kapsamında dokuz sakin şehirden on sekiz akademisyenin görüşüne başvurulmuştur. Sonuçlar göstermektedir ki sakin şehir unvanının yanında kitle turizmine de hitap eden destinasyonların sükûnetleri kaybolmuştur. Bir diğer önemli sonuç ise yerel idarecilerin sakin şehirler birliğine dahil olmayı destinasyon pazarlamasına yönelik bir strateji olarak gördükleridir. Sakinliğini kaybetmiş örnek destinasyonların varlığı ve yerel idarecilerin pazarlama odaklı bakış açısı karşısında görüşmeciler, kriterlerin denge mekanizması olarak kullanılmasının gerekliliğini belirtmiş ve kriterler bağlamında gerçekleştirilen turizm faaliyetleri sonucunda sürdürülebilir turizm hedeflerine de ulaşılabileceğini ifade etmişlerdir.
Anahtar kelimeler: Sakin Şehirler, Cittaslow, Turizm, Sürdürülebilir Turizm

1. INTRODUCTION

Globalization is one of the most common words used to explain today's world and many current events. In a globalized world, differences disappear and everyone is forced to become uniform, no matter how hard they resist. According to Genç (2021), the homogenizing effect of globalization has been debated and criticized with phrases such as McDonaldization (Ritzer, 1996) or Americanization (Demirhan & Taylan, 2017), which references the United States of America as the country that introduced globalization to the world. Some of the areas where uniformization is intensely demonstrated involve eating habits and cities.

International chain food companies can move faster than people. People do not have to go to the company's founding city to consume the products of these chains, as they can easily access these companies wherever they are. For many people, this situation is pretty normal and pleasing. However, some people see the negative aspects yet remain involved in the process without knowing what they can do to defeat it. Meanwhile, a few other people take a more conservative stance and actually do something to preserve their local values. These actions may include not consuming from global companies or becoming a member of a non-governmental organization. Beyond these individual reactions are some movements like slow food, slow cities (Cittaslow), and slow tourism.

In 1986, a demonstration pushing back against the opening of a fast-food chain paved the way for more serious developments, such as signing the Slow Food manifesto at the meeting held in

1989 with the participation of representatives from 15 countries (Slow Food, 2021). This manifesto is a sign that a war had begun against globalization through fast-food criticism. The manifesto states, "In the name of productivity, the 'fast life' has changed our lifestyle and now threatens our environment and our land (and city) scapes" (Slow Food, 2021). In 1999, the Cittaslow association was established under the leadership of the head of the Slow Food movement, Carlo Petrini, and four mayors from Italy. Today, the Cittaslow movement involves a network of municipalities covering 287 cities in 33 different countries and ironically uses the weapon of globalization in order to establish an opponent philosophy against the concept of globalization.

As can be seen in Figure 1, Türkiye has 21 slow cities as of 2023. These cities and their provinces can be listed as follows in order of having joined the association: Seferihisar in İzmir in 2009, Gökçeada in Çanakkale in 2011), Akyaka in Muğla in 2011, Yenipazar in Aydın in 2011, Yalvaç in Isparta in 2012, Vize in Kırklareli in 2012, Perşembe in Ordu in 2012, Halfeti in Şanlıurfa in 2013, Şavşat in Artvin in 2015, Uzundere in Erzurum in 2016, Eğirdir in Isparta in 2017, Gerze in Sinop in 2017, Göynük in Bolu in 2017, Mudurnu in Bolu in 2018, Ahlat in Bitlis in 2019, Köyceğiz in Muğla in 2019, Güdül in Ankara in 2020, Arapgir in Malatya in 2021, İznik in Bursa in 2021, Foça in İzmir in 2021, and Kemaliye in Erzincan in 2022.

Within and beyond Türkiye are some slow cities that host a number of tourists way in excess of their capacity. Although experts do not find this proper, the administrators of the related destinations have seen and introduced this as a sign of success. Ekincek's (2014) study understood Cittaslow city administrators
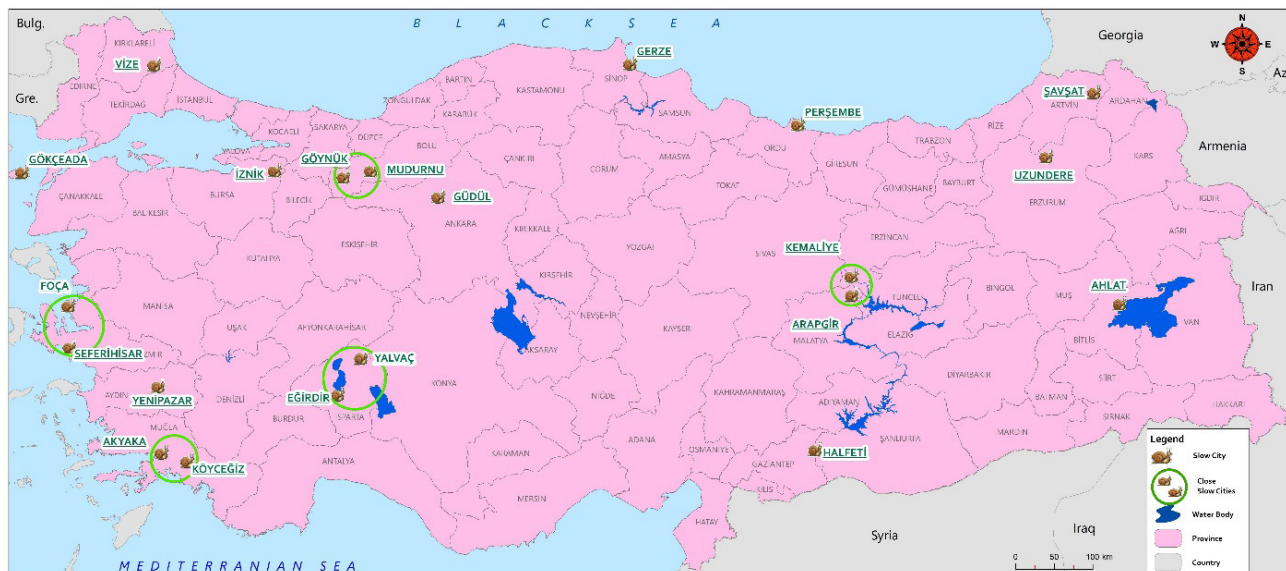
Figure 1. Slow Cities of Turkey

to view becoming a member of the Cittaslow association as an important step toward strengthening the image of the destination and toward branding. These so-called success stories make many micro-destination managers want to become a part of the Cittaslow movement. However, having Cittaslow become a successful concept in marketing destinations also brings the risk of eroding the resources Cittaslow aims to protect and improve (Nilsson et al., 2011; Karadeniz, 2014).

Slow city destinations have a high tourism demand, and despite having different touristic attractions that cause this, marketing a destination with the label of being a Cittaslow member may raise a dispute between the essential points of this philosophy and the business of tourism. Within this context, this study aims to evaluate the validity of the possible disputes and concerns on this matter from the perspective of academicians specialized on the subject.

1.1 The Paradox of Tourism in Slow Cities

The Cittaslow movement actually has a deep philosophy behind it. Therefore, one cannot really say that for all slow cities that their local administrators who have decided to join the Cittaslow association fully understand the Cittaslow philosophy, nor all local residents or tourists who visit there. With the increased demand in tourism, investors may possibly engage in actions counter to the Cittaslow philosophy. Thus, to believe that the possible adversities of tourism that are expected to occur in all destinations will not occur in slow cities is unrealistic. Moreover, these destinations being at a microscale makes the fact that these adversities will be experienced more intensely in these cities inevitable.

The best example of the coexistence of a slow city and tourism n Türkiye would be Seferihisar, which has been the subject of many studies. One of these studies (author, year) concluded that some of adversities the city may face could be increased traffic, noise, construction, prices, and population, as well as shoddy construction, protected areas turning into construction sites, the establishment of big hotels, parking issues, migration, cultural corruption, deterioration of the ecological texture, an unaware public that only cares about their short-term interests, and investors being attracted. Other studies have also had similar results, reasserting the above-mentioned study and pointing out the conflicting aspects of slow cities and tourism. As Genç (2021) stated, the tourism activities experienced in Seferihisar have brought along intensive tourism investments; as a result, the number of hotels has increased from 15 in 2009 to

163 in 2021. Nevertheless, various studies have revealed Seferihisar to mostly attract daily visitors rather than tourists who will spend the night (Coşar, 2013; Çıtak, 2016). These same-day visits may sometimes cause overcrowding at a level that can disturb the locals (Doğan et al., 2014; Dündar & Sert, 2018). Coşar (2013, p. 80) reported one local resident to have the following opinion: "Our life has become more difficult as the crowds have increased. Especially on weekends, the traffic jams are really disturbing. The current structure of Seferihisar cannot handle such a crowd." These crowds are caused not only by pedestrians but also by vehicles, which also brings up the issue of parking.

As the area has become a tourist attraction, secondary residents (see Ak & Bıçkı, 2016), investors, and those who move to the region for employment in these investments (see Farhadi, 2012) have caused a population increase. As Genç (2021) explained, the population of Seferihisar was 28,603 in 2009 and increased to 48,320 in 2020. An increase has also occurred in construction with the increase in the settled population and the demand for tourism. Ak Çetin and Akpınar (2021) stated the number of companies in the construction business in the district to have reached a very high level and 48% of houses for sale to be new. The number of houses had been 14,284 in 2009 and reached 44,053 in 2021. Parallel to the population growth, the demand for housing and rentals have also increased, with land prices also rising for new house construction.

Öztürk (2012) reached such a conclusion in her study asking local people's opinions. Genç (2021) reported real estate prices to have increased by 160% between 2017-2021, with this being 135.61% for Izmir. Price increases are experienced not only in the real estate market but also with consumer goods. Farhadi's (2012) study concluded 48% of the participants to believe that Cittaslow tourism had had the effect of increasing prices.

With the motive for higher rental income, property owners may think about evicting tenants who are local residents and selling their current residences to investors, which may result in local residents being displaced. Moreover, the local people in such a scenario are compelled by their relatively high income to live their lives removed from their traditional lifestyles and outside of the neighborhoods they have left. In short, gentrification may begin through the tourism demand and the impact of new residents (Özmen & Can, 2018). For the Sığacık Kaleiçi area in particular, the area as an attraction point for visitors can be said to be on its way to becoming a symbol of capitalism with its new generation of restaurants, cafes, and

boutique hotels (Köstem & Yüksel, 2020). The growing income disparity between the residents of Sığacık and other neighborhoods in favor of the new residents is also a clear sign of gentrification (Özer Tekin, 2018).

One can see gentrification emerging through tourism and new residents in the district not only through places of consumption but also through new residences. As a matter of fact, the number of pools, which was only 6 in 2009, had increased to 287 in 2021. This increase cannot be explained simply by the increase in the number of hotels. The fact that new residents build their new houses with a pool can be interpreted as a departure from the traditional architectural pattern of the region (Genç, 2021).

The situations conveyed through Seferihisar may also be valid for other slow cities and have been revealed by various studies. In the article "Slow Cities, Fast Tourists", Çıtak (2016) stated some slow cities in Türkiye to be exposed to mass tourism. Besides Seferihisar, another good example would be Akyaka. Akyaka is frequently featured in the national press with the number of tourists it hosts, which far exceeds its own population. Although not as much as Akyaka or Seferihisar, Halfeti now has 6,000 vehicles entering it daily, with very loud music being played on boat tours. This completely contradicts the Cittaslow philosophy, which includes prioritizing pedestrians and having environmentally sensitive approaches (Özmen & Can, 2018).

While Goolwa had been a river port city in Australia, after joining the Cittaslow association, it started to face an intense demand for tourism and started opening art galleries, cafes, and hostels in the historical buildings of the city in response to this demand. This indicates gentrification to have started through places of consumption and the effect of tourism (Serin, 2009). Mayer and Knox (2006) also stated the slow cities of Hersbruck and Waldkirch in Germany to be important alternatives for the residents of large nearby cities for entertainment purposes. As explained above, however, gentrification happens not only through place of consumption but also through residences. For example, high-income groups working in cities such as Milan and Turin prefer the nearby slow cities for their residences (Nilsson et al., 2011). This fact not only doesn't add value to slow cities but also causes housing prices to rise.

Similar developments took place in the destination city of Taraklı, which was removed from the Cittaslow association in 2022. Large spa facilities with a timeshare system were established at a point very close to the district center of Taraklı,

targeting people in big cities such as Istanbul and Ankara, especially Arab tourists. These facilities have had an undeniable impact on the increase of brand chains in this destination and the replacement of neighborhood grocers by large markets after being designated as a Cittaslow city (Toprak, 2018). According to Semsari and Giritlioğlu (2021), such cases can see the voices of the new residents of the city drown out the voices of the local residents regarding urban management issues, and this is quite in contrast to the slow city philosophy.

This study has found within its scope no research to have established a direct relationship between being included in the Cittaslow association and an increased demand in tourism for the destination. Arikan et al.'s (2015) study on three slow cities located in Austria concluded the partial increase in tourists after joining the Cittaslow association to not be able to be directly associated with its membership, nor could the study make a comparison between the cities due to each slow city having a unique profile. Hence, explaining the increased demand in tourism and other aforementioned developments only with having become a slow city does not seem very appropriate. To give an example from Türkiye, the slow cities of Seferihisar and Köyceğiz have seen an increase in the square meter housing costs after joining the Cittaslow association, despite no rise in real estate prices occurring in other slow cities such as Gökçeada, Eğirdir, or Perşembe.

2. METHODOLOGY

2.1 Purpose and Importance of the Study

This study aims to start a debate on the idea that situations contradicting the slow city philosophy may arise as a result of the increase in tourism activity in slow city destinations. In line with this aim and based on the collected opinions collected, the importance of the study can be stated in the suggestions that will be presented to the local governments of existing and potential slow cities regarding the requirements of the philosophy and the execution of balanced tourism activities.

2.2 Data Collection Method

The research data were obtained using the interview method, one of the most frequently used qualitative research methods. To collect opinions, the researchers created a semi-structured interview form based on the literature review and the suggestions of researchers who have studied slow cities as a subject. Different districts are the subject of the study, and because the experts

whose opinions are to be consulted live in different places, the interview form has been sent by e-mail.

The interview form consists of nine questions. The questions are used to obtain opinions on the coexistence of slow cities and tourism, and these opinions are expected to be presented based on the current situation in the destination city. The questions were designed in line with this, and this situation was also conveyed to the interviewees. The interview form is has the following questions:

1. Can you briefly introduce yourself and your institution?
2. Can you evaluate the effect being in the Cittaslow network has on destination marketing?
3. Can you comment on the current tourism demand (accommodations, daily tourists) in your destination? Has being included in the Cittaslow network had an impact on demand?
4. Do you have any observations or thoughts that the negative developments (e.g., crowding, noise and visual pollution, secondary housing, expensiveness) that occur in destinations that are overly dependent on the tourism sector are being experienced in your destination or may be experienced according to the current trend?
5. Can you comment on the positive and negative effects of slow cities' use of unique values (e.g., cultural values such as local dishes, handcrafts, events) as a way to draw tourism? Can you talk about the commodification of values?
6. Can you comment on the purpose of including administrators in the Cittaslow network? Do you think their main purpose is to consider and adopt the Cittaslow philosophy as beneficial to the settlement or is it an initiative for tourism?
7. What are your thoughts on how the local people have responded to the tourism activities (e.g., the increased demand for tourism-oriented businesses) that comes with the title of being a slow city?
8. Can you comment on the idea that the destinations being marketed with the Cittaslow label to attract attention contradicts the Cittaslow philosophy?
9. What is your belief on the ability of the Cittaslow philosophy and criteria being carried out alongside the tourism sector?

When forming the sample, the study used the purposive sampling method, which involves selecting knowledgeable and experienced individuals on the subject (Yağar & Dökme, 2018). In line with this method, the decision was made to consult the opinions of tourism academicians who work in slow cities, as well as tourism academicians who've chosen to reside in slow cities despite working elsewhere. This preference was made with the aim of benefitting both from their fields of expertise as well as from their daily life experiences and observations due to living in the relevant cities. As of January 19, 2023, eight of the 21 slow cities in Türkiye were determined to have tourism departments and programs at the higher education level or departments and programs closely related to tourism (e.g., gastronomy, tour guiding) and to have 70 instructors within the scope of these departments and programs. All participants in the study were informed about the subject and content of the research. Consent was obtained from all participants, and their participation in the study occurred voluntarily.

Table 1: Information Defining the Sampling

Interviewee Code	Destination	Destination membership date	Interviewee working/residence time
I-1	Akyaka	2011	11 years
I-2	Yalvaç	2012	13 years
I-3	Yalvaç	2012	6 months
I-4	Eğirdir	2017	26 years
I-5	Eğirdir	2017	2 years
I-6	Gökçeada	2011	5 years
I-7	Gökçeada	2011	2 years
I-8	Gökçeada	2011	12 years
I-9	Gerze	2017	12 years
I-10	Gerze	2017	2 years
I-11	Mudurnu	2018	5 years
I-12	Mudurnu	2018	3 years
I-13	Mudurnu	2018	8 years
I-14	Mudurnu	2018	5 years
I-15	Mudurnu	2018	2 years
I-16	Perşembe	2012	15 years
I-17	Köyceğiz	2019	33 years
I-18	Halfeti	2013	1 year

Table 2: Population and Number of Tourists with Accommodation in Slow Cities (2018/2021)

Destination	District Center Population 2022	Tourist number 2018	Tourist number 2021	Destination	District Center Population 2022	Tourist number 2018	Tourist number 2021
Seferihisar	54993	68291	80,453	Gerze	19144	16,456	11,869
Gökçeada	7479	15571	19,596	Göynük	4332	5,881	5,537
Akyaka*	3147	26,240	24,712	Mudurnu	5428	106,793	97,270
Yenipazar	11863	No data	No data	Ahlat	28904	7,836	7914
Yalvaç	22538	27,929	21,839	Köyceğiz	39242	44,762	58,245
Vize	15116	5,193	6,894	Güdül	8079	No data	No data
Perşembe	30101	8,967	8,180	Arapgir	9964	1700	7,860
Halfeti	41662	14,967	3,060	İznik	44236	42,885	47,772
Şavşat	5885	10,263	19,532	Foça	34946	21,080	52,780
Uzundere	7625	5,863	2,734	Kemaliye	2536	4687	4,221
Eğirdir	16759	32,245	26,076				

*Because it is connected to the Ula district, statistics actually belong to Ula.

As can be seen in Table 1, 18 academicians from nine different slow cities had submitted answers for the interview form that had been sent. Although no higher education department or program on tourism exists in Akyaka, Perşembe, and Köyceğiz, answers were received from the tourism academicians residing in these cities. The highest number of answers was received from Mudurnu.

2.3 Data Analysis

As a result of the combining the interviews with the evaluations from the three researchers, two themes were determined: evaluating the current situation and evaluating the coexistence of a slow city and tourism. Based on the purpose of the study, descriptive analysis was carried out by presenting direct quotations of the interviewees' statements regarding certain themes. Secondary data such as the number of tourists, population sizes, and newspaper content were also included in the analysis alongside the interviewees' statements.

Triangulation is a commonly used technique for establishing the credibility of qualitative research. The purpose of triangulation is to compare the obtained results from different perspectives (Işık & Semerci, 2019) and to realize a consistent analysis. According to Patton (2014), qualitative analysis can benefit from triangulating the methods, sources, analysts, and theories. This study uses source and analyst triangulation. The use of secondary data sources in addition to the interview data shows how the source triangulation was used, and the inclusion of three researchers in the data collection and interpretation stages shows how analyst triangulation had been used.

3. FINDINGS

3.1 Evaluating the Current Status

Table 2 shows the number of tourists with accommodations in the slow cities of Türkiye for 2018 and 2021. The 2018 figures have been included to reflect the situation before the COVID pandemic, and the 2021 figures have been included to reflect the situation after the gradual lifting of the pandemic restrictions. Although this table is far from being able to explain the impact
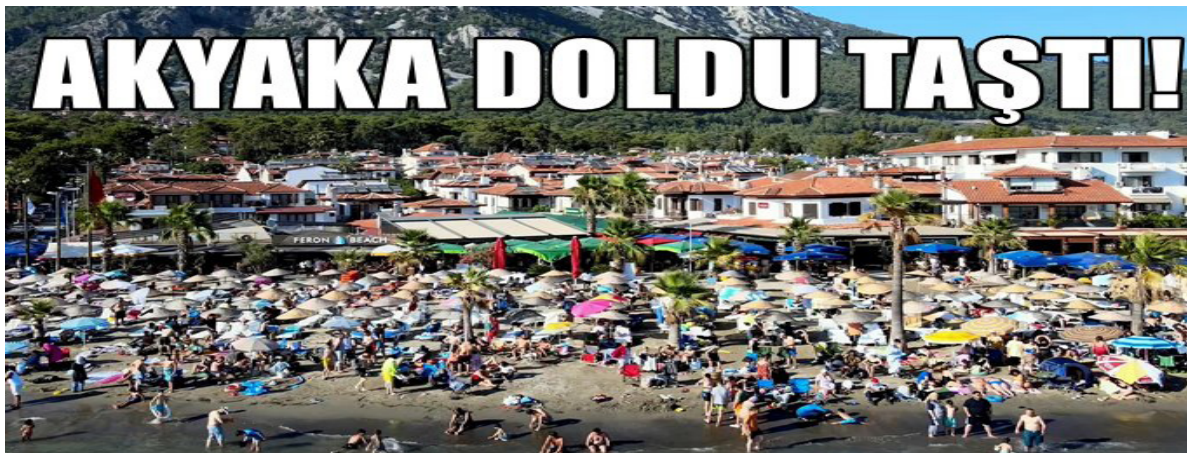
Figure 2. A Picture from the Slow City, Akyaka
Source: Haberekspres, 2022

being a Cittaslow city has on the demand for tourism in the destination, it does provide partial information on the current situation of these destination cities. As can be seen from the table, the number of tourists with accommodations in slow cities is not very high. However, as can be understood from the views, a higher demand is found for day trips compared to overnight stays in slow cities. Representing Köyceğiz, Interviewee 17 (I-17) stated the following about daily visits still being predominant despite the increased demand accompanying the Cittaslow title:

This place can be described as a place where daily visits are more common than visits with overnight accommodations. Visitors to this area don't really interact much with the locals as they pass by here on their way to more popular destinations around the district such as Fethiye, Marmaris, or Bodrum.

In terms of the number of tourists with accommodations, the destinations that are at the top of the list for having reached more than 50,000 tourists are in order Mudurnu, Seferihisar, Köyceğiz, and Foça. For both years, Mudurnu had the highest number of tourists. The factors that make Mudurnu stand out among the slow cities are its high-end hotels and Abant Nature Park, which is located in the middle of the country's largest domestic tourism market and includes cities such as Ankara and Istanbul, is located within the boundaries of the district. Otherwise, the overnight capacity of Mudurnu city center is 253 persons in 12 facilities (Genç, 2016); this place lacks the potential to compete with summer tourism destinations such as Seferihisar, Akyaka, and Foça, which have attractions such as sea, sand, and sun, as well as being slow cities. The demand for Mudurnu city center can be understood from the statements of all participants from Mudurnu to not be overnight tourism but to mainly involve same-day visits, as in many other slow cities. I-15 expressed their views, stating, "People generally stay in Abant or the facilities on the way to Abant. I believe they have day trips to Mudurnu."

As explained above, tourism demand for slow cities in Türkiye is not high. Hence, no generalization can really be made about a positive or negative effect of tourism originating from slow cities. To come to a conclusion on this effect is much more difficult, especially in destinations that have recently been included in the Cittaslow movement. However, in slow cities such as Seferihisar, Akyaka, and Gökçeada, which also host tourists within the scope of mass tourism, the positive and especially negative effects of tourism can be felt and interpreted much more clearly. In fact, due to being micro-destinations, they may face challenges in meeting the demand due to their infrastructure and superstructure. These destinations are also

featured in the press from time to time with news about the intense demand for tourism.

Gökçeada representative I-10 explained as follows about how the social life of the local people is adversely affected during the summer in particular:

*For Gökçeada, especially in spring and summer, the demand is at a disturbing level. It has become worse, especially after that movie (*Hedefim Sensin*) was shot on the island. For the last two years, it has exceeded its carrying capacity. I don't think being included in the Cittaslow association has had a noticeable effect on this demand. I'm sure there are also tourists who are attracted to this title, but I believe their numbers are far lower than what they should be. Those who go to the island to work in June like us later experience serious difficulties. Although the ferry times are more frequent now, most of the time, we cannot get on the ferry with our personal cars. We have to leave our vehicle in the car park at Kabatepe Port and continue on foot. When we continue on foot, there are times when we cannot board the minibuses on the island or find a taxi. Besides, prices increase tremendously in the summer time. This is another huge problem for the locals. In addition, houses for students and civil servants are rented until the end of May. Once the season starts, even if the schools are not closed yet, the students and workers must evacuate their homes because these houses have been rented to domestic and foreign tourists as daily rentals or hostels. These are the biggest difficulties the locals face.*

Linking the adversities experienced in destinations with a high number of tourists from mass tourism directly to destinations being designated as slow cities does not seem like the right approach. These destinations have the potential to attract many tourists, even if they were not designated as slow cities. For this reason, the most appropriate explanation to this would be that the adversities do not directly originate from these cities being slow cities and that these adversities are unacceptable for a slow city. I-1 expressed their opinion on Akyaka, summarizing the events and explaining their thoughts on how Akyaka should be removed from the Cittaslow union as follows:

Akyaka is no longer a slow city, and it should not be called one anymore. In the summer months with the influx of domestic and foreign tourists, vehicles form a queue. The beach is bursting at the seams, accommodations remain insufficient, and we witness a scene with a terrible crowd of people on the beach as a result. Thus, the demand in Akyaka is way above its carrying capacity. This hurts its slow city identity and the natural texture of the district.

The answers to the question of how the local people view the developments in the destination due to tourism are in line with the theory of social change. A substantial number of participants stated that those who make money from tourism and the young people who benefit from businesses such as cafes opened for tourism purposes have a more positive perspective. Akyaka representative I-1's views on the subject are as follows:

We can divide the local people into two groups: those who make money and those who do not. The local people who make money are happy. Of course, with profit comes satisfaction. However, those who cannot earn money from tourism or do not have any work are unhappy about this hecticness. They think the root cause of problems such as noise, crowds, and costs is the tourists, and they are quite disturbed by this situation.

The opinions of the representative of Köyceğiz (I-17), which attracts the attention of investors as a touristic destination compared to many other slow cities in Türkiye, are as follows:

In this process, I can say that those who migrated to the district from outside have been more advantageous than the locals, because the owners of the newly opened businesses are not locals but settlers from outside. Young people are more positive because they see new cafes and restaurants as alternatives. However, I do not think that the local people respond positively to the increased demand in tourism. Only one or two local people earn money as a result of the increased demand, such as boat tour owners in certain months of the summer season. Other than that, how the situation benefits the local people is open to question.

3.2. Evaluations on the Relationship Between Slow Cities and Tourism

While 11 interviewees stated being included in the slow cities association to be a marketing strategy for tourism, seven interviewees abstained from judging between a marketing strategy and the belief and desire to internalize philosophy. The main argument of the interviewees who believe the primary goal of joining the Cittaslow association to have been tourism involves the developments they associate with tourism in the destination. Explaining their views on Akyaka, interviewee I-1 explained the following about how no actions are taken to protect the slow city's identity and how tourism is prioritized:

I think joining the slow city union is an initiative for tourism purposes. The administrators who adopt the slow city philosophy also aim to preserve the slow city identity and establish a plan in

this direction. But we cannot see such planning in Akyaka. The scenery during the peak season is not pleasant at all.

The representative of Mudurnu district (I-14) explained how local administrators had considered joining the Cittaslow network as a marketing strategy, had been unsuccessful in their strategy, and only carried out activities to impress the local people, stating the following:

The sensations of the district administrators on this issue are only a pretense of what they see in the surrounding districts. They are quite ineffective in internalizing the philosophy of the subject. They just say that they think this is important for tourism. But in practice, they only exhibit show activities to the local people.

Stating how they see no negativity in destination marketing with the Cittaslow title, I-16 explained their views on how slow cities with a limited supply of tourism cannot become a destination where the negative effects of tourism will be seen due to marketing, stating the following:

Except for Seferihisar and Akyaka, the districts are outside the general tourism supply regions. Therefore, they should become more noticeable so that tourism can develop there as well. The solution to the contradiction and its philosophy can be found later on. I think that tourism cannot develop enough to cause deteriorations and similar problems in slow cities.

I-6 shared an abstaining view and explained how the perspectives of the administers are what determine their attitude toward the slow city approach, stating the following:

In certain destinations, we can really feel that the main purpose is to live and maintain the slow city philosophy. But in other places, it is the total opposite. They use it as a marketing tool. This may vary depending on the management skills and life philosophy of the administrator.

When one accepts that local administrators see inclusion in the Cittaslow network as a marketing strategy, which the majority has suggested, one can say that most administrators have been unsuccessful in implementing the strategy in their minds when by considering the number of tourists. In addition, the opinions of the interviewees allows understanding of how awareness of the slow city philosophy is not enough and how destinations included in the association do not convey to their potential visitors any information about slow cities and their inclusion in the association. Many interviewees stated that tourists do not

visit the destination with the awareness of the slow city philosophy. I-9 explained how visitors are more interested in the features that prepare the ground for the slow city title rather than the title itself, stating the following:

I believe that visitors to Gerze find the district to have a Cittaslow certificate only after coming to the city. To my knowledge, the facilities here do not use this feature in their marketing activities. People do not come here because Gerze has been included in the Cittaslow network, I think they come here because Gerze partially meets some of the slow city features.

When questioning the contradiction between the Cittaslow title and the idea of destination marketing, the majority of the interviewees pointed out that sustainability should be ensured by acting in accordance with the criteria and stated that conflicting situations would arise if this could not be achieved. I-18 from the Halfeti destination had the following opinions on the subject:

I think the key point here is to create an environment where sustainability is ensured and the carrying capacity not exceeded by improving all the conditions regarding being a slow city, rather than just being marketed as a Cittaslow. I don't think there is any harm in branding and marketing by adopting a balanced tourism understanding. In cases where this situation is used only as a marketing tool, the destination loses its feature of being a slow city; when commercial purposes are pursued carelessly, negative consequences may arise.

The above-mentioned and other similar views give rise to the debate on whether Cittaslow criteria and tourism can truly go hand in hand in any balanced way. In other words, the question arises regarding the extent to which the desired results in tourism can be achieved without violating the Cittaslow criteria. The opinions of the interviewees were formed within the framework of the slow city criteria being in line with the principles of sustainable tourism, while in practice, administrative policies and the perceptions of locals and tourists are the decisive factors. Representing the destination spot of Gerze, I-9 expressed their views on the importance of stakeholder cooperation in destination management as follows:

In my opinion, sustainable tourism approaches fit the Cittaslow philosophy well. This theoretical good fit should be also demonstrated in practice. The important thing here is having the central public authority, universities, local governments, businesses, and non-governmental organizations work in coordination to establish a sustainable tourism approach in the destination. The criteria for sustainability should be determined scientifically, and compliance with these criteria should be strictly controlled. To the extent that these can be achieved, I think the Cittaslow approach can be followed in harmony with the principles of sustainable tourism.

Another important aspect of benefiting from the tourism sector by complying with the criterion of being a Cittaslow is stakeholder perception. Representatives from destinations that have problems in terms of the coexistence of a slow city and tourism, as well as the interviewees who foresee that such problems may occur, underlined the need to have the right perception first. Yalvaç representative I-2's had the following views on the subject:

What needs to be done is to keep the controls in place regarding the implementation of the Cittaslow concept through conscious residents and administrators and to prevent situations such as excessive tourism and excessive construction.

Pointing out the utilitarian approach, Gökçeada representative I-7 explained how the quality of tourism activities is more important than tourism activity itself in the destination and how perceptions should change in this direction, stating:

Although the tourism sector sometimes serves excessive consumption and monotony in the globalizing world, it is also important for people to receive service in a planned way. In my opinion, creating the right perception of tourism will not harm the Cittaslow philosophy. The idea of a slow city includes increasing public investments and stimulating the local economy, as well as preserving cultural values. However, adopting a tourism approach focused entirely on the perception of benefit contradicts the Cittaslow philosophy.

Carrying capacity is frequently mentioned in the execution of sustainable tourism in a destination with regard to not violating the Cittaslow philosophy. The interviewees emphasized this because they are aware of the situation in destinations such as Seferihisar and Akyaka, both from the press and from their visits, and they know that these slow cities have limited infrastructure and superstructure. I-17 stated knowing Akyaka very well despite residing in Köyceğiz, and had the following opinions:

The Cittaslow movement includes very important criteria in its essence. It focuses on the sustainable development of the region and the preservation of both the local values and the essence of the region. However, after being included in the

Cittaslow network, a rapid development occurs that draws the attention of more people, contrary to the philosophy of this movement. I'm talking about a process that results in more noise, more waste, more people, and more construction. It is not just about joining the Cittaslow network. What are the plans regarding carrying capacity? Do we have an action plan for development? We should think about these questions.

In the event that carrying capacity is exceeded, the dominant opinion is that all stakeholders have a responsibility to prevent the occurrence of adverse events contradicting the philosophy of slow cities. Mudurnu representative I-11 explained how the responsibility should be shared among local administrators, the public, travel agencies, and such, stating:

By increasing the movement of people through tourism, you can cause a region that you have declared to be slow to become fast and the peace and tranquility to be lost in the region. First of all, if regions really adopt the fact that they are slow cities, if the public becomes more aware of the subject and believes in and embraces this concept, then I believe tourism activities can also be carried out. I mean, first you need to truly be a slow city, then be a destination. But the most overlooked criterion is carrying capacity. Once people begin to earn money from tourism, they tend to not care about the criteria, unfortunately. When regarding carrying capacity, agencies that bring tours to the region as well as local governments need to be conscious and act sensitively.

4. CONCLUSION

Beyond official statistics, the conclusion can be reached based on the interviews conducted within the scope of the study that a heavy demand exists for slow cities in Türkiye that have daily tourism. This outcome of the study is also supported by other studies (Coşar, 2013; Çıtak, 2016; Pajo, 2017). This can be explained by the lack of activities attracting tourists to spend the night in slow cities. Studies conducted in Göynük (Zengin & Genç, 2018) and Mudurnu (Genç, 2016) found the lack of attractive activities to inhibit overnight stays. The fact that destinations such as Seferihisar, Foça, and Akyaka, which have a relatively high number of tourists who spend the night, are coastal destinations confirms the importance the presence of activities has for overnight stays.

Although the current tourism demands are not at a level that will cause negative results apart from in certain slow cities, the interviewees seem to be resistant to the idea of coexistence between slow cities and tourism. The most pessimistic opinions regarding this were received from the representatives of the Seferihisar, Akyaka, Köyceğiz, and Gökçeada destinations. However, these destinations should be note for having a high tourism potential independent of their Cittaslow title. These destinations are frequently in the news with their high tourist numbers during the summer season and on special days such as bank holidays. Therefore, the problems faced in these destinations cannot be attributed to them being slow cities. Nevertheless, these destinations in their current state can clearly be stated to have lost their tranquility, so much so that the Akyaka representative expressed an opinion that they should be removed from the Cittaslow association. Other representatives, being experts on the subject, underlined a forward-looking approach regarding why the slow city criteria, which they believe to be compatible with the criteria of sustainable tourism, should not be abandoned and how administrative policies are not established with the participation of all parties. In their opinions, this is the only way for slow cities and tourism to be able to coexist.

Arıkan et al.'s (2015) study on three slow cities of Austria defined slow city tourists as being highly educated and quality-oriented, having low price sensitivity, and being highly interested in culture and history. This cannot be said to apply absolutely to the tourists visiting slow cities in Türkiye. In fact, a considerable number of interviewees expressed how visitors do not have enough knowledge of slow cities, do not act with awareness of this concept, and even more so don't find out the destination is a slow city until after they've arrived at the destination. This data indicates the lack of quantity regarding slow cities to also be valid in terms of quality.

Of the 18 representatives interviewed within the scope of the study, 11 stated the primary consideration for joining the Cittaslow network to have been destination and tourism marketing rather than the Cittaslow philosophy. Similarly, Ekincek (2014) reached the conclusion directly through the opinions of local administrators that inclusion in the Cittaslow network is considered a marketing tool. However, adopting marketing as the main objective while overriding the Cittaslow philosophy poses a threat to slow cities' becoming a part of the global world (Semsari & Giritlioğlu, 2021) and in the long run these cities may risk becoming everywhere cities (Akman et al., 2013) or clone cities (Semmens & Freeman, 2012). Representatives of destinations with a high demand for seasonal tourism, such as Gökçeada, Köyceğiz, Seferihisar, and Akyaka, stated that these places resemble other destinations. This is completely against the Cittaslow philosophy, which is based on

the idea that cities are not duplicates of one another but are places that have preserved their originality.

Finally, in line with the findings obtained from the literature review and interviews, the following suggestions can be presented for the maintenance of sustainable tourism in slow cities by acting in line with the relevant criteria.

· Prioritizing the welfare of the local people should be kept in mind as one of the basic requirements of being a slow city. Administrators should keep this in mind while forming their policies.
· The framework of the destination administration's policies should be based on Cittaslow criteria.
· Information should be exchanged with other slow cities. Destination comparisons are needed in terms of positive and negative effects.
· Data should be collected in order to understand the views of all stakeholders, especially local people, and this data should be used in management.
· Cittaslow marketing should be prioritized over traditional destination marketing. The title of Cittaslow should stand out so that tourists who will consciously choose to visit the region can be targeted. Modern and local artistic and cultural activities should be carried out and highlighted in marketing. A region's cultural activities should be included within the framework of the principle of conservation. A good example in this regard is the "Tradesmen's Prayer," which was held in Mudurnu as an application of the Ahi culture (Genç et al., 2016). Discussions come to the fore occasionally about moving the Tradesmen's Prayer event, which has been held every Friday for centuries, to the weekend for tourism purposes. Despite these discussions, the proper decision was mad to not change the day of the event. However, the event retains important value for marketing Mudurnu as a tourist destination.
· Infrastructure (e.g., traffic arrangements, parking lots) should be completed and developed through scientific studies. This is important for preventing overcrowding that may occur due to tourism from negatively affecting the welfare of the local people. Especially in high-volume seasons, centers may be closed to vehicles. In addition, selling property to investors and individuals from outside the area should be made difficult or prevented.
· Close relations should be established and meetings organized with the relevant departments of universities whose fields of study cover urbanism and tourism.
· In particular, the number of accommodation facilities should not be increased to meet the demand, and local governments

should make strict decisions in this regard. Otherwise, commitment to tourism through other businesses may increase, and the negative effects of tourism may trigger one another. In slow cities by the sea, cultural and artistic activities should be emphasized rather than mass tourism activities, with the aim needing to be a positive change in the tourist profile.

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A Bibliometric Analysis of Mountain Research Literature on Journal of Mountain Research and Development: Current Situation and Future Directions

Mountain Research and Development Dergisi Üzerinden Dağ Araştırması Literatürünün Bibliyometrik Analizi: Mevcut Durum ve Gelecek Yönelimler

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ABSTRACT
Academic studies on mountains have increased since the 1990s. The aim of this study is to examine the current situation and development of the international literature on mountainous areas. The Mountain Research and Development Journal was determined as a sample and formed the data set of 1574 articles published in the journal. Network analysis method was applied using VOSviewer v.1.6 program. To conduct the research, only the terms in the keywords were used as the unit of analysis. In this context, frequency, relationality, clustering and time trend analyses were performed, respectively. When the clustering of the most used concepts in the keywords of the articles published in the MRD journal according to the network analysis was examined, eight clusters were determined. It turned out that the most frequently used concept among these clusters was "climate change". When the time trend is examined according to the network analysis of the concepts, studies on the effects of climate change have gained importance, especially in the last 10 years. Where there are conceptual transformations in the studies carried out on mountain slopes in certain years, anthropic emphases have come to the forefront rather than natural conditions.
Keywords: Mountain Research, Bibliometric Analysis, Network Analysis

ÖZ
Özellikle 1990'lı yıllardan itibaren dağla ilgili akademik çalışmalar artmıştır. Araştırmanın amacı, dağlık alanlarla ilgili uluslararası literatürün mevcut durumunu ve gelişimini incelemektir. Dağ Araştırma ve Geliştirme Dergisi örneklem olarak belirlenmiş ve dergide yayınlanan 1574 makalenin veri setini oluşturmuştur. Ağ analiz yöntemi VOSviewer v.1.6 programı kullanılarak uygulanmıştır. Araştırmayı yürütmek için sadece anahtar kelimelerdeki terimler analiz birimi olarak kullanılmıştır. Bu kapsamda sırasıyla frekans, ilişkisellik, kümeleme ve zaman trendi analizleri yapılmıştır. MRD dergisinde yayınlanan makalelerin anahtar kelimelerinde en çok kullanılan kavramların ağ analizine göre kümelenmesi incelendiğinde sekiz küme belirlenmiştir. Bu kümeler arasında en sık kullanılan kavramın "iklim değişikliği" olduğu ortaya çıktı. Kavramların ağ analizine göre zaman trendi incelendiğinde, belirli yıllarda dağ yamaçlarında yapılan çalışmalarda kavramsal dönüşümlerin yaşandığı özellikle son 10 yılda iklim değişikliğinin etkilerine yönelik çalışmalar önem kazanmıştır. zaman içinde doğal koşullardan çok antropik vurgular ön plana çıkmıştır.
Anahtar kelimeler: Dağ Araştırmaları, Bibliyometrik Analiz, Ağ Analizi

1. INTRODUCTION

Mountains are defined in many different ways. In addition to slope and height, criteria such as profile, relative elevation, land use, biogeography and environmental factors are also included (Price, Arnesen, Gløersen, & Metzger, 2018). However, the indispensable criterion for the definitions is the altitude value above sea level (Sarmiento, 2011). Bevington, Brideau and Geertsema (2017) stated that a mountainous area can be defined by evaluating the absolute and relative criteria together. Hereunder, topographic shapes that are higher than sea level and have a different ecosystem compared to their surroundings are defined as mountainous areas. According to the European Charter of Mountain Region, mountains are defined as "areas with special conditions such as altitude, sloping surface structure and climate that will affect human activities" (CLRAE, 1995). Despite the difficulty of defining a single mountainous area, it is accepted that approximately one-fourth of the world is mountainous today (Scott, 2006). Mountainous areas are significant geographical regions of the world, due to biodiversity and water resources, ecological structure, cultural diversity and traditional living qualities. These areas contain vital resources not only for those living in the areas, but also for those living on plains (Borowski and Munteanu, 2011; Price et al, 2018).

Awareness of mountainous areas has increased globally since the 1990s. Considering the development of institutional importance, it should be specified that 1992 and 2002 were breaking points. The United Nations (UN) at the Rio Earth Summit Conference emphasized the issue of mountainous areas in 1992 for the first time. As an output of the meeting, in the Agenda 21 action plan, mountainous areas were included in a special section and the 13th title was named as "Management of the Fragile Ecosystem: Sustainable Mountain Development". Afterwards, 2002 was declared the "International Year of Mountains" by the UN. Moreover, suggestions have been made

for countries to develop cooperative plans and policies in order to consider mountainous areas in the context of sustainable development and to change the global perspective. These developments are of great importance for both global mountainous areas and those living in these regions (Grabherr and Messerli, 2011). The rise in academic interest in mountainous areas is in parallel with the period when institutional interest increased. In a basic search in the Scopus database, the distribution of the articles with the concept of "mountain" in the keywords, title and abstract sections of the publications is seen according to years (**Figure 1a**). Nevertheless, after 1997 is the period when the interest largely increased in the subject just a short time after the 1992 Rio Earth Summit. The quantitative increase in the number of studies has been mostly carried out in the field of natural sciences (**Figure 1b**). The natural sciences followed, with studies on the field of environment and agriculture. Considering the development of mountain literature, it is obviously seen that certain fields of study gained importance in it. Still, it is not possible to draw conclusions about when the fields of study began to diversify, as well as which concepts were discussed. As a result of the overall development approach in the 1990s, interdisciplinary studies were started in mountainous areas, thus social issues were included in the research.

With the increasing importance given to mountainous areas at the international level, the quantitative development in the literature and the diversity of topics, researchers have started to focus on human issues. In addition, initiatives that support various platforms and interdisciplinary approaches have increased. In this context, the most significant activity has been the establishment of research networks to increase the cooperation of researchers interested in mountainous areas. Some of these networks are Instituto de Montana (1996), Rete Montagna (2000), The Global Mountain Biodiversity Assessment (2000), The Mountain Research Initiative (2001), Mountain Partnership (2002), Mountain Invasion Research Network (2005), Science
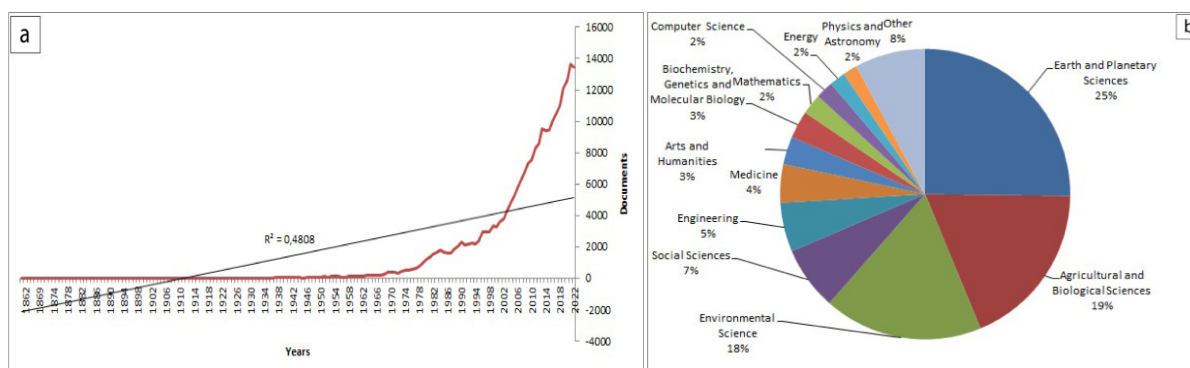
Figure 1. Distribution of publications on mountainous areas by years (a) and research areas (b) (Resource: Scopus, 2022).

for the Carpathians (2008), Our Alps Network (2011), Scientific Network for the Caucasus Mountain Region (2014) and Canadian Mountain Network (2019). The common features of prominent networks are to draw attention to the environmental, social, cultural and economic problems of mountainous areas in order to ensure sustainable development in these areas, as much as to protect biodiversity. All these efforts have led to the development of many different disciplines, methods and perspectives in the mountain range literature today.

Even though to access the quantitative change of studies on mountainous areas and general information about the study field are possible, to comprehend temporal changes of concepts and future trends ascertained from the concepts are discussed in the literature are not as possible. The main objective of this research is to understand the current situation of the mountain literature by making bibliometric analyses on the Mountain Research Development (MRD) Journal, which directly publishes studies on mountainous areas. In this regard, the aim of the paper is to examine the development, change and current status of studies in the international mountain literature, and to identify *new concepts*, *themes* or *topics* with bibliometric techniques to provide substantial suggestions for multidisciplinary concepts for future research. In this framework, the focus of the paper is to address issues in the international mountain research and seek answers for the following questions:

RQ1: What are the recent and main concepts in the field of mountain research?

RQ2: How have they changed over time?

RQ3: What will be the future studies are mostly focused on?

In order to answer the research questions, the bibliometric data were analysed by using the VOSviewer program with the network analysis technique. It is seen that the VOSviewer application, which has been used in recent years, has been used in many studies for different purposes and patterns (Garousi, 2015; Yalçın and Yayla, 2016; Güzeller and Çeliker, 2018; Kocak, García-Zorita, Marugán-Lázaro, Çakır & Sanz-Casado, 2019; Güney and Somuncu, 2020; Jiménez-García, Ruiz-Chico & Peña-Sánchez, 2020; Kumar, Sureka & Vashishtha, 2020; Rodríguez-Soler, Uribe-TorilJ. & Valenciano, 2020; Donthu, Kumar, Pandey & Gupta, 2021; Herrera-Franco, Montalván-Burbano, Carrión-Mero, Jaya-Montalvo & Gurumendi-Noriega, 2021; León-Gómez, Ruiz-Palomo, Fernández-Gámez & García-Revilla, 2021; Rosato, Caputo, Valente & Pizzi, 2021). In these

papers, there are different focal points, such as the citation pattern between the authors, prominent concepts, the most studied areas, and the changes according to the years. Herrera-Franco et al (2021) analysed the geopark literature using VOSviewer as an example of bibliometric analyses made on concepts. Furthermore, Donthu et al (2021) made bibliometric analyses through the publications of the International Journal of Information Management for over 40 years, and Kumar et al (2020), did the same on the publications of the Journal of Heritage Tourism between 2006-2019. Although there has been no study conducted with the bibliometric analysis method on any journal about mountains, important guidance and determinations have been made. There are important studies on the development and future trends of mountain literature. It has been emphasized in previous studies that mountainous areas are in constant change, and it has been stated that what this process brings can be turned into an opportunity (Adler et al, 2020). In addition, many studies have been carried out in order to draw the boundaries of the concept of mountainous area and to emphasize its importance (CLRAE, 1995; Scott, 2006; Kapos, Rhind, Edwards, Price & Ravilious, 2000; Körner, Paulsen & Spehn, 2011; Price, 2015; Drexler et al 2016; Karagülle et al 2017). Despite the fact that there are important determinations regarding the literature on mountainous areas in the mentioned studies, a study based on bibliometric techniques has not been conducted yet. The proximate research to the subject carried out with the bibliometric method, was conducted by del Río-Rama, Maldonado-Erazo, Durán-Sánchez & Álvarez-García (2019) in the field of mountain tourism. The study was carried out by searching the term "Mountain Tourism" on Scopus and Web of Science. In addition, highlighting that Scopus is more inclusive regarding the concept mentioned above, it was revealed that the concepts of "climate changes", "sustainable development" and "tourist system" were the most studied subjects. Also, Zeng, Li, Nuttapong, Sun & Mao (2022) made a network analysis of the articles published in many journals on mountain tourism by citation, keywords and countries, using the bibliometric network analysis method and VOSviewer.

Conducting the research with bibliometric indicators provides more objective findings and results. Therefore, the most important motivation of this research is to be a guide for future studies by determining the gaps and implicit information in the literature based on a bibliometric analysis with substantial indicators. The prominent concepts, according to the findings of the research, allow some inferences to be made for the direction of future studies on mountainous areas. For this reason, this research might be important for researchers working on

mountainous areas to understand the current situation, opportunities, current research areas and methods. With this motivation, firstly, in the data and method section of the research, how the data was obtained and how it was analysed are discussed. In the findings section that follows, the results of the analysis are evaluated in the context of the research questions. Finally, in the conclusion and discussion section, the findings are discussed and implications for future studies are given.

2. MATERIAL AND METHODS

2.1. Data Collection and Sample

This section explains how the data and method selection was made and how the analyses were interpreted in line with the research question and purpose (**Figure 2**). In order to answer the research questions, firstly a suitable sample is determined. Scimago Journal & Country Rank (SJR), which provide the subject area weights and impact factors of the journals, was used to determine the sample. In this ranking index, when the journals with the concept of mountain in their names are examined, a total of seven journals came to the fore. Among these journals, three important criteria were developed for the validity and reliability of the research at the stage of sampling. The first one is that it has a *long publication life*, the second is that the journal focuses on *mountainous areas* as a research topic, and, last but not least, that it is among the *most influential journals* internationally. Considering these, in this study, Mountain Research Development (MRD), one of the most important journals leading mountainous field studies, was determined as the sample (**Table 1**). It is necessary to state that in addition to the developed criteria, content-based criteria are also important for the selection of this journal as a sample. The most important factor taken into consideration in this regard is that the journal includes papers from various dimensions about the mountainous

areas with an interdisciplinary approach. Hereby, the research aims to deal with mountainous areas and the environmental conditions associated with these areas in a wider context in the literature. Besides, in order to follow the latest developments in the mountainous area literature, the journals must be open access, which allows the journal to have a wide readership as well as allows researchers from all over the world to access mountain studies. Having these features, MRD was chosen as an important data repository for understanding the current situation and future perspective of the mountain literature in this study.

2.2. Statistical Analysis and Assumptions

In the third stage, the method of research is determined as network analysis in line with the purpose of the research and the data set obtained. Network analysis is a visualization method which is frequently used in many fields to examine the relations of individuals, institutions or objects in the social system formally as well as the changes of these relations in the social structure in space and time (Tindall and Wellman, 2001; Al, Sezen & Soydal, 2012). In order to answer the research questions, the bibliometric data obtained were analysed with the network analysis method using the VOSviewer v.1.61 (Centre for Science and Technology Studies) Program. VOSviewer is a scientific mapping program designed for visualizing networks of bibliometric data. In the program, many bibliometric network analyses, such as co-authorship analysis and visualization of citation networks, can be performed based on the distance-based visualization approach (Van Eck and Waltman, 2007). Within the scope of the research, the concepts in the keywords as the analysis unit were subjected to co-existence analysis. According to this analysis, the most used common concepts in the keywords section of the publications in the sample were visualized by making a network analysis (**Figure 3**).
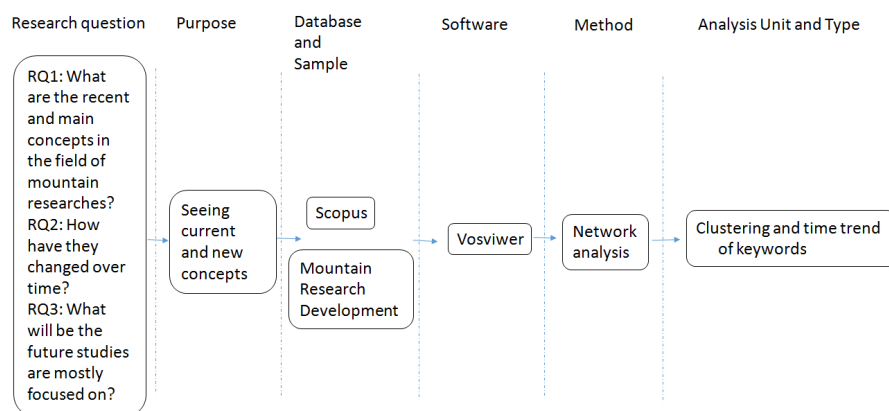
Figure 2: Research matrix (edited by using Güney et al. 2020)

Table 1: Ranking of the most influential journals in mountain range research (Resource: Scopus, 2022).

	Source title	CiteScore	Highest percentile	SJR	Publisher	Publishing since
1	Journal of Mountain Science	3.1	75% Geography, Planning and Development	0.551	Science Press	2004
2	Mountain Research and Development	3.0	75% Development	0.465	Springer Nature	1981
3	Sustainable Development of Mountain Territories	1.4	61% Sociology and Political Science	0.468	North Caucasian Institute of Mining and Metallurgy, State Technological University	2009
4	Rocky Mountain Geology	0.8	23% Geology	0.169	University of Wyoming	1998
5	Rocky Mountain Journal of Mathematics	0.8	31% General Mathematics	0.374	Rocky Mountain Mathematics Consortium	1971
6	Mountain Geologist	N/A	N/A	N/A	Rocky Mountain Association of Geologists	1964
7	Rocky Mountain Medical Journal	N/A	N/A	N/A	Colorado Medical Society	1948

In the second stage, the data set is created. The data set containing bibliometric information about 1574 works published in the MRD journal was obtained from Scopus data on 13.04.2021. In this context, the concepts used in the keywords section were determined as main data in order to evaluate the new trends towards the mountainous area phenomenon in line with the purpose of the research.
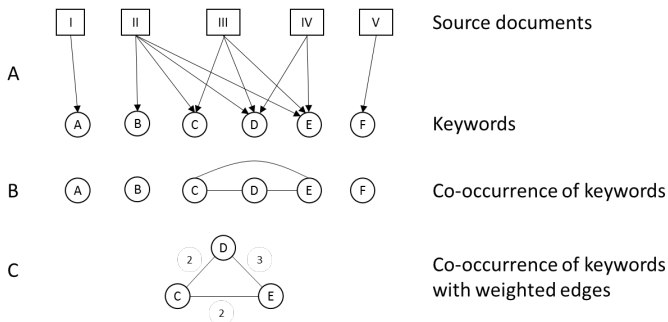
Figure 3: Demonstration of co-occurrence analysis for the concepts in the keywords section (edited by using Trujillo and Long, 2018)

The connections between the filtered concepts depending on the parameters determined during the bibliometric network analysis form cluster and time trend maps under various statistical assumptions. Within this framework, frequency, relationality, clustering and time trend analyses were performed, respectively. The statistical basis of these analyses comes from the work of Van Eck and Waltman (2010).

First of all, it is the relational score that emerges based on the frequency with which the concepts are used with each other. *Relationality* is the expression of the combination of concepts determined by the frequency assumption. It can also be given numerically or as a relational score by normalizing it, as shown in table 2. The relational score provides easier expression of high numeric expressions of the findings. Therefore, a relationality matrix is obtained by normalising the differences in the number of co-occurrence of concepts. VOSviewer first develops the similarity measure to calculate this relational score. Using power attribution, the similarity s_{ij} between the items (keywords) represented by i and j is calculated as (Van Eck and Waltman, 2010):

$$\frac{c_{ij}}{w_i w_j} = s_{ij} ,$$
(1)

Where, c_{ij} denotes the number of occurrences of i and j, and where w_i and w_j denote the total number of occurrences of i and j, or the total number of occurrences of these elements. It can be shown that the similarity between items i and j calculated using (1) is proportional to the ratio between the observed number of occurrences of items i and j on the one hand, and the expected number of co-occurrences on the other (Van Eck and Waltman, 2010).

The next step is to transfer the data into a distance-based network map. n represents the number of items to be matched. The VOS mapping technique creates a two-dimensional map in which the elements 1,…,n are placed in such a way that the distance between any pair of elements i and j reflects their similarities as accurately as possible. High-matching pairs of items should be placed close together, while low-matching items should be farther apart. The goal of the VOS mapping technique is to minimize the weighted sum of squared Euclidean distances between all pairs of elements. The higher the match between two items, the higher the weight of the squared distances in the total. Accordingly, the average distance between two items is equal to 1. Although there is no such conclusion in the Euclidean calculation, this equation is added to the algorithm as a constraint in order to prevent overlapping of nodes with high similarity in the program. In mathematical notation, the objective operation to be minimized is given as (Van Eck and Waltman, 2010):

$$V(x_1, \dots, x_n) = \sum_{i<j} s_{ij} \lVert x_i - x_j \rVert^2,$$
(2)

$x_i = (x_{i1}, x_{i2})$ vector specifies the position of i on a two-dimensional map, where $\| \bullet \|$ specifies the Euclidean norm. Therefore, downscaling is performed subject to restriction because the results are understandable.

$$\frac{2}{n(n-1)} \sum_{i<j} \|x_i - x_j\| = 1. \tag{3}$$

The constrained optimisation solution for the problem of reduction (2), which is the subject of (3), the majorization algorithm used by VOSviewer, is a variant of the multidimensional scaling SMACOF algorithm. To increase the probability of finding a globally optimal solution, the majorization algorithm can be run multiple times using a randomly generated initial solution each time (Van Eck and Waltman, 2010).

Findings from the first and second stages of the analysis give us the network maps. Therefore, in the first stage, the most used concepts among the keywords, which are the unit of analysis, were obtained. Secondly, the concepts with the highest relationality were calculated and the network map emerged. In other words, within the keywords section, a network analysis of the most used common concepts was created. To interpret these network maps, it can be stated that the program transfers units with high relationality to the network map, while excluding units with low relationality. In this way, concepts with low relevance are excluded, and concepts with high levels are filtered out and passed to more specific and more informative concepts about the general view of the literature. Concepts with high relevance tend to represent specific topics/areas and trends, while concepts with lower relevance on the map are subsidiary concepts. The distance between two related elements reflects the strength of the relationship. Nodes at closer distance are more closely related (Van Eck and Waltman, 2010, pp. 525).

In the third stage of the analysis, *cluster analysis* was carried out. Relationship networks connecting the concepts/units forming the nodes were clustered according to their spatial proximity. The clusters consist of the relationship between a set of all nodes and binary nodes, called a social network. Relations are the joint work or coexistence of these nodes with each other (Tindall and Wellman, 2001; Al et. al., 2012). In this visual analysis, first of all, the substance density $D(x)$ of a point x= (x1, x2) was calculated as (Van Eck and Waltman, 2010):

$$D(x) = \sum_{i=1}^{n} w_i K(\|x - x_i\|/(\bar{d}h)), \tag{4}$$

Here K: $[0, \infty \rightarrow [0, \infty)]$ represents the kernel function and creates the parameter called h>0 kernel width. w_i indicates the

weight of the element i, that is, the total number of occurrence or co-occurrence. The kernel function *K* must be non-increasing. Hence, the VOSviewer Gaussian kernel function is used (Van Eck and Waltman, 2010):

$$K(t) = \exp(-t^2), \tag{5}$$

The substance density of a point on a map was calculated separately for each cluster. For a cluster p denoted by $D_p(x)$, the matter density of a point x is defined as (Van Eck and Waltman, 2010):

$$D_p(x) = \sum_{i=1}^{n} I_p(i) w_i K(\|x - x_i\|/(\bar{d}h)) \tag{6}$$

Here $I_p(i)$ specifies an indicator function that is equal to 1 if i belongs to the cluster p. It shows the Gaussian kernel function given by K(5), as in the ordinary density view. At the end of this process, finally, cluster maps are generated (Van Eck and Waltman, 2010).

After calculating the elements' intensities, the colour of a point on the map is determined in two steps. Each cluster is associated with a colour. In the first step, the colours of the clusters are mixed with each other. This is done by calculating the weighted average of the colours, where the weight of one colour is equal to the element density for the corresponding cluster, as given in (6). In the following step, the colour obtained in the first step is mixed with the background colour (black or white) of the cluster density view. The ratio at which two colours are mixed depends on the total substance density of a point given by (4). The lower the total substance density of a dot, the closer the dot's colour to the background colour (Van Eck and Waltman, 2010). The results of the stage are interpreted on the map as follows: The density of a concept depends on both the number of neighbouring elements and the weight of these elements. VOSviewer uses a colour scheme by default. Accordingly, red has the highest intensity and blue the lowest.

In the final stage of the analysis, eventually, the *time trend* analysis, and the progress of the periodically prominent issues in other periods and the thematic areas created are shown on the map. The publication dates of the articles containing the concepts are used to determine the thematic areas that stood out here. In this case, temporal longitude analysis is possible. A thematic area can be defined as a group of themes that develop over different periods. A development map, for instance, enables the thematic areas to identify the conceptual link between the

research themes of different periods in four consecutive periods. Relationships between the year of publication and keywords are examined by time trend analysis. The analysis reveals which concepts came forward in which periods within the changing and transforming structure of the literature. Therefore, the temporal longitudinal analysis of the concepts is possible in this way, and this provides the opportunity to make important predictions about the future of the literature (Yıldız and Aykanat, 2017).

3. RESULTS

In this part of the research, answers to the following secondary questions are sought: RQ1: What are the main issues in mountain research according to the keywords or title? What kind of a pattern does their use together and their use over time reveal? In this regard, the keywords of the articles published in the MRD journal are the unit of analysis related to which subjects and concepts have been examined in mountainous field studies because, at this point, researchers give information to the reader about which concepts the work is built on. Although this section is limited to five or six words, compared to the title section, it conveys much more specific information or concepts about the work (Kozak, 2018).

3.1. Co-occurrence Network of Keywords: Cluster and Time Trend

The textual data in the keywords section of 1574 articles published in the MRD journal in the Scopus database were analysed according to their co-occurrence. In order to determine the words with conceptual value in the research, 144 concepts were found that were repeated at least 4 times out of 2512 words used in the keywords section of 1574 documents. In the analysis, the frequency and co-occurrence of the concepts, in other words 144 concepts with the highest correlation, were included in the network mapping (**Figure 4** and **Table 2**). The words that exist structurally and the words related to copyrights in the title section were ignored in the analysis. The findings regarding the frequency and concomitant use were analysed in two different dimensions. These concepts formed 9 different clusters according to their coexistence (**F**igure **4** and **Table 2**). Moreover, the temporal trend of the network analysis consisting of 144 concepts was created (**Figure 5**). The results obtained from this analysis can be listed as follows:

3.1.1. Cluster One and Two: Climate Change, Protected Areas and Europe

The first cluster is represented by the colour red. There are 27 concepts in total. The basic concept in this cluster is "climate

change" due to its central location and frequent use. The spatial context of this concept is continental Europe. When the other concepts in this cluster were examined, the density of spatial regions expressions such as "Switzerland", "Alps", "Austria", "Italy", "Europa" are seen (**Figure 4** and **Table 2**). The most important social phenomenon in the analysis of the concept of "climate change" in continental Europe and the Alps plane was "tourism". Once the analyses were examined, the density of the concepts such as "snowmaking", "regional development", "adaptive capacity", which are the auxiliary themes for the concept of tourism, can be seen (**Figure 4** and **Table 2**).

The closest cluster to the first cluster—the cluster of climate change—is the second cluster indicated by green. It can be said that the key concept among the 25 concepts in this cluster is "gender". Additionally, there is the concept of "women" in the cluster, which is commonly used together with gender. In the first cluster, the key concept is climate change. It can be explained by the fact that the red and green clusters are very close and intertwined, and by the concept of "climate change" is very close to the green cluster. Other frequently repeated concepts in this cluster are "conservation" and "mountains". It is seen that "protected area(s)", which are used closely with the concepts, are used intensively in the cluster too. Therefore, this gives an idea about another spatial context for the first and second clusters (**Figure 4** and **Table 2**).

3.1.2. Third, Fourth and Ninth Clusters: Spatial Analysis and the Continent of Asia

According to the analysis, the third cluster of concepts is represented in blue and there are 24 concepts. The prominent concepts in this cluster are "Pakistan", "Kyrgyzstan", "Tajikistan", "Tibetan Plateau", "Central Asia", "Tibet", "Georgia", "Karakoram". Therefore, it is seen that the spatial context of this cluster is formed by the studies in the Asian Continent and especially in the Turkic Republics (Figure 4 and Table 2). The fourth cluster is represented in yellow and there are 20 concepts. This cluster is closest to the blue cluster. This indicates that these two clusters are studied in very close areas or places. The concepts in the most central position in the fourth cluster, thus, are "Nepal", "China", "India" and "Himalaya". Factual concepts discussed in the third and fourth clusters are "migration", "remote sensing", "land cover change", "human disturbance", "soil", "species diversity" and "vegetation". Furthermore, the closest cluster to these two due to their connections and location on the network map is the ninth cluster, represented in pink. In this cluster, while the spatial context is

Figure 4: Clustering of the most used concepts in the keywords of the articles published in the MRD journal according to the network analysis

"Thailand", the main concept is "livelihoods". Therefore, it is seen that the studies on the Asian continent are subjects within the natural sciences in general (**Figure 4** and **Table 2**).

3.1.3. Fifth, Sixth, Seventh and Eighth Clusters: Spatial Analysis and Europe

The regional segregation in the network analysis, on the one hand, clearly shows that some research topics are also segregated regionally. On the other hand, there are studies that are common for both regions. In this sense, clusters five, six, seven and eight have been the common subjects examined in both regions due to their position and connections in the network analysis. These clusters show that the fifth cluster, which is represented in purple, has 20 concepts, and three of them stand out as key concepts, namely, "landscape change", "soil erosion", and "natural resource". Other clusters supporting this are the seventh with 12 concepts and represented in orange and the eighth represented in brown. When the concepts in these clusters are examined, it is seen that "GIS", "landscape", "land use change", "forest cover" are the main ones. As a result, clusters five, seven, and eight represent a group working with GIS-based techniques. The sixth cluster, represented in turquoise, showed little divergence from these clusters. This area is a cluster where joint agricultural studies are predominant for both continental European and Asian research (**Figure 4** and **Table 2**).

3.1.4. New Trends

The use of the concepts over the years also illustrates the change in the research focus in the literature. According to the analysis, the use of concepts such as "GIS", "landscape", "vegetation", "grazing" and "afforestation" are intense in 2006 (**Figure 5**). In 1995, the Council of Europe prepared the European Charter on mountain regions to create the concept of "European Highlands" and to develop policies for solving problems through cooperation in bordering mountain regions in the 13th Congress of Local and Regional Authorities of Europe (with the Resolution no. 202) (CLRAE, 1995). Afterwards, 2002 was declared the "International Year of Mountains" by the UN. Suggestions have been made to develop plans and policies based on cooperation between countries in order to address the mountainous areas in the context of sustainable development and to change the global perspective. These institutional movements have increased the studies in the literature to define mountainous areas, to draw their borders and to determine threshold values in this context. Moreover, the fact that geographic information systems (GIS) allows easy queries and macro-scale applications in the classification systems has made necessary changes in the criteria and threshold values used. The first global digital mapping work on the distribution of forests was held in 1996 by the UN World Conservation Monitoring Centre (WCMC) (Kapos et al, 2000). On top of this study, different criteria and threshold values are included in GIS, and the boundaries of mountainous areas are determined. Therefore, it should be emphasised that one of the

Figure 5: Time trend according to the network analysis of the most used concepts in the keywords in the articles of the MRD journal

most debatable concepts in mountain literature has been GIS and the studies related to the technique (Kapos et al, 2000; Blyth, Groombridge, Lysenko, Miles & Newton, 2002; Körner et al 2011; Karagülle et al, 2017).

Considering the development of the importance given to mountainous areas, it should be noted that 1992 and 2002 were the breaking points. Previous studies on mountainous areas were dealt with only in terms of geology and physical geography. Since these breaking points, the focus shifted to human problems in mountainous areas. In the following years, the importance given to mountainous areas at the international level has increased, and support is provided to encourage researchers to work in these areas. According to the report of the European Economic Area (EEA), which was published in 2010 and includes 10 messages for mountainous areas in Europe, the mountainous areas are both very fragile as well as rich. They are seriously affected by changes in factors such as agriculture, tourism, deforestation, climate change and natural disasters. This is interpreted as the low resilience of mountainous areas. In order to protect and develop the sensitive structure of mountainous areas, the necessity of strengthening the local with international cooperation is emphasised. In this context, mountain studies focused on local and regional development have increased in these years. New mountainous areas studies have emerged, resulting in keywords such as "China", "Nepal", "Switzerland" and "Pakistan". The diversification in the field of study is also reflected in the theoretical concepts. Accordingly, especially the concepts of "conservation", "ecosystem", "land use change" draw attention (**Figure 5**).

It can be said that the most discussed problem in mountain studies in the analysis is climate change and related risks because the areas are sensitive ecosystems and vulnerable to climate change. The climate has begun to change globally since the last quarter of the 20th century, due to factors such as the use of fossil fuels as an energy source after the Industrial Revolution, the inability to reabsorb the gases released into the atmosphere, the greenhouse effect of the world system, and intense urbanization (Stocker et al 2013; Swinburn et al 2019). According to the Stocker et al (2013), anthropogenic pressures have increased the intensity of extreme weather and climate events since 1950. The change poses a huge threat to clean water resources, biodiversity, economic activities and social structures in mountainous areas. At this point, instead of perceiving mountainous areas as isolated, marginal, forgotten or excluded places, their water basins, military and strategic locations, the positioning of observatories and communication tools should be evaluated all together with the sheltered opportunities they offers for an alternative future (Sarmiento, 2011). In the light of these sensitivities, concepts such as "climate change", "gender", "biodiversity" and "adaptive capacity" have been used more frequently in the period after 2014. Another finding is that these most recent concepts are specific to Europe, which creates a spatial context for the first and second clusters (**Figure 5**).

Table 2: Statistical results of the most used concepts in the keywords of the articles published in the MRD journal

No.	Keywords	Frequency	Frequency of connection	Cluster	No.	Keywords	Frequency	Frequency of connection	Cluster
1	climate change	45	76	1	73	grazing pressure	4	6	3
2	Switzerland	19	29	1	74	Karakorum	4	7	3
3	Alps	18	36	1	75	Pamirs	4	8	3
4	Italy	16	28	1	76	water management	4	7	3
5	European alps	13	24	1	77	Nepal	66	113	4
6	tourism	12	22	1	78	china	49	65	4
7	Austria	10	17	1	79	India	32	57	4
8	sustainability	10	21	1	80	Himalaya	21	45	4
9	policy	7	17	1	81	grazing	10	21	4
10	water	7	14	1	82	vegetation	10	18	4
11	development	6	10	1	83	Yunnan	10	28	4
12	Ladakh	6	9	1	84	land cover change	9	19	4
13	USA	6	9	1	85	medicinal plants	7	17	4
14	water governance	6	12	1	86	disturbance	6	9	4
15	amenity migration	5	10	1	87	ethnobotany	5	9	4
16	Canada	5	5	1	88	human disturbance	5	11	4
17	history	5	12	1	89	livelihood strategies	5	6	4
18	Kenya	5	7	1	90	pasture management	5	10	4
19	mountain communities	5	9	1	91	soil	5	5	4
20	New Zealand	5	7	1	92	species diversity	5	10	4
21	adaptive capacity	4	8	1	93	Uttarakhand	5	5	4
22	Europe	4	9	1	94	mountain farming	4	6	4
23	regional development	4	7	1	95	nature conservation	4	9	4
24	resettlement	4	6	1	96	plant diversity	4	7	4
25	sacred mountains	4	7	1	97	Peru	16	33	5
26	snowmaking	4	10	1	98	Spain	8	14	5
27	urbanization	4	7	1	99	landscape change	6	11	5
28	conservation	21	47	2	100	soil erosion	6	11	5
29	gender	15	37	2	101	forest management	5	8	5
30	mountains	14	19	2	102	runoff	5	7	5
31	sustainable development	13	27	2	103	land degradation	4	16	5
32	ecosystem services	13	26	2	104	mountain development	4	6	5
33	Bhutan	12	16	2	105	mountain tourism	4	7	5
34	sustainable development goals	10	32	2	106	natural resource management	4	4	5
35	regeneration	10	20	2	107	Pyrenees	4	10	5
36	community forestry	9	20	2	108	system dynamics	4	5	5
37	agenda 2030	9	30	2	109	united states	4	3	5
38	participation	8	19	2	110	water quality	4	7	5
39	protected areas	7	11	2	111	biodiversity	13	30	6
40	global change	7	13	2	112	land use	11	29	6
41	agroforestry	7	13	2	113	vulnerability	10	17	6
42	natural hazards	6	9	2	114	deforestation	9	25	6
43	Mexico	6	7	2	115	Himalayas	9	22	6
44	protected area	5	12	2	116	agriculture	8	27	6
45	perceptions	5	11	2	117	livestock	8	19	6
46	women	4	12	2	118	land cover	7	15	6
47	transdisciplinary research	4	12	2	119	biodiversity conservation	4	4	6
48	resilience	4	10	2	120	farming systems	4	9	6
49	Norway	4	7	2	121	fuelwood	4	8	6
50	family farming	4	7	2	122	poverty	4	9	6
51	environment	4	10	2	123	Andes	28	59	7
52	Argentina	4	5	2	124	rural development	11	30	7
53	remote sensing	24	45	3	125	Ecuador	9	15	7
54	Pakistan	23	34	3	126	Bolivia	7	11	7
55	Ethiopia	14	29	3	127	Chile	7	6	7
56	Kyrgyzstan	13	24	3	128	landscape	6	17	7
57	Tajikistan	13	24	3	129	perception	5	11	7
58	migration	11	24	3	130	mountain agriculture	4	11	7
59	food security	10	23	3	131	Paramo	4	10	7
60	Tibetan plateau	10	8	3	132	GIS	23	47	8
61	Central Asia	9	16	3	133	land use change	20	51	8
62	precipitation	8	9	3	134	Carpathians	7	22	8
63	adaptation	7	20	3	135	afforestation	6	16	8
64	Tibet	7	8	3	136	Slovakia	5	14	8
65	agrobiodiversity	5	10	3	137	forest cover	4	17	8
66	elevation	5	10	3	138	Poland	4	13	8
67	pastoralism	5	10	3	139	Vietnam	4	1	8
68	species richness	5	13	3	140	livelihoods	15	36	9
69	sustainable mountain development	5	8	3	141	shifting cultivation	5	5	9
70	capacity building	4	4	3	142	Laos	4	4	9
71	energy	4	6	3	143	poverty alleviation	4	4	9
72	Georgia	4	3	3	144	Thailand	4	2	9

4. DISCUSSION AND FUTURE DIRECTIONS

In this paper, the evolution and bibliometric structure of mountainous areas studies, which is an interdisciplinary field, were examined.

Within the framework of the main objectives of the research, three main research questions were formed and the answers to these questions were reached within the scope of the research. In this context, the outputs of the findings obtained from the research can be summarized as follows:

First of all, it turns out that many researchers examine different subjects in the mountainous area literature. As a research area, the majority the studies focused on natural sciences, environment and agriculture. The names "Nepal", "China" and "India", which give information about the research field in the thematic issues discussed, reveal the dominant locations in their studies. In addition to the spatial distribution, the concepts of "climate change", "remote sensing", "GIS" and "land use change" constitute thematic distribution in mountainous area studies. These concepts also show which themes the future studies in natural sciences will be based on. When the temporal development of the literature is examined, this research determined that the study subjects of mountainous areas have diversified and the field of natural sciences has remained in the background, within the scope of the increasing number of studies and interdisciplinary collaborations. In this sense, this study found that certain fields of study have come to the fore since the 2010s, and concepts such as "climate change", "gender", "biodiversity" and "adaptive capacity" have been increasingly used. This shows that researchers from social sciences as well as natural sciences are articulated in mountainous area studies. This shows that research on "climate change" is diversified in terms of subject. In addition to the physical findings of climate change, gender, sustainability, etc. are now mentioned in the literature. This shows that it is often associated with concepts.

An analysis of the journal also allows an evaluation of the performance of the journal. Paper type and methods used were determined. In this sense, the results of the research can give an idea about the concept of the special calls that the journal will open in the future. This evidence will be helpful in developing the field as the scholars will be able to identify the topics currently being researched by further analysing the issues.

As a result, it should be underlined which concepts should be emphasized for future research. We see that interdisciplinary studies are gaining importance in mountainous areas. However, it would be beneficial to focus on the concepts of climate change, ecosystem, biodiversity and sustainability.

This paper deals with the development of mountain literature through a journal in terms of its findings. It should be noted that the research was conducted using only the Scopus database, thus it has limitations. For future research, it would be useful to correlate the findings of the research, which is conducted on solely one journal, with the findings of a more comprehensive study to be conducted by evaluating different sources. In other words, besides the studies obtained merely through MRD, journals such as Journal of Mountain Science, Sustainable Development and Mountain can be added to the analysis to achieve more comprehensive results about the topic. Apart from this, the research was carried out only on keywords. No evaluation was made regarding the words in the title and abstract. In conclusion, considering the limitations of the study, it can be stated that this study could be a start for future research.

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Projecting Agricultural Land Abandonment and Expansion in Turkiye Using the Subspace KNN Algorithm (2030)

Türkiye'de Tarımsal Arazilerin Terk Edilmesi ve Genişlemesinin Subspace KNN Algoritmasıyla Projeksiyonu (2030)

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ABSTRACT
One of the most important changes in agricultural land worldwide is the problem of land abandonment in underdeveloped and developing countries and in regions with low resilience to climate change. This problem is also an ongoing debate in Turkiye. This study first evaluates the process of abandonment and expansion of agricultural land in Turkiye based on the literature before presenting maps of the probability of abandonment and recovery of agricultural land. In this context, the abandonment and expansion of agricultural land due to changes in Coordination of Information on the Environment (CORINE) data for 2006-2018 are used as the dependent variables. Probability maps were constructed using the subspace KNN model with 13 independent variables. The immediate surroundings of cities are seen to come first as the places with a high probability of abandonment. For rural areas, this appears as the areas close to roads and places with forced natural environmental conditions. A very low recovery situation has emerged in terms of places that can be reclaimed. The areas that stand out among these are where hazelnut and tea plantations have expanded in the Black Sea region, as well as the areas with relatively favorable topography in the interior of the Western and Central Taurus Mountains in the Mediterranean region.
Keywords: Abandonment of agricultural land, Expansion of agricultural land, Subspace KNN, projection, Turkiye

ÖZ
Küresel çapta tarım arazilerinde gözlemlenen önemli değişikliklerden biri, az gelişmiş ve gelişmekte olan ülkelerde ve iklim değişikliğine karşı dirençliliğin düşük olduğu bölgelerde görülen, tarımsal arazilerin terk edilmesi problemidir. Bu problem Türkiye genelinde de tartışmaların devam ettiği bir süreci yaşamaktadır. Çalışmada ilk olarak Türkiye'de tarım arazilerinin terk edilmesi ve genişlemesi süreci literatüre dayalı olarak değerlendirilmekte; ikinci olarak tarımsal arazilerde terk edilme ve geri kazanma olasılığına yönelik haritalar sunulmaktadır. Bu kapsamda CORINE verilerindeki (2006-2018) değişikliğe bağlı olarak terk edilen ve genişleyen tarımsal araziler bağımlı değişken olarak kullanılmıştır. Subspace KNN modeli ile 13 bağımsız değişken kullanılarak olasılık haritaları oluşturulmuştur. Terk edilme olasılığı yüksek yerler arasında öncelikle kentlerin yakın çevresi görülmektedir. Kırsal alanlarda ise yollara yakın alanlar ile doğal ortam koşullarının zorladığı yerler belirmektedir. Yeniden kullanılabilecek yerler açısından ise oldukça düşük bir geri kazanma durumu ortaya çıkmıştır. Bu yerler arasında, Karadeniz Bölgesinde fındık ve çay arazilerinin genişlediği alanlar ile Akdeniz Bölgesinde, Batı ve Orta Torosların iç kesimlerindeki topografyanın nispeten elverişli olduğu alanlar dikkati çekmektedir.
Anahtar kelimeler: Terk Edilmiş Tarımsal Araziler, Tarım arazilerinin genişlemesi, Subspace KNN, Projeksiyon, Türkiye

INTRODUCTION

Agriculture has been one of the most significant changes in human history. Various fields have developed as a result of the cultivation of plants and raising of animals. The agriculture sector remains the most critical economic activity, within which significant transformations have occurred since the Industrial Revolution. Rural areas play a crucial role in utilizing and preserving agricultural potential when viewed from a sustainability perspective (Food and Agriculture Organization 2006, p. 12).

Rural areas are also being reshaped and transformed in terms of demographics, economics, and society with the widespread acceleration of urbanization around the world (Dahms 1995; Montgomery et al. 2013). The most prominent effect of this transformation on rural areas is the gradual loss of their vitality accompanied by a decrease in population (Hart et al. 1968; Dahms 1995; Peters et al. 2018). Recently, the abandonment of agricultural land in rural areas has become one of the most significant trends in land-use change and one of the main indicators of rural decline (Benayas et al. 2007; Díaz et al. 2011; Güreşci 2014; Canpolat and Hayli 2018; Tao et al. 2021).

Agricultural land is the most important element defining rural areas and rurality. The abandonment of this type of economic activity identified with rural areas actually indicates a loss of rurality. Abandoned land as a term refers to land that had previously been used for agricultural activities but now human intervention and use has ceased for various reasons (Bielsa et al. 2005). The abandonment of agricultural land has led to many negative effects such as disappearing villages, abandoned settlements, declining rural economic benefits, and the inability to preserve cultural landscapes and heritage. However, these areas are also the most important resources for rural renewal and revitalization. By using these unused agricultural areas, the functions of rural areas can be recovered through support and regulation. In this way, rural landscapes can be transformed and rural economies revitalized (McManus et al. 2012; Naldi et al. 2015; Zhou et al. 2020b).

Research on agricultural land expansion is less common and has focused mainly on studying forest loss-related degradation (Ngoma et al. 2021), land rehabilitation (Shabanov 2009), land use changes and their influencing factors (Wang et al. 2022), and the relationships among climate change, water resources, and land expansion (Liu et al. 2021).

The abandonment of agricultural land is widespread throughout the world both in developed and developing countries and requires more attention due to agricultural land abandonment being closely related to food security and ecological security (Du et al. 2019). Research on the abandonment of agricultural lands is increasingly being conducted on a global scale (Huang et al. 2020), with studies on idle agricultural lands having examined and evaluated the problem from many angles. In fact, bibliometric and synthesis studies are found to have covered research on the subject (Huang et al. 2020; Qianru and Hualin 2021), focusing on the processes that contribute to the abandonment of agricultural land (Prishchepov et al. 2013; Levers et al. 2018; Zhou et al. 2020a), the impacts and consequences of the problem (MacDonald et al. 2000; Benayas et al. 2007; Filho et al. 2017; Deng et al. 2020), policies for solutions (Renwick et al. 2013; Deng et al. 2020), and the mapping of abandoned agricultural land (Yin et al. 2018; Levers et al. 2018).

Since the 19th century, a gradual decline has been occurring for agricultural land in Europe, which has seen one of the most significant land-use changes, especially in mountainous and semi-arid areas (Lasanta et al. 2017, p. 810). This decline is often attributed to the modernization and intensification of agriculture, which allows for increased agricultural productivity while reducing the amount of land and labor devoted to farming (Hatna and Bakker 2011, p. 720). Another study has attributed the continuing loss of agricultural assets leading to land abandonment to a lack of continuity, either due to a lack of direct descendants in families or to inheritance-related issues (Bernués et al. 2005; Bryden and Bruce 1995; Riedel et al. 2007). Garcia-Martínez et al. (2008) found the number of agricultural holdings in the Central Pyrenees of Spain to have fallen by 30% between 1990-2004. Of these farms, 40% ceased to exist due to the owner retiring and 56.6% due to the cessation of livestock farming. In addition, 42% of the farms remaining in 2004 had no guarantee of continuity because their children or grandchildren preferred to work in the industrial or service sector rather than to continue farming (Azima and Ismail 2011). However, the abandonment of agricultural land is a much more complex phenomenon. Indeed, different studies on the subject have shown the causes of the phenomenon to arise from the interaction of numerous variables related to social, demographic, economic, legal, administrative, and physical environmental characteristics (**Figure 1**).

A study conducted by the European Union (EU) on the abandonment of agricultural land highlighted three possible scenarios for the continent (Andronic et al. 2020). The first is that climate change will lead to an increase in disasters and the
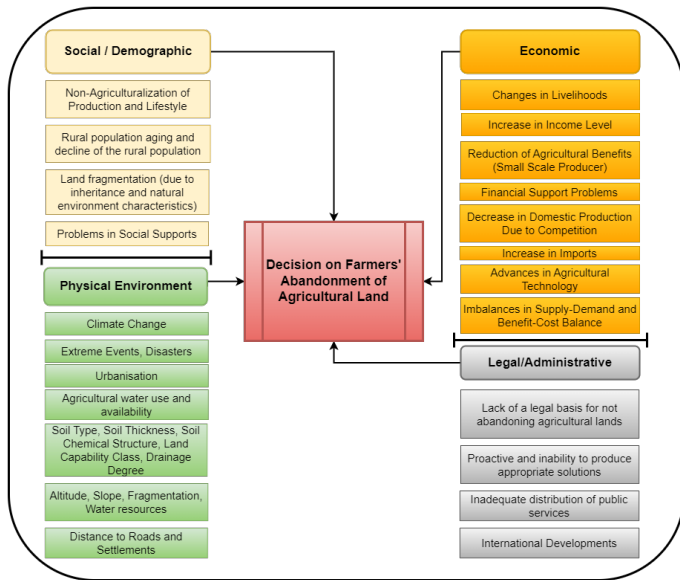
Figure 1: Factors influencing farmers' decisions to abandon agricultural land.

abandonment of agricultural land in mountainous and coastal areas due to changes in sea levels. The scenario regarding the globalization of markets predicts that small- and medium-sized enterprises will not be able to compete, leading to the abandonment of agricultural land in remote regions. Finally, the scenario of a major health crisis expressed before the outbreak of the pandemic that a migration would occur from urban centers to rural areas that would lead to an increase in the value of agricultural land and that land abandonment would no longer be a problem. These three potential scenarios can be observed to be intertwined synthetically for Türkiye. On the one hand, pandemics and disasters (especially earthquakes, apart from climate change) are shifting the population to rural areas and agricultural land is being reclaimed; on the other hand, agricultural land is being left to fallow in different regions due to small-scale producers' yield, credit, and market conditions.

In decreasing order of importance, the negative impacts of idle agricultural land are loss of biodiversity, increased frequency and intensity of fires, soil erosion and desertification, loss of cultural and/or aesthetic values, reduced landscape diversity, and reduced water supply (Benayas et al. 2007). Abandoned agricultural land is generally converted to sparse vegetation, tall grasses, shrubs, or forest ecosystems, depending on climate and soil conditions (Alcantara et al. 2012, p. 335). In Türkiye, however, a significant portion of such land is concentrated on the periphery of settlements and is therefore converted into functional land use areas for construction or settlement.

Türkiye has made announcements in recent years about the sanctions and support the government will apply to abandoned farmlands. This is because the trend in production value has increased the concerns about food security, both in terms of exports and for meeting needs internally. The decline in the rural population and the consequent reduction in the number of people working in agriculture may even bring radical regulations to the agenda as a solution to the problem. According to the Ministry of Agriculture and Forestry, Türkiye has about 3 million hectares of unused agricultural land. However, no qualified classification statistics are found on how much of this land is fallow, state land, or truly unused land.

Before the Tanzimat Decree of 1839, farmers who had left their land uncultivated (i.e., did not produce anything) were subject to a double tax called the *çift bozan*, and a farmer who left their land uncultivated for three years would have it taken away. This was the government's way of controlling production and ensuring continuity. The Land Law of 1858 divided the country's land into five parts and introduced the principle of individual ownership. The aim was to distribute the land to peasants through small farms. A farmer could use the land as they wished, grow any crop they wanted, rent it out, or sell it to anyone (Sumaytaoğlu 2012). As a result, the pressure on landowners to use their property rights was greatly reduced.

Currently, the preservation, development, classification, determination of minimum agricultural land sizes, and prevention of the division of agricultural lands, as well as the determination of principles and procedures for the planned use of agricultural lands, are regulated by the Law No. 5403 on the Protection of Agricultural Lands and the Utilization of Land. This law has no concrete provision regarding the abandonment or disuse of agricultural lands, which can be evaluated as a result of the global axiom (Pejovich 1990) that people cannot be pressured on how they use their property. However, in terms of today's changing conditions, re-evaluating this axiom has become mandatory, because in the post-capitalist society, value is created through the productivity and innovation of knowledge workers. Therefore, the correct, efficient, and sustainable use of property is more important than ever (Drucker 1993). The establishment of a legal framework to ensure the continuity of agricultural activities through legislation should therefore be reconsidered both as a means of encouraging and ensuring accountability.

DATA AND METHOD

Similar to other regions of the world, rural areas in Türkiye are undergoing a problematic metamorphosis demographic and structural changes. This article focuses on the geographical analysis of the status of vacant land and the reuse of agricultural land for the sustainability and permanence of agricultural function, which is a characteristic feature of rural areas.

Figure 2: Map of the study area.

Türkiye is a country at the crossroads of Europe and Asia between Southeast Europe and West Asia. It is surrounded by the Black Sea to the north, the Aegean Sea to the west, the Mediterranean Sea to the south and the Southeast Anatolian region to the east. Türkiye is located in the eastern part of the European continent, and the western part of the Asian continent and the Middle East. Türkiye has a total area of 783,356 square kilometers and average altitude of 1,141 meters. The Anatolian Peninsula has a rugged terrain due to the Pontic, Taurus, and other mountain ranges in the Alpine-Himalayan belt, with depressions and plateaus forming the main plains in this rugged topography (**Figure 2**).

Türkiye has 77.9 million hectares of land, of which 23.20 million are cultivated agricultural land (Kurugöllü and Ünel 2021). According to the results of the General Agricultural Census (Topçu 2012), the amount of unused land suitable for agriculture was identified as 4.995 million hectares in 1980, 2.161 million hectares in 1991, and 1.898 million hectares in 2001. Of the cultivated agricultural land, 31.36% is irrigable and 68.64% is non-irrigable (Turkish Statistical Institute 2016). Furthermore, between 2001-2018, the total agricultural area had decreased by 8% from 40.97 million hectares in 2001 to 37.82 million hectares in 2018. This decrease is larger than the area of

87 countries in the world. In addition, the production area for grains and other crops (cultivated and fallow land) had decreased by 17%, while the area for growing vegetables had decreased by 13.75%. The reasons for this include the land having fragmented, scattered, small, shared, and/or sloping structures (Kurugöllü and Ünel 2021).

Abandoned agricultural land has been classified into three categories: idle land (never used), semi-idle land (used very infrequently), and compulsory idle land (not used due to land reform or restructuring;(Keenleyside and Tucker 2010). No accurate monitoring methods are currently found for active, fallow, and abandoned agricultural land (Estel et al. 2015, p. 313). Therefore, data generated on the basis of land use change can be used as a data source to identify abandoned and newly utilized land. This study uses Coordination of Information on the Environment (CORINE) data (European Union 2018) to identify land use changes across the country. Although these data were first produced in 1990, the data for Türkiye cannot be said to have been produced accurately until 2006. Therefore, the dependent variables (abandoned land and expanding land) for land change scenarios were created based on the changes between 2006-2018. However, this short period has also shortened the projection time and eliminated the possibility of detecting changes over longer periods.

The study groups the CORINE land use/cover categories into three categories: arable land, non-arable land, and other land use types. The non-arable land category represents landcover types that emerge after abandonment (e.g., natural grassland, scrub, and wetlands). Conversions from arable to non-arable land between 2006-2018 were used to represent abandonment cases, while conversions from non-arable to arable land between 2006-2018 (i.e., arable land expansion cases) were used to represent gains. A total of 305,334 pixels were used for abandoned agricultural land and 310,491 pixels for gained agricultural land, of which 50% were randomly sampled. The results of both models were applied to 12,531,446 pixels nationally, and an attempt was made to model the land that would be abandoned and expanded by 2030. The study aims to use the obtained results as follows:

- To determine the process of agricultural land change based on CORINE data between 2006-2018,
- To identify the factors influencing the abandonment and recultivation of agricultural land,
- To evaluate the potential agricultural land use change based on the land change scenario.

The abandonment of agricultural land in Europe has occurred mainly in warm regions with high population density and accessibility (close to roads and/or cities). In eastern and southern Europe, farmland abandonment has been more common in areas with shallow soils, low water retention capacity, and/or relatively rocky and hilly terrain, while in western Europe it has occurred mainly on sloping or shallow soils. In Southern Europe, agricultural land abandonment has been more common in arid regions. In terms of expansion, it occurred in Western Europe in accessible areas near cities with high water retention capacity, while it occurred in Eastern Europe in rainy areas and near cities. In Southern Europe, it occurred mostly in dry areas close to roads but away from cities (Hatna and Bakker 2011, p. 725). In Türkiye, similar factors have affected the abandonment of agricultural land, so models have been developed using other parameters that may be suitable and effective for this observation.

Spatial Variables

Thirteen independent spatial variables were used in the models, which were created at a resolution of 250 meters, with resampling ensured by overlapping pixels (**Figure 3**). Real data, normalized data (min/max), and standardized data (deviation from mean) were used separately to build the models. Although no significant difference was found among them, the study has preferred the standardized data because these are commonly used when dealing with data in different units. Therefore, the models were built using standardized data. The subspace KNN algorithm, a type of ensemble learning model, was used to predict abandoned (lost) and reclaimed lands. The variables used in the models were selected and prepared under the following headings.

Elevation

Due to the significant global problem of abandonment of agricultural land being based on natural environmental conditions, studies have occurred on the management and development of unused agricultural land resources (Azima and Ismail 2011). Resultantly, variables indicative of natural environmental conditions are primarily used in relation to the probability of abandonment. The first of these variables is elevation, and data on this were obtained from the Shuttle Radar Topography Mission (SRTM) digital elevation model. Elevation is one of the most important variables due to its effects on soil depth, soil integrity, erosion, access, and climate in agricultural areas. The current physiography of Türkiye has a structure where elevation changes significantly over short distances. Therefore,

both ruggedness and elevation changes are important variables that directly affect agricultural land.

Slope

This is an important factor that directly affects the productivity and integrity of the land, as well as its accessibility and cultivability. The compactness of the land, which determines the size of the plots and hence the yield, depends on the slope and terrain (Rehman et al. 2015). Similarly, slope is one of the factors with a high contribution to the model as it affects drainage, soil depth, and suitability for the use of agricultural machinery and transport.

Topographic Roughness Index (TPI)

The abandonment of agricultural land has been a widespread trend in rural mountain areas around the world since the 1940s. Technological development and the commercialization of agriculture as a result of industrialization and urbanization in accessible lowland areas have motivated many mountain farmers to migrate temporarily or permanently (Khanal and Watanabe 2006). Difficulties in working areas with agricultural machinery are one of the main agroecological factors for abandonment, as manual techniques make products uncompetitive in a free market economy. Therefore, steep slopes, small plots, and areas with poor accessibility are no longer cultivated. Many terraced slope areas in the Mediterranean mountains have been abandoned due to poor conditions for mechanization rather than due to soil fertility (Lasanta et al. 2017, p. 818). TPI actually complements the slope parameter (Gallant and Wilson 2000) and is calculated by comparing the height of each pixel with its neighbors. Elevation, slope, aspect, and curvature are combined to determine how the topography as a whole has changed, as well as the effect this change has on land abandonment using a numerical elevation model and the SAGAGIS software.

Topographic Wetness Index (TWI)

TWI describes the tendency of a cell to accumulate water using digital elevation models. The basic variables used in the index are catchment area and slope (Mattivi et al. 2019). One of the most important variables in the use or abandonment of agricultural land is water demand. TWI is actually the primary variable used to determine this requirement, which indicates the size of surface runoff and water collection basins. This index can also be used to determine the current water potential of agricultural areas and their proximity to potential water sources. The index was developed using the SAGAGIS software.
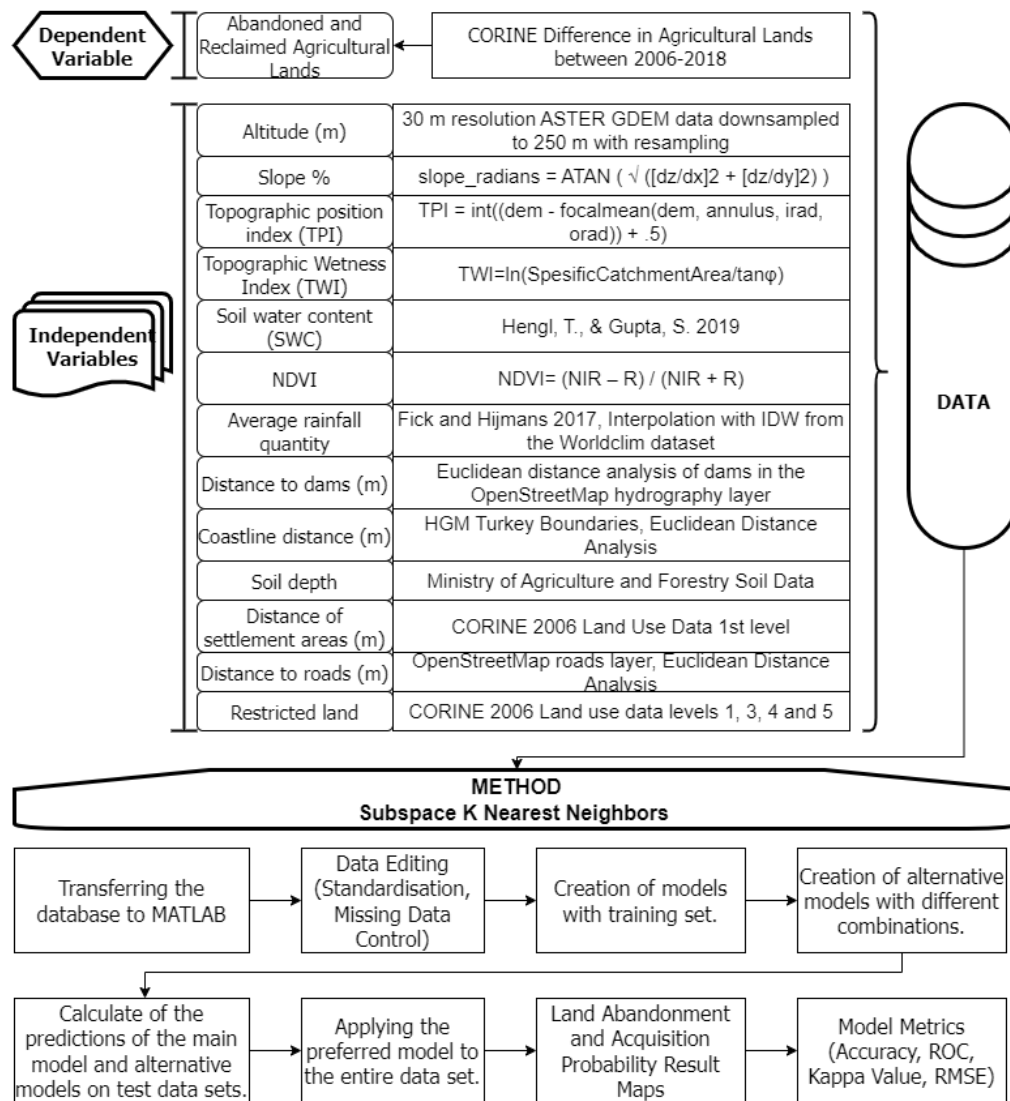
Figure 3: Methodology of this study.

Soil Water Content (SWC)

This datum type shows the volumetric SWC as a percentage at six standard depths (0, 10, 30, 60, 100, and 200 cm) estimated at a resolution of 250 m based on a global compilation of soil profiles from 1957-2017 (Gupta and Hengl 2019). The open-access six-banded data were reduced to a single band by averaging and used as a variable for SWC across Türkiye. It has been included as an important factor in models to detect abandoned agricultural land due to climate change and drought.

Normalized Difference Vegetation Index (NDVI)

NDVI data are an important parameter used as a variable or indicator in land use change studies. The main reason is that data

produced by remote sensing provide spatially continuous/ numerical data and time series information, from which changes, trends, variations, and relationships can be derived (Yengoh et al. 2015). As a variable with the potential to provide data on drought, planted area in different agricultural use types, and moisture, NDVI has been included in the models by resampling the average of Sentinel 2 satellite imagery taken at 10 m resolution between 2016-2022 and then down-sampled to 250 m resolution.

Average Rainfall

One of the most important parameters for the productivity and continuity of agricultural land is the amount of precipitation that falls on a field. In a country with a highly heterogeneous distribution of rainfall values, in order to understand the

possibility of abandonment of agricultural land, nationwide data and interpolation are needed to include this factor in the model. For this purpose, the WorlClim 2 database, an open-access climate database, was used (Fick and Hijmans 2017). The 900 m resolution raster dataset was converted to point data, and the sum of monthly mean precipitation values was calculated to produce the distribution of precipitation values across the country at 250 m resolution using the inverse distance weighted (IDW) interpolation method.

Distance to Dams

As dams are an important factor in the irrigation of agricultural land, the distance to dam lakes was added to the models to show their impact on the abandonment or acquisition of agricultural land. For this purpose, dams were selected in the hydrography layer of the OpenStreetMap data, and a distance variable to dams was created using Euclidean distance analysis (OpenStreetMap 2022b).

Distance to the Coastline

Distance to the coast was used as the last parameter for the water demand of agricultural land. This parameter was added to the model to test and verify the impact of the abundance of rainfall values in coastal regions, as well as the degradation and transformation processes of the land on its abandonment or reuse. Coastline distances were obtained from the Turkey administrative boundaries (General Directorate of Mapping 2022) country boundary data, and the distance was calculated using the Euclidean distance tool.

Soil Depth

One of the factors that directly affects the productivity and sustainability of agricultural activities is soil depth, which is obtained by digitizing the provincial land asset maps (Ministry of Agriculture and Forestry 1987). The deepest soils are classified in the data with a 1 and the shallowest with a 9, creating a hierarchical classification from 1 to 9. As deeper soils tend to be more productive, these are less likely to be abandoned. The data have been entered into the models as continuous variables, despite not containing intermediate values.

Distance to Settlement Area

One of the factors that have been shown to have the greatest impact on the abandonment of agricultural land is the growth of settlement areas (Andronic et al. 2020). Due to the rapid urbanization in Türkiye, agricultural land in the vicinity of cities has been transformed by remaining within the building zones, with the surrounding land being converted and developed. Therefore, as with other distance-related variables, the settlement areas obtained from the CORINE land use data have been transformed into a continuous numerical variable using the Euclidean Distance tool and then included in the models.

Distance to the Road

One of the most important changes in rural areas throughout Türkiye is the increased dispersion of rural dwellings. This dispersal is related to the construction of new houses on agricultural land close to roads rather than in village centers. As a result, some of these agricultural lands have lost their function, while others are beginning to be reused. Therefore, the probability of abandonment of agricultural land close to a road is low, and if it becomes unused, the probability of reuse is high. To create the variable, the road network obtained from OpenStreetMap data was converted into a numerical variable using the Euclidean Distance tool (OpenStreetMap 2022a).

Restricted Areas

Intuitive models apply a weighted overlay analysis in the final stage of creating the result maps. In this stage, constraints can be imposed by selecting classes that will not be included in the map creation process for each variable. However, this cannot be applied to statistical methods because the model equation evaluates all the data to arrive at a result. To overcome this limitation, the variable of restricted areas was added to the model. A variable consisting of two categories was obtained by classifying settlement areas, bare rocks, lakes, and swamps as areas that have no possibility of being converted into agricultural land as 0, with agricultural areas and areas of natural vegetation being coded as 1 in the land use data for 2006 in CORINE. The aim here is to increase the probability of excluding these areas in the event of abandonment or recovery.

In order to determine the probability of abandonment and reuse of agricultural land throughout Türkiye, dependent and independent variables were created before entering the stage of selecting the correct algorithm. This phase next phase trains and tests different models on the data within the Classification Learner in MATLAB and also performs accuracy analyses. To achieve accurate results from a highly heterogeneous dataset, ensemble learning models were prioritized that are commonly

used for this purpose. Among these, the KNN subspace, random forest, support vector machine, and artificial neural network algorithms produced better results in terms of time and accuracy compared to the other models. Therefore, a projection of agricultural land to be abandoned was made by predicting the abandonment and acquisition of agricultural land for the year 2030 and then synthesizing the results.

Subspace k-Nearest Neighbors Algorithm

Assuming non-parametric data, the k-nearest neighbors (KNN) model is a simple and basic classification/regression algorithm that searches for vectors similar to the query vector based on the score provided by the similarity function equation. However, the traditional KNN algorithm does not sufficiently take into account the spatial distribution of the training examples, resulting in low accuracy when processing high-dimensional data sets. In addition, the creation of K-nearest neighbours requires the involvement of distance calculations for all known examples, which leads to a high time overhead. To solve these problems, a subspace-based KNN algorithm model has been developed, as subspace KNN is a widely used community machine learning model that is simple in concept, mature in theory, and easy to implement (Ma et al. 2021, p. 225). This algorithm is similar to the KNN algorithm, but subspace KNN performs feature selection to reduce the number of dimensions in the data set. This means the algorithm selects the most effective features by measuring the impact each feature has on classification in the dataset. This increases classification accuracy and reduces the risk of overfitting.

Typically, multi-classifier or community-based techniques are preferred over their single-classifier counterparts because they reduce the likelihood of weak selection. Ensemble learning combines different models to improve prediction performance and has different approaches such as selecting a random subset of features (selected subspace) before running the learning algorithm, making the learning algorithm random, and then combining the outputs of the models using majority voting. Subspace KNN is based on a simple majority voting rule (Ashour et al. 2018). Simple majority voting rule equation is as follows:

$$d(x, y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$
(1)

The KNN algorithm has three stages. The first stage finds k points with similar features. The similarity (proximity) is determined using a distance metric (Euclidean, Manhattan, or Minkowski) that measures how far apart two data sets are $(x_1, x_2, ...,$

$x_i)$ and $(y_1, y_2, ..., y_i)$ are. Then, for classification, the majority class of similar data is found, and the k-point is assigned to that class. Finally, the average distance between the k-points is calculated to predict the class for the new data (Bruce et al. 2020, p. 238). The equation that explains this process is as follows:

$$Class(a) = \underset{c_i \in dom(y)}{\arg \max} \left(\sum_v h(y_v(a), c_i) \right)$$
(2)

To apply subspace KNN, c-class random T subsets are selected after KNN classification, and ct classifiers are created. Then, a random subspace ensemble model is built. Finally, the ct classifiers are combined and class assignments are made using majority voting (Ashour et al. 2018).

RESULTS AND DISCUSSION

A correlation analysis was carried out to check for the presence of positive or negative relationships among the variables in the model. The correlation matrix was observed to have a moderate negative correlation (-0.48) between slope and the topographic moisture index. The lowest correlation values were found between distance to dams and soil depth with regard to the other variables. Slope and altitude were the parameters having the highest correlations with other variables. These were followed by distance to settlements and precipitation. The variables having the highest correlations with distance to settlements were slope, distance to roads, and elevation. The VIF (variance inflation factor), which measures collinearity between variables, was used, and its value is generally expected to be less than 10, which indicates no variables with multicollinearity problems to be present in the model (**Table 1**).

The kappa value is a non-linear statistical measure used to evaluate the accuracy of a classification model. It is expressed not as a percentage but as a value that varies between 0 and 1. While the general accuracy value represents the percentage of correctly classified examples in the classification, the kappa value takes into account both correct and incorrect predictions, thus indicating the probability that the classifier will randomly make incorrect predictions while attempting to make correct predictions. In this way, it is a more objective evaluation metric. The overall accuracy of the model is approximately 86% for both the training and test data. The kappa value was measured to be around 0.7 for both datasets, indicating good discrimination. Finally, when looking at Figure 4, which shows the accuracy of the decisions made at different thresholds through the area under the curve (AUC), the obtained value of 0.94 for the test data set indicates the model to have good performance (**Table 2**).

Table 1: Correlation Matrix of the Variables Used in the Models.

Correlation	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	VIF
x1	1.00	0.00	0.03	0.15	-0.04	0.15	-0.02	-0.03	0.02	0.01	-0.01	0.11	0.18	1.06
x2	0.00	1.00	-0.14	-0.11	0.14	-0.02	0.07	0.10	0.01	-0.01	-0.03	-0.08	-0.08	1.07
x3	0.03	-0.14	1.00	0.10	-0.32	-0.12	0.29	0.22	0.02	-0.48	0.29	0.39	0.26	1.82
x4	0.15	-0.11	0.10	1.00	-0.26	0.17	-0.16	-0.18	0.09	-0.06	-0.05	0.27	0.33	1.25
x5	-0.04	0.14	-0.32	-0.26	1.00	-0.03	-0.08	0.03	-0.13	0.22	-0.11	-0.27	-0.24	1.24
x6	0.15	-0.02	-0.12	0.17	-0.03	1.00	-0.44	-0.32	0.03	0.00	-0.33	0.05	0.44	1.56
x7	-0.02	0.07	0.29	-0.16	-0.08	-0.44	1.00	0.35	-0.01	-0.17	0.37	0.10	-0.20	1.48
x8	-0.03	0.10	0.22	-0.18	0.03	-0.32	0.35	1.00	-0.04	-0.09	0.36	0.05	-0.19	1.31
x9	0.02	0.01	0.02	0.09	-0.13	0.03	-0.01	-0.04	1.00	-0.35	-0.01	-0.01	0.11	1.19
x10	0.01	-0.01	-0.48	-0.06	0.22	0.00	-0.17	-0.09	-0.35	1.00	-0.09	-0.22	-0.29	1.60
x11	-0.01	-0.03	0.29	-0.05	-0.11	-0.33	0.37	0.36	-0.01	-0.09	1.00	0.17	-0.23	1.42
x12	0.11	-0.08	0.39	0.27	-0.27	0.05	0.10	0.05	-0.01	-0.22	0.17	1.00	0.37	1.40
x13	0.18	-0.08	0.26	0.33	-0.24	0.44	-0.20	-0.19	0.11	-0.29	-0.23	0.37	1.00	1.83

x1 = Distance to Dam x2 = Depth x3 = Slope x4 = Distance to Roads x5 = Restricted Area x6 = Distance to Coastal x7 = NDVI (Normalized Difference Vegetation Index) x8 = SWC (Soil Water Content) x9 = TPI (Topographic Position Index) x10 = TWI (Topographic Wetness Index) x11 = Precipitation x12 = Distance to Settlements x13 = Elevation
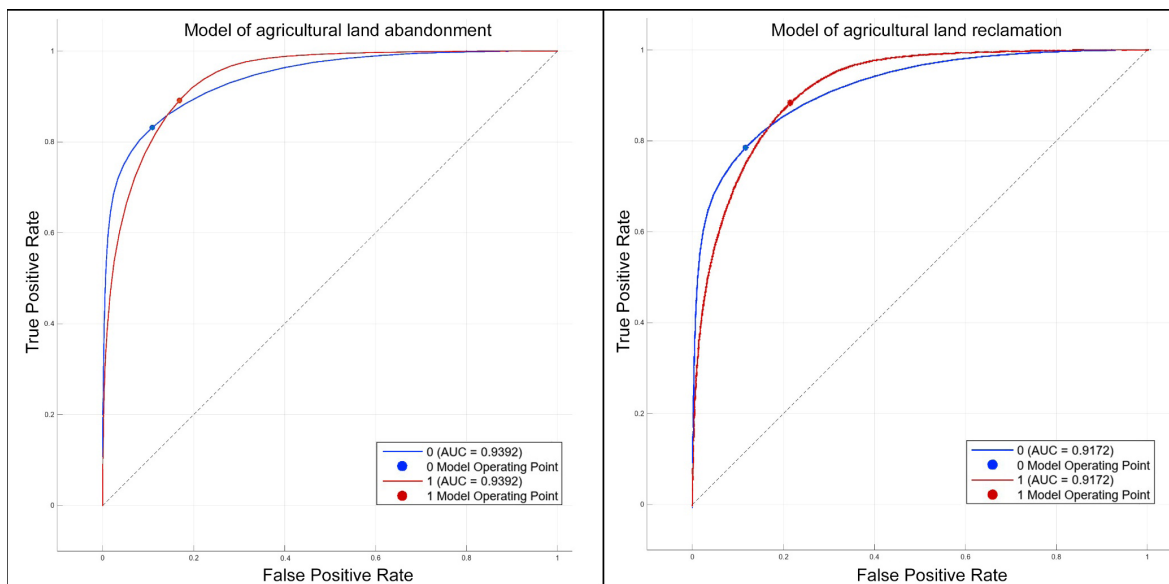
Figure 4: ROC curve and AUC values of models for the probability of abandonment and reclamation of agricultural land in Türkiye.

Table 2: *Accuracy Analysis Results of the Subspace KNN Model for the Probability of Abandoned Agricultural Land in Türkiye*

Type of data	Class Type	0	1	Classifica-tion Error	Overall Accuracy	Kappa Value
Trai-ning data	0 (Excluding Abandoned Agricultural Land)	116505	23634	16.9	86%	0.72
	1 (Abandoned Agricultural Land)	14607	119578	10.9		
Test data	0 (Excluding Abandoned Agricultural Land)	12982	2589	16.6	87%	0.73
	1 (Abandoned Agricultural Land)	1467	13442	9.8		

Table 3: *Distribution of Probability of Abandonment of Agricultural Land by Class in Türkiye*

Model Interval Values	Abandonment probability classes	Area (ha)	Percentage %
0.001 - 0.23	Very low abandonment probability	459.410	7.4
0.23 - 0.4	Low abandonment probability	1.301.330	20.8
0.40 - 0.57	Likely abandonment probability	2.401.829	38.4
0.57-0.73	High abandonment probability	1.287.234	20.6
0.73-1	Very high abandonment probability	800.198	12.8
Total		6.250.001	100

According to the projection made for the probability of abandonment of agricultural land, approximately 800,000 hectares have a high probability of abandonment throughout the country. When including the areas with a high and probable probability of abandonment, this figure rises to around 4 million hectares. In this case, agricultural land, which was 38 million hectares in 2018, will most likely reach between 36 and 34 million hectares by 2030 (**Table 3**).

The projection map obtained from the subspace KNN model shows proximity to roads and to settlements to be an important determinant for agricultural land with a high probability of abandonment. Therefore, when analyzing the probability of abandonment, the areas where human activities and changes are most concentrated are those close to roads and settlements.

In Türkiye, the main areas with a high probability of abandonment are agricultural land within settlements and the agricultural land surrounding settlements and vary based on the size of the city. Bringing the 2006-2018 data into the present allows one to directly confirm the change. In fact, if one looks at the map projecting the process until 2030, the agricultural areas in and around the cities can be seen to be made up of areas that have been developed or subdivided into urban plots ready for development. This is a change that can be directly observed in all cities. In addition to the growth of cities inward and toward their immediate surroundings, leapfrogging also extends the impact area of the probability of abandonment. Because the first stage of construction leading to land abandonment is the provision of roads and infrastructure, proximity to roads becomes a more decisive factor in the model in terms of its effect on land abandonment (**Figure 5**).

The number and distribution of areas with a high risk of abandonment vary according to the size and primary functions of the nearby city. For example, even in small cities on the Mediterranean coast, the areas with a high risk of abandonment in their immediate vicinity are quite numerous due to the influence of tourism. In Çukurova, the areas where settlements are expanding are effective, as well as settlements with other functional areas. The situation in the Ergene basin is more complex. Despite the presence of fertile plains, industrialization and the pollution of soil and water as a result of industrialization, rapid urbanization, and flooding have increased the probability of the abandonment of agricultural land.

Proximity to roads continues to be the most important parameter for rural land abandonment. The urbanization process that began in Türkiye in the 1950s continued with increasing momentum and eventually developed into a structure where the rural population had decreased significantly. Today, due to the deterioration of old dwellings or new housing construction based mainly on the demand for second homes, rural dwellings are mainly located on agricultural land close to roads. As a result, while the probability of using some of these areas has increased, the probability of abandoning others due to functional changes has also increased. This situation can be observed in the agricultural land in the southern part of Uşak province and in the land near rural settlements that extend in a crescent along the Kızılırmak River in Central Anatolia and is visible throughout the country.

The second most important factor influencing the model is the normalized difference vegetation index. This factor is identified as both a causal and summative parameter. In the Black Sea region, which has the highest forest coverage in the country, the concentration of high-risk abandonment areas inland

Figure 5: Türkiye-wide map of probability of agricultural land abandonment results.

is due to both forest cover and topographic structure. The topographic roughness index is ranked third after the NDVI in terms of effectiveness. Both forest cover and land topography increase the number of restricted areas for human activities and accelerate the conversion of forests and agricultural land into settlements and other functional areas. The hi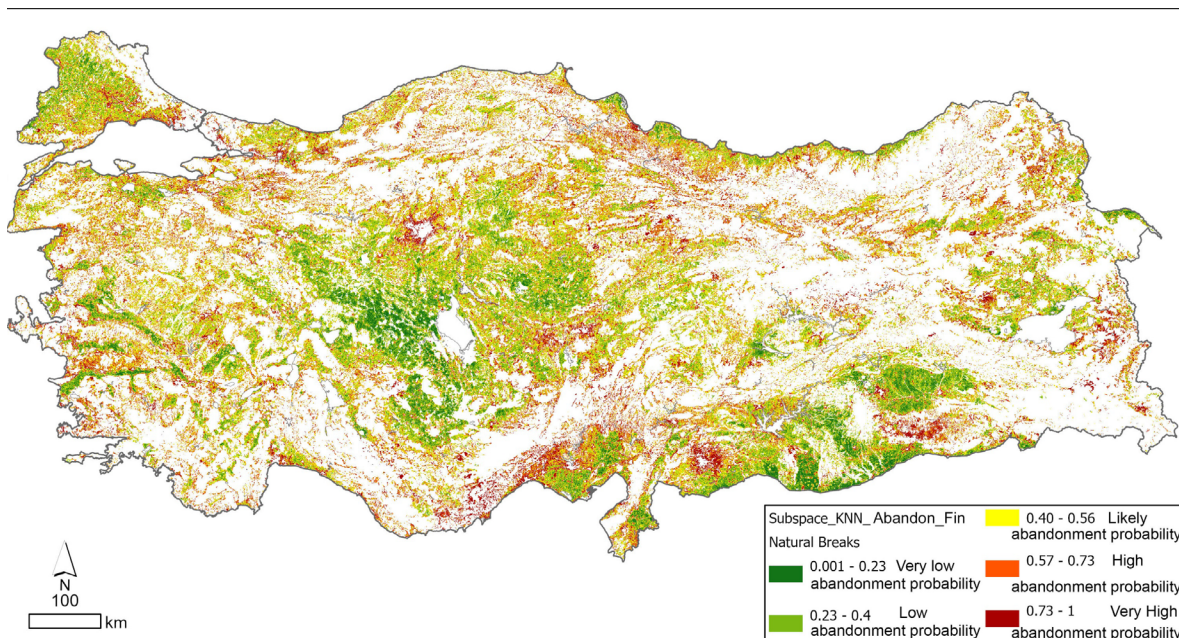gh-risk abandonment areas observed along the Black Sea Mountains show how widespread the conversion and degradation of not only agricultural land but also forest land is. As a result, all agricultural lands in the immediate vicinity of rural or urban settlements in the region are found to have a high probability of abandonment. The same situation is observed in the vicinity of forest areas in the Mediterranean and Aegean regions.

Another important factor in land abandonment is the degree of fragmentation and resultant negative conditions such as erosion. This can be observed in many areas of the country, particularly in regions where narrow valleys are common due to dendritic drainage, such as hillsides. For example, a significant proportion of the land surrounding the Atatürk Dam reservoir consists of this type of area.

According to the model, mountainous areas are the second most likely to be abandoned. Despite their rural character, the mountainous areas of the Taurus Mountains, the Black Sea Mountains, and Western Anatolia stand out as areas at high risk of abandonment. This is related to natural factors such as slope, fragmentation, and soil depth, as well as factors such as low efficiency due to distance from cities and small-scale enterprises. Although rural-urban migration in Türkiye has decreased in recent years, it is still ongoing. This suggests that rural areas are running out of young people or people with the skills to farm. Therefore, the problem of fallow land in potential agricultural areas has become increasingly important. Meanwhile, Tables 4 and 5 show the distribution of agricultural land with a high probability of reclamation.

Table 4: *Accuracy Analysis Results of Subspace KNN Model for Land Reclamation Probability of Türkiye's Total Area*

Type of data	Class Type	0	1	Classification Error	Overall Accuracy	Kappa Value
Training data	0 (Excluding agricultural land reclaimed)	108560	29756	21.5	83%	0.67
	1 (Agricultural land reclaimed)	16376	124297	11.6		
Test data	0 (Excluding agricultural land reclaimed)	12193	3175	20.7	84%	0.69
	1 (Agricultural land reclamation)	1682	13948	10.8		

The overall accuracy of the land reclamation probability model was around 83% for both the training and test datasets. The kappa value was around 0.67 for both datasets, indicating good discriminative power (**Table 4**). Finally, the AUC value of 0.91 obtained by applying the model to the test data indicates the model to have quite good performance (**Figure 4**).

Table 5: *Distribution of Probability of Recovery by Agricultural Land Class Excluding Land Unsuitable for Agriculture Across Türkiye*

Model Interval Values	Probability of Reclamation Classes	Area (ha)	Percentage %
0.001 - 0.23	Very Low Probability of Reclamation	961.556	15.4
0.23 - 0.4	Low Probability of Reclamation	2.090.450	33.4
0.40 - 0.57	Likely Probability of Reclamation	2.162.509	34.6
0.57-0.73	High Probability of Reclamation	742.678	11.9
0.73-1	Very High Probability of Reclamation	292.807	4.7
Total		6.250.001	100

The following results were obtained by projecting the probability of agricultural land reclamation and reuse using the same algorithm across the country and by excluding restricted areas (settlements, mountain areas, wetlands, and forests). According to the model, an estimation coefficient of 0.5 is assumed to indicated that no very likely or highly likely areas are found that can be reused or opened for use; however, when evaluating the results on the basis of natural breaks (i.e., if the classes are evaluated according to the structure of the data), approximately 100,000 hectares of agricultural land are seen to be present in these two classes throughout Türkiye. One can therefore assume that all the land that could be made available for agriculture throughout the country is already in use, with very few areas found that can be brought back into use from abandoned land (**Table 5**).

Different from the probability of abandonment, the parameters that are effective in the distribution of land with a high probability of recovery are mainly related to physical environmental conditions such as slope, distance to the highway, soil depth, precipitation, elevation, distance to dams, and the topographic roughness index. Therefore, potentially usable areas appear as criteria for agricultural suitability. In this case, currently unused agricultural land with relatively favorable topography and therefore better soil depth, high precipitation values, and proximity to dams and highways can be said to have a higher probability of being recultivated.

When looking at the distribution of agricultural areas with a high probability of recovery at the regional level, the areas
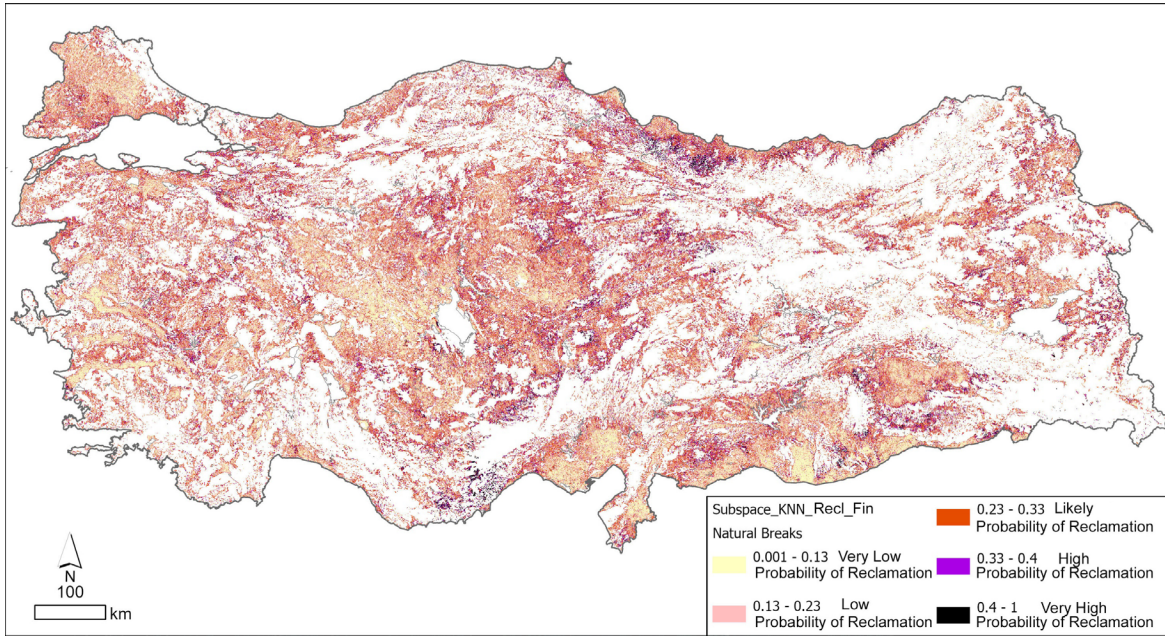
Figure 6: Reclamation probability result map for agricultural land in Türkiye.

around rural settlements in the Canik Mountains appear to be suitable for hazelnut cultivation. In addition, the possible tea growing areas in the Rize section of the Eastern Black Sea Mountains where the coastal effect can reach about 20 km inland and the mixed agricultural areas that are relatively suitable for cultivation on the plateau and slopes where the karst topography is relatively suitable in the Akçalı Mountains in the eastern part of the Western Taurus Mountains and immediately east of the Bolkar Mountains have a relatively higher probability of recovery (**Figure 6**).

In Türkiye as a whole, the same phenomenon is observed in areas near the upper limit of agriculture in different geographical units, as well as in areas near dams and water sources, which can be considered marginal agricultural areas.

In rural areas, a significant proportion of the areas estimated to have a high probability of recovery are located in mountainous areas where slopes and barriers have been relatively reduced. These areas also appear to require significant improvements in order to be converted into agricultural land.

According to the model, the areas identified as having a high, low, and very low likelihood of recovery in rural areas are mainly important agricultural areas where agricultural activity is currently taking place. However, when compared with the abandonment likelihood map, a significant degree of consistency is seen across all classes. Namely, areas with a low abandonment likelihood have also been identified as areas with a very low

restoration likelihood on the restoration likelihood map. In fact, when comparing the abandonment and restoration likelihood maps, the *RMSE* value is found to be 0.3. In other words, as the data set ranges from 0 to 1, this *RMSE* indicates a 30% margin of error between the two maps.

In conclusion, assessing the probability of abandonment rather than the possibility of recovery for agricultural land throughout Türkiye and carrying out preventive and regulatory work accordingly would be more rational. As one of the earliest settlement areas in history, the study area has given people the time and opportunity to transform many of the places accessible to them. Some of these areas are not even very suitable for agricultural use. Some of the abandonment can be said to have occurred naturally and to be considered reasonable. However, the main problem has been the phenomena of transformation and loss due to construction in priority agricultural areas. Therefore, qualified and sustainable urbanization, as well as rational construction and transformation in rural areas, are vital issues that need to be prioritized in terms of spatial issues.

RESULTS

Recent years have shown a growing interest in scientific studies on farmland abandonment in different regions of the world. Although the scope, methodology, and content of these studies vary, they do also focus on some common issues, including economic improvement on different spatial scales related to agriculture, food security, and sustainable development,

as well as land degradation related to urbanization and development. Of course, the transformation of agricultural land lies at the heart of these issues.

One of the most important issues regarding land change is the transformation of agricultural land. Supporting this change with predictive analysis alongside theoretical and field studies by looking at the spatial representation of the problem, is a prerequisite for accurately identifying the problem. Despite not covering all parameters, this way can take into account qualified information on the distribution of abandoned land when preparing environmental and regional development plans.

In the absence of qualitative data on the abandonment of agricultural land, this study has used CORINE land use data for 2006-2018 to identify the likely areas of agricultural abandonment. A total of 13 independent numerical variables have been used to identify the reasons these areas were abandoned. Subspace KNN provided a higher accuracy rate compared to the other models. In addition to land abandonment, land that could potentially be reclaimed or developed for new uses was projected using the CORINE dataset as the dependent variable. The study also produced abandonment and reclamation projection maps for the year 2030 using the same independent variables and model.

Türkiye has a geographical structure with rugged terrain that shows significant changes over short distances in the temperate zone. Therefore, predicting farmland abandonment with high accuracy in a heterogeneous space is both difficult and limited. Even with the highly successful subspace KNN algorithm, an accuracy of only about 85% could be achieved. By 2023, a significant part of the projected changes was also observed to have already had occurred.

The parameters that primarily influence the high probability of abandonment of agricultural land throughout the country are proximity to roads and settlements. Therefore, rural areas close to cities where human intervention is concentrated have been identified as priority areas at risk. However, rural areas where natural environmental conditions have reached a critical threshold in terms of suitability for agriculture (e.g., terrain, rainfall, soil depth) have also been identified as having a high probability of abandonment.

The Middle Black Sea region where hazelnut farming dominates, the Eastern Black Sea region where tea farming dominates, and various parts of the Central Taurus Mountains where mixed farming is practiced all have a high probability of recovering agricultural land. Furthermore, marginal agricultural areas that surround primary agricultural areas, areas near dams and water sources, and areas that can be improved by human intervention are also among the probable agricultural conversion areas.

Globally, sustainability, food supply, and green economy have become increasingly important, leading to more planning and projects aimed at achieving these. Additionally, as food trade becomes more of a negotiation between states, leaving agricultural land unused should be seen as a national security issue and evaluated accordingly. Non-marginal agricultural land should not only be encouraged for use, but so should a legal framework be established to hold landowners accountable for unused land.

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Trend Analysis of Precipitation in the Thrace Peninsula

Trakya Yarımadası'nda Yağışların Trend Analizi

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ABSTRACT

This study focuses on the Thrace Peninsula located in the Marmara Region, comprising the territories of the provinces of Edirne, Kırklareli, Tekirdağ, İstanbul, and Çanakkale. The Thrace Peninsula is within the Mediterranean macroclimate region, where the regions receiving rainfall of over 600 mm cover the largest area. The highest and lowest annual average precipitation are observed in the municipalities of Sarıyer (819.3 mm) and Çorlu (576.6 mm), respectively. This study utilized the long-term precipitation data of 13 meteorological stations located in and around the Thrace Peninsula between 1937 and 2021. Trend analyses of monthly, seasonal (winter, spring, summer, fall), semiannual (October–March, April–September), and annual total precipitation averages of the water year were performed using the Mann–Kendall test, Kendall's tau test, and Sen's slope test at a confidence interval of 95% and statistical significance level of α = 0.05. The results of the monthly precipitation analysis show a significant negative trend in August, November, and February in Lüleburgaz, Tekirdağ, and Ipsala, and a significant positive trend in June and October, September, and June in Sarıyer, Malkara, and Çanakkale. In terms of seasonal average precipitation on the Thrace Peninsula, a statistically significant and positive trend was observed in Saryer in the summer and in Kumköy and Sarıyer in the fall. In terms of semiannual and annual precipitation averages, a statistically significant and positive trend was observed in Kumköy, Çorlu, and Sarıyer between April and September and in Kumköy and Sarıyer annually. In terms of monthly maximum precipitation, a positive and significant trend was observed in orlu, Saryer, and Malkara. This study is expected to help in the formulation of plans and implementation of measures to address potential water-related issues in the Thrace Peninsula, given the increasing demand for water and its resources.

Keywords: Thrace Peninsula, Precipitation, Trend analysis

ÖZ

Bu çalışmada araştırma alanını Marmara Bölgesi'nde Edirne, Kırklareli, Tekirdağ, İstanbul ve Çanakkale illerinin topraklarının yer aldığı Trakya Yarımadası oluşturmaktadır. Akdeniz makroklima alanı içinde kalan Trakya Yarımadası'nda 600 mm üzerinde yağış alan yerler en geniş sahayı kaplamaktadır. En yüksek yıllık ortalama yağış Sarıyer'de (819,3 mm) ve en düşük yıllık ortalama yağış Çorlu'da (576,6 mm) görülmektedir. Araştırmada Trakya Yarımadası ve çevresinde bulunan 13 meteoroloji istasyonunun 1937-2021 yılları arasında değişen yağış verilerinden yararlanılmıştır. Aylık, mevsimlik (kış, ilkbahar, yaz, sonbahar), su yılının altı aylık (ekim-mart, nisan-eylül) ve yıllık toplam yağış ortalamalarının, %95 güven aralığında ve istatistiki olarak α=0,05 önem seviyesinde Mann-Kendall Testi, Kendall'ın Tau Testi ve Sen'in Eğim Testi kullanılarak trend analizleri yapılmıştır. Aylık yağış analizlerine göre Lüleburgaz'da ağustos, Tekirdağ'da kasım ve İpsala'da şubat ayında negatif yönlü anlamlı bir trend, Sarıyer'de haziran ve ekim aylarında, Malkara'da eylül ve Çanakkale'de haziran ayında pozitif yönlü anlamlı bir trend olduğu sonucuna ulaşılmıştır. Öte yandan yine Trakya Yarımadası'ndaki ortalama yağışlarda yaz mevsiminde Sarıyer, sonbahar mevsiminde Kumköy ve Sarıyer, nisan-eylül arasındaki dönemde Kumköy, Çorlu, Sarıyer ve yıllık yağışlarda Kumköy ve Sarıyer'de istatistiksel olarak anlamlı ve pozitif yönlü bir trend bulunmuştur. Aylık maksimum yağışlarda Kumköy, Çorlu, Sarıyer ve Malkara'da pozitif yönlü ve anlamlı bir trend olduğu sonucuna ulaşılmıştır. Bu çalışmanın Trakya Yarımadası'nda suya ve su kaynaklarına olan ihtiyacın her geçen gün arttığı düşüncesinden hareketle yaşanması olası sorunlarla ilgili olarak alınacak önlemlere ve yapılacak planlamalara katkı sağlayacağı düşünülmektedir.

Anahtar kelimeler: Trakya Yarımadası, Yağış, Trend Analiz

1. INTRODUCTION

Global warming and climate change are among the most challenging problems of today's world. Increases in temperature, changes in precipitation patterns, melting of glaciers, rise of sea levels, and changes in river flows are among the main indicators of climate change (Hanedar et al., 2019). Fluctuations in precipitation values due to climate change cause increases or decreases at regional or local scales or trends in these aspects. In the analysis of precipitation trends in any study area, statistical methods are used to determine the aspects of changes that occur due to decreases or increases in the time series data (Gönençgil and İçel, 2010; Avcı and Esen, 2019; Eroğlu, 2021; Kocaoğlu and Çağlıyan, 2022, Karakuş and Güler, 2022).

Recent analyses of temperature and precipitation trends in Turkey show that temperatures and precipitation are increasing and decreasing, respectively (Partal, 2003; Türkeş, 2012; Karakuş and Güler, 2022). However, seasonal and annual precipitation trends are not as strong as the trends observed in air temperatures (Türkeş, 2012; Türkeş, 2016). Significant trends in the direction of increase in temperature averages currently measured in the Thracian Peninsula are in line with this trend (Eroğlu, 2022).

Climate model studies have revealed that global warming will lead to climate change in and around Turkey (Önol and Semazzi, 2009), and temperatures and precipitation will increase and decrease (Demir, Kılıç and Coşkun, 2008; Türkeş, 2011). According to the MPI-ESM-MR model RCP4.5 scenario results in the TR21 Region covering the provinces of Tekirdağ, Edirne, and Kırklareli, it was emphasized that the changes in total precipitation amounts between 2015 and 2100 depending on location and time are expected to decrease in general (Hanedar et al., 2019). There is a relationship between the positive and negative periods of the North Atlantic Oscillation (NAO) and precipitation changes in Turkey (Erlat, 2002; Türkeş and Erlat, 2005; Karakoç and Tağıl, 2014; Erlat, 2016; Sezen and Partal, 2019); thus, this factor should also be considered in evaluating the interannual climate patterns and water potential (Karabörk, Kahya and Karaca, 2000).

The Thrace Peninsula is one of the most socioeconomically significant areas in Turkey (Figure 1). The changes in the amount and regime of precipitation may lead to the emergence of significant challenges in the Thrace Peninsula, such as shortage of water resources, water scarcity, or drought. Therefore, identifying the trends of increase or decrease in precipitation in the Thracian region considering the current data would significantly contribute to future planning against possible challenges. Various studies have focused on the amount of precipitation, distribution, regime characteristics, and trend analysis of precipitation in the Thrace Peninsula (Kurter, 1974–1977; Türkeş,1996; Erlat, 2000; Türkeş, Sümer and Kılıç, 2002; Partal, 2003; Türkeş and Erlat, 2005; Türkeş, Koç, and Sarış, 2007; Sarış, Hannah, and Eastwood, 2010; Gönençgil and İçel, 2010; Aydınözü, 2010; Türkeş, 2011; Türkeş, 2012; Türkeş, 2016; Topuz, Feidas, and Karabulut 2020; Kocaoğlu and Çağlıyan, 2022). The trend analyses of monthly, seasonal, semiannual, and annual precipitation averages of the Thrace Peninsula were performed using the Mann–Kendall test (Mann, 1945; Hirsch & Slack, 1984), Kendall's tau test, and Sen's slope test (Sen, 1968) by utilizing data from 13 meteorological stations located in and around the Thrace Peninsula.

This study aims to clearly reveal the increasing or decreasing trends in precipitation amounts due to climate change in the Thrace Peninsula, which is located in the Mediterranean macroclimate area, and to contribute to the sustainability of human–natural environment relations in this area from a geographical perspective. For this purpose, trend analyses of monthly, seasonal (winter, spring, summer, fall), semiannual (October–March, April–September), and annual total precipitation amounts of the water year were performed.

1.1. Research Area

The Thrace Peninsula in northwestern Turkey was determined as the research area. It forms the territory of the Marmara Region on the European continent and is surrounded by the Bosporus and the Sea of Marmara to the east; the Sea of Marmara, the Dardanelles, and the Aegean Sea to the south; Greece and Bulgaria to the west; and Bulgaria and the Black Sea to the north (Figure 1). Some of the provincial lands of İstanbul and Çanakkale and all of the provincial lands of Tekirdağ, Kırklareli, and Edirne are within the borders of the Thrace Peninsula, which has a surface area of 23.854 km² (Özşahin ve Eroğlu, 2018).

Agriculture, industry, and trade sectors are the most developed sectors in the Thrace Peninsula. A wide variety of agricultural products are grown using modern methods on large and fertile agricultural lands, constituting an area with a significant population potential. As of 2022, the total population living in the Thrace Peninsula is 12,220,690 (Edirne, Kırklareli, Tekirdağ, Eceabat, Gelibolu, and İstanbul's districts having 414,714 residents, 369,347 residents, 1,142,451 residents, 8,684 residents, 43,984 residents, and 10,241,510 residents, respectively) (TUİK (2023)).
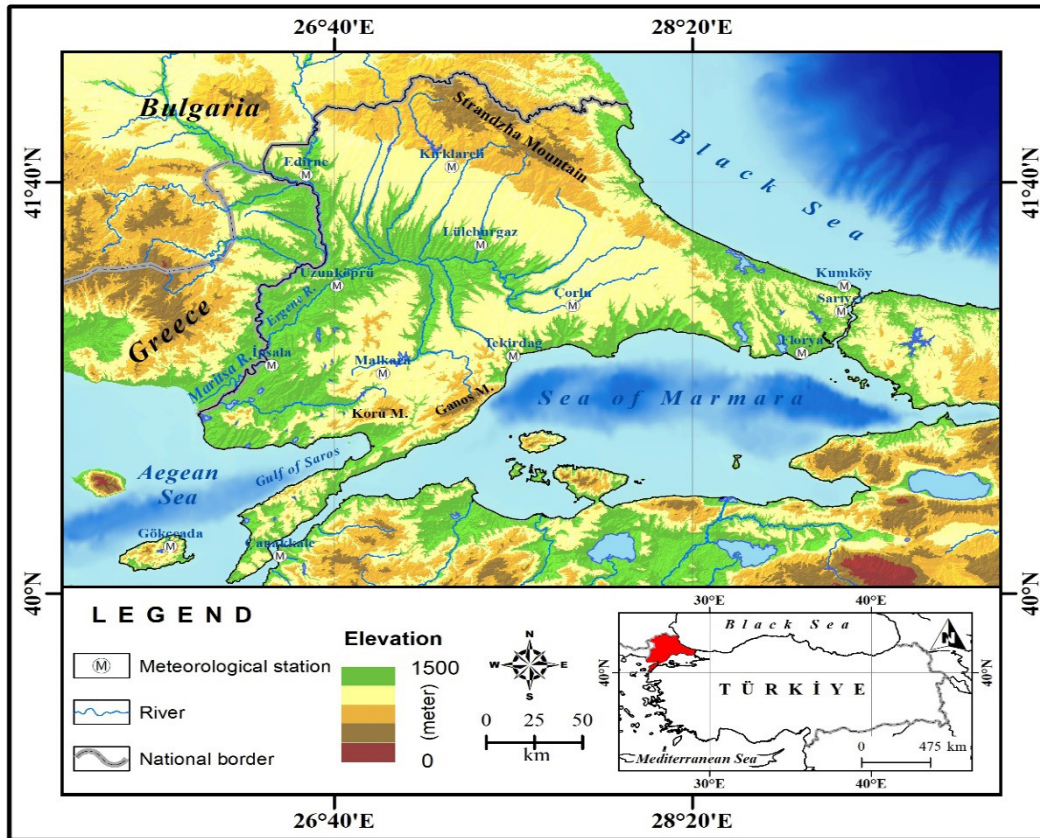
Figure 1: Location map of the research site.

The monthly precipitation averages of the meteorological stations in the Thrace Peninsula show that the rainiest month is December in all stations, and the months with the least precipitation are July in Kumköy, Sarıyer, and Florya and August in other meteorological stations (Table 1, Figure 2). The monthly precipitation regime of the Thrace Peninsula is characterized by a rapid onset of the December peak, a rainy winter season, and a gradual transition to dry summer (Sarış, Hannah, and Eastwood, 2010).

The average annual precipitation of meteorological stations in the Thrace Peninsula is 583.4 mm in Kırklareli, 607.3 mm in Edirne, 605.9 mm in Lüleburgaz, 666.2 mm in Uzunköprü, 790 mm in Kumköy, 576.6 mm in Çorlu, 819.3 mm in Sarıyer, 639.9 mm in Florya, 580.9 mm in Tekirdağ, 610.2 mm in İpsala, 668.3 mm in Malkara, 736.4 mm in Gökçeada, and 610.3 mm in Çanakkale (Table 2). The highest precipitation is observed in the meteorological stations of Gökçeada (329.3 mm) in winter, Gökçeada (171 mm) in spring, Sarıyer (108.8 mm) in summer, Sarıyer (251.3 mm) in fall, Gökçeada (572.8 mm) in October–

Table 1: The monthly average precipitation of meteorological stations in the Thracian Peninsula.

Meteorology Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Kırklareli	66,3	50,5	49,6	44,0	49,8	53,5	27,6	21,1	32,6	52,9	64,9	70,6	583,4
Edirne	67,1	52,2	51,9	48,5	53,0	47,3	32,2	23,7	35,6	56,8	67,6	71,3	607,3
Lüleburgaz	69,0	54,2	56,4	46,1	44,3	47,5	32,6	15,9	33,7	58,5	70,0	79,3	605,9
Uzunköprü	75,2	64,9	69,5	49,4	42,1	40,5	27,4	19,0	33,7	67,8	84,2	90,8	666,2
Kumköy	96,5	72,5	71,0	45,6	37,4	32,5	25,5	43,9	68,8	87,5	94,2	115,1	790,5
Çorlu	62,8	52,5	50,3	42,7	45,5	44,6	25,1	17,0	35,5	56,3	67,1	77,1	576,6
Sarıyer	106,2	78,7	69,4	45,0	35,4	34,7	34,5	39,6	63,9	85,9	101,5	124,4	819,3
Florya	84,7	70,1	60,1	45,6	30,8	27,6	20,6	22,6	37,3	64,6	79,4	96,7	639,9
Tekirdağ	68,6	54,3	53,8	42,0	37,5	38,0	25,0	15,6	32,6	60,6	72,0	80,9	580,9
İpsala	66,9	62,3	62,4	44,2	37,9	36,0	20,7	14,2	32,0	61,8	81,0	90,8	610,2
Malkara	75,3	62,4	67,3	48,1	44,0	48,8	24,0	11,1	39,6	65,4	86,8	97,8	668,3
Gökçeada	110,9	92,2	83,2	53,7	34,1	21,2	14,3	9,3	31,0	59,4	100,9	126,2	736,4
Çanakkale	91,4	70,0	66,1	45,6	30,3	25,8	13,9	8,3	24,5	55,5	82,7	106,1	610,3

March, and Kumköy (253.7 mm) in April–September and of Sarıyer (819.3 mm) in annual precipitation. The lowest precipitation is observed in Kırklareli (187.4 mm) in winter, Tekirdağ (133.3 mm) in spring, Çanakkale (42.1 mm) in summer, Kırklareli (150.3 mm) in fall, Kırklareli (354.8 mm) in October–March, and Çanakkale (140.4 mm) in April–September and Çorlu (576.6 mm) in annual precipitation.

The areas in the Thrace Peninsula are categorized as medium precipitation areas in terms of precipitation amount and intensity (Erlat, 2000). In these areas, the Mediterranean precipitation regime is observed in the northern part of the Saros Gulf, and the Marmara transition-type precipitation regime is observed in the Mediterranean to the Black Sea, which is characterized as very rainy in all seasons with a hot and less rainy summer season in other areas (Türkeş, 1996; Türkeş, 1998; Türkeş et al., 2002;

Türkeş et al. 2007; Türkeş et al. 2009). Furthermore, the Thrace Peninsula was classified with a costal regime pattern, as observed in the Marmara, Aegean, and Mediterranean coasts of Turkey due to its significant December precipitation (Sarış, Hannah, and Eastwood, 2010).

According to the Erinç Precipitation-Effectiveness Index, a semi-humid climate is observed in Kırklareli (I:30.9), Edirne (I:30.8), Lüleburgaz (I:30.8), Uzunköprü (I:33.8), Çorlu (I:32), Florya (I:34.8), Tekirdağ (I:32.5), İpsala (I:31), Malkara (I:35.5), Gökçeada (I:38.4), and Çanakkale (I:31). On the other hand, a humid climate is observed in Kumköy (I:44.2) and Sarıyer (I:46.6). the Erinç Precipitation-Effectiveness Index values shows that the Black Sea coast of the Thrace Peninsula is humid, while the other areas remain in the semi-humid climate zone (Aydın et al., 2019). In the annual precipitation series of the
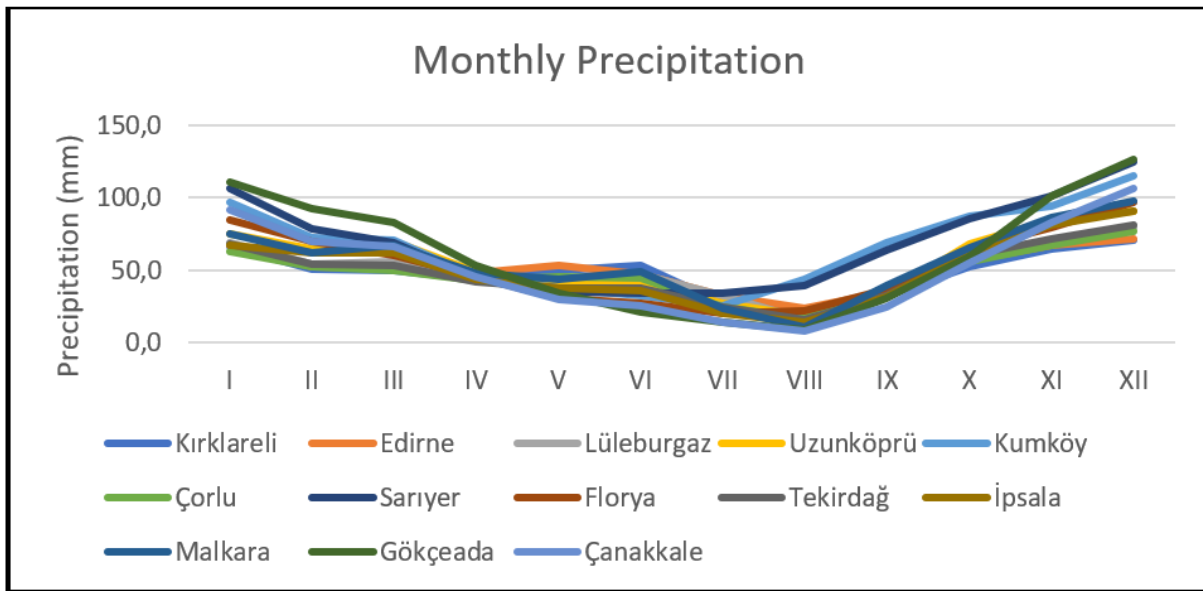
Figure 2: Figure of the monthly average precipitation of the meteorological stations in the Thracian Peninsula.

Table 2: Average precipitation values of meteorological stations in Thrace Peninsula.

Meteorology Station	Winter	Spring	Summer	Fall	October- March	April- September	Annual
Kırklareli	187,4	143,4	102,2	150,3	354,8	228,6	583,4
Edirne	190,7	153,5	103,2	160	367,1	240,2	607,3
Lüleburgaz	202,4	146,7	94,6	161,8	387,4	218,1	605,9
Uzunköprü	230,9	161	86,9	185,7	452,5	212,1	666,2
Kumköy	284,1	153,9	102	250,4	536,8	253,7	790,5
Çorlu	192,4	138,5	86,7	159	366,2	210,4	576,6
Sarıyer	309,4	149,9	108,8	251,3	566,2	253,1	819,3
Florya	251,6	136,5	70,5	181,2	455,6	184,2	639,9
Tekirdağ	203,8	133,3	78,6	165,3	390,2	190,7	580,9
İpsala	220	144,5	71	174,7	425,1	185,1	610,2
Malkara	235,5	159,5	81,6	191,8	455	213,4	668,3
Gökçeada	329,3	171	44,2	191,3	572,8	163,1	735,9
Çanakkale	267,5	141,9	42,1	158,7	469,9	140,4	610,3

Reference: General Directorate of Meteorology.

Thrace Peninsula, significant dry conditions were found in Kırklareli in 1989–1997, Tekirdağ in 1992–1993 and 1989–1990, and Çorlu in 1992–1994. (Gönençgil 2012).

2. MATERIALS AND METHODS

The data of this study are based on the monthly precipitation values of Kırklareli, Edirne, Lüleburgaz, Uzunköprü, Kumköy, Çorlu, Sarıyer, Florya, Tekirdağ, İpsala, Malkara, Gökçeada, and Çanakkale meteorological stations obtained from the General Directorate of Meteorology of the Ministry of Environment, Urbanization, and Climate Change (Table 3). This study also utilized the long-term precipitation measurement data from Çanakkale (17112) and Gökçeada (17110) meteorological stations to enrich the results of the field analysis and obtain more accurate results. The longest and shortest periods evaluated in the precipitation trend analysis are found in Florya (84 years (1937–2020)) and Malkara (42 years (1980–2021)) meteorological stations, respectively. Among the other meteorological stations, this study analyzed precipitation data of Kırklareli (covering 63 years (1959–2021)), Edirne (70 years (1952–2021)), Lüleburgaz (67 years (1955–2021)), Uzunköprü (57 years (1965–2021)), Kumköy (70 years (1951–2020)), Çorlu (64 years (1958–2021)), Sarıyer (67 years (1954–2020)), Florya (84 years (1937–2020)), Tekirdağ (82 years (1940–2021)), İpsala (58 years (1964–2021)), Malkara (42 years (1980–2021)), Gökçeada (56 years (1965–2020)), and Çanakkale (84 years (1937–2020)).

Monthly precipitation data were organized as seasonal (winter, spring, summer, fall), semiannual (October–March, April–September) periods of the water year, and annual total precipitation series. The homogeneity of each dataset was tested at a 99% confidence interval according to the results of Pettitt's test (Pettitt, 1979), standard normal homogeneity test (SNHT), Buishand's test, and von Neumann's test in XLSTAT (2022) package program. Parametric and nonparametric trend tests are conducted to analyze the trends in hydrometeorological variables (Karakuş, 2017). In this study, the Mann–Kendall test (Mann, 1945; Hirsch, & Slack, 1984), Kendall's tau test, and Sen's slope test (Sen, 1968) were used to investigate the trend analysis of precipitation time series at a 95% confidence interval and statistical significance level α = 0.05. The Mann–Kendall test, also known as Kendall's tau, and Sen's slope test are the nonparametric tests used to analyze climatological and hydrometeorological data (Partal, 2003). In Sen's slope test, a negative and a positive value indicate a decreasing and an increasing trend, respectively (Kocaoğlu and Çağlıyan, 2022). XLSTAT (2022) package program was used for the trend and homogeneity analyses. A geographic information system (GIS) ArcGIS 10.8 program was used to draw the maps. Inverse distance weighting (IDW) method was used to obtain precipitation distribution maps based on the average precipitation values of the meteorological stations presented in Table 2. Study maps showing the precipitation distribution and precipitation trend status were formed by adding signs indicating the trend status of the stations to these maps. IDW is an interpolation method commonly preferred for determining the cell values of unknown points using the values of known sample points. The cell value is calculated by examining the various points away from the relevant cell and depending on the increase in distance. This method involves surface interpolation based on the weighted average of the sample points (İlker et al., 2019).

2.1. Mann–Kendall Test

In the Mann–Kendall test, the H0 hypothesis states that observations x1, ..., xn, which are time independent and similarly

Table 3: Meteorological stations used in the study and their characteristics.

Meteorology Station	Meteorology Station	Latitude	Longitude	Altitude (m)	Observation Years	Data Length (Years)
Kırklareli	17052	41.7382 N	27.2178 E	232	1959-2021	63
Edirne	17050	41.6767 N	26.5508 E	51	1952-2021	70
Lüleburgaz	17631	41.3513 N	27.3108 E	46	1955-2021	67
Uzunköprü	17608	41.2726 N	26.7056 E	45	1965-2021	57
Kumköy	17059	41.2505 N	29.0384 E	38	1951-2020	70
Çorlu	17054	41.1798 N	27.8160 E	145	1958-2021	64
Sarıyer	17061	41.1464 N	29.0502 E	59	1954-2020	67
Florya	17636	40.9758 N	28.7865 E	37	1937-2020	84
Tekirdağ	17056	40.9585 N	27.4965 E	4	1940-2021	82
İpsala	17632	40.8900 N	26.3900 E	81	1964-2021	58
Malkara	17634	40.8873 N	26.9080 E	207	1980-2021	42
Gökçeada	17110	40.1910 N	25.9075 E	79	1965-2020	56
Çanakkale	17112	40.1410 N	26.3993 E	6.0	1937-2020	84

Reference: General Directorate of Meteorology.

distributed random variables, are time sorted. Meanwhile, the H1 hypothesis states that for all (k, j ≤ n), where (k ≠ j), the distributions of xk and xj in the series are not identical. Equation (1) is used to derive the statistic S of the Mann–Kendall. Equation (2) gives the value of (xj-xk) in this equation (Terzi and İlker, 2021).

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(x_j - x_k) \qquad (1)$$

$$sgn(x_j - x_k) = \begin{cases} (x_j - x_k) > 0 \Rightarrow +1 \\ (x_j - x_k) = 0 \Rightarrow 0 \\ (x_j - x_k) < 0 \Rightarrow -1 \end{cases} \qquad (2)$$

The variance of the test statistic S is obtained as follows:

$$Var(S) = \frac{n(n-1)(2n+5)}{18} \qquad (3)$$

Equation (4) is used if similar variables are present in the time series ("tie condition"):

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_i^r t_i(t_i-1)(2t_i+5)}{18} \qquad (4)$$

The significance of the Mann–Kendall test, for which the variance value is determined, is compared with the critical Z value of the standard normal variable Z calculated in the equation. The numbers 1 in the numerator are continuous correction units.

$$Z = \begin{cases} \dfrac{S-1}{[Var(S)]^{\frac{1}{2}}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \dfrac{S+1}{[Var(S)]^{\frac{1}{2}}} & \text{if } S < 0 \end{cases} \qquad (5)$$

If the α significance level |z| ≤ zα/2, the null hypothesis H0 is supported. Otherwise, it is rejected. A positive and a negative S value indicate the presence of an increasing and a decreasing trend, respectively (Yu et al., 1993; Partal, 2003; Yüce et al.2018; Terzi and İlker, 2021).

2.2. Sen's Slope Test

Sen's slope test is a nonparametric trend test proposed by Hirsch (1982) and developed by Sen (1968). It is not affected by data errors and extreme values. This test indicates that if the trend (X₁, X₂…., Xn) is time-sorted data, the values of X_j and X_k, (being the data at any j and k times, provided that (j>k)) are found using the following relation.

$$\beta = \frac{X_j - X_k}{j - k}$$

The number of all β values found is N. N=n(n + 1)/2 data are sorted from smallest to largest. The median value of these sorted data gives us the change per unit of time (Partal, 2003).

3. FINDINGS

3.1. Homogeneity Analysis

Pettitt's test (Pettitt, 1979), SNHT (Alexandersson, 1986), Buishand's test (Buishand, 1982), and von Neumann's test (Von Neumann, 1941) were utilized for homogeneity analysis of annual precipitation data of meteorological stations in the Thrace Peninsula (Table 4). These tests were conducted with a 99% confidence interval. Based on the homogeneity analysis results, all the tests performed at Kırklareli, Edirne, Uzunköprü, Kumköy, Çorlu, Tekirdağ, Malkara, and Gökçeada stations showed homogeneity. Although the SNHT, Pettitt's test, and von Neumann' test in Lüleburgaz, Florya, İpsala, and Çanakkale respectively, are rejected, the annual precipitation data are considered homogeneous. On the other hand, the annual precipitation data is considered doubtful in Sarıyer as the SNHT and Buishand's test are rejected (Wijngaard, Klein Tank, & Konnen, 2003).

3.2. Trend Analysis of Monthly Precipitation

The significant trend in monthly precipitation in the Thrace Peninsula is observed at Lüleburgaz, Sarıyer, Tekirdağ, İpsala, Malkara, and Çanakkale stations (Table 5, Figure 3). No significant trend is observed in the monthly precipitation of other stations. A significant negative trend is found in August, November, and February in Lüleburgaz, Tekirdağ, and İpsala, respectively. On the other hand, a significant positive trend is observed in June and October in Sarıyer, September in Malkara, and June in Çanakkale. In other words, a significant increasing trend in monthly precipitation is found in Sarıyer, Malkara, and Çanakkale, and a decreasing trend is noted in Lüleburgaz, Tekirdağ, and İpsala.

On the other hand, there is a statistically increasing trend in October precipitation with 1 significant station and 12 insignificant stations, in June precipitation with 2 significant stations and 9 insignificant stations, in September precipitation with 1 significant station and 8 insignificant stations, and in July precipitation with 9 insignificant stations. One station has a significant negative trend and 9 stations have an insignificant trend in November precipitation, and 11 stations have a insignificant decreasing trend in December precipitation.

Table 4: The results of the homogeneity tests of the annual precipitation data of the meteorological stations in the Thracian Peninsula.

Meteorology Station	Name of the Test	P Value	Year of Change	Meteorology Station	Name of the Test	P Value	Year of Change
Kırklareli	Pettitt	0.375	2004	Florya	Pettitt	**0.019**	1957
	SNHT	0.145	2008		SNHT	0.590	2018
	Buishand	0.095	2004		Buishand	0.976	1957
	Von Neumann	0.433	-		Von Neumann	0.341	-
Edirne	Pettitt	0.713	2004	Tekirdağ	Pettitt	0.357	1994
	SNHT	0.364	2008		SNHT	0.087	1940
	Buishand	0.261	1994		Buishand	0.763	1994
	Von Neumann	0.211	-		Von Neumann	0.100	-
Lüleburgaz	Pettitt	0.121	1971	İpsala	Pettitt	0.894	2015
	SNHT	**0.046**	1966		SNHT	0.071	2016
	Buishand	0.060	1971		Buishand	0.374	2015
	Von Neumann	0.050	-		Von Neumann	**0.001**	-
Uzunköprü	Pettitt	0.440	1981	Malkara	Pettitt	1.000	1994
	SNHT	0.579	1981		SNHT	0.169	1993
	Buishand	0.362	1981		Buishand	0.069	1994
	Von Neumann	0.237	-		Von Neumann	0.097	-
Kumköy	Pettitt	0.051	1973	Gökçeada	Pettitt	0.619	1993
	SNHT	0.103	1973		SNHT	0.582	1993
	Buishand	0.051	1973		Buishand	0.257	1993
	Von Neumann	0.200	-		Von Neumann	0.095	-
Çorlu	Pettitt	0.734	1994	Çanakkale	Pettitt	0.386	1981
	SNHT	0.222	2008		SNHT	0.394	1981
	Buishand	0.247	2008		Buishand	0.143	1981
	Von Neumann	0.188	-		Von Neumann	0.031	-
Sarıyer	Pettitt	0.083	1967				
	SNHT	**0.037**	1967				
	Buishand	**0.042**	1995				
	Von Neumann	0.078	-				

3.1. Trend Analysis of Winter Precipitation

When the winter season precipitation in the Thrace Peninsula is analyzed, no statistically significant increasing or decreasing trend at α = 0.05 significance level is found in any of the stations used in the study (Table 6, Figures 4 and 8). A positive trend in winter precipitation is observed in Edirne, Kumköy, Sarıyer, and Malkara stations, and a negative trend is found in Kırklareli, Lüleburgaz, Uzunköprü, Çorlu, Florya, Tekirdağ, İpsala, Gökçeada, and Çanakkale stations.

3.2. Trend Analysis of Spring Precipitation

In the spring season, no statistically significant increase or decrease in the trend of precipitation is found at any of the stations used in the study (Table 7, Figures 5 and 8). On the other hand, the number of stations with an increasing trend is increasing in the spring. Kumköy, Sarıyer, and Malkara stations, where a positive trend is observed in winter precipitation, are accompanied by Çorlu, Florya, Gökçeada, and Çanakkale stations in spring precipitation. Again, Edirne, which shows an increasing trend in the winter season, follows a decreasing trend in the spring. Kırklareli, Lüleburgaz, Uzunköprü, Tekirdağ, and İpsala are other stations with negative trends in precipitation during this

season. Although statistically insignificant, it is understood that the number of stations showing a positive trend in spring precipitation in the Thrace Peninsula has increased compared to the winter season.

3.3. Trend Analysis of Precipitation in Summer

In the Thrace Peninsula, a statistically significant and positive trend in summer precipitation is detected only at Sarıyer station (Table 8, Figures 6 and 8). A positive but insignificant trend in summer precipitation is found in Kırklareli, Edirne, Uzunköprü, Kumköy, Çorlu, Florya, Tekirdağ, İpsala, Malkara, Gökçeada, and Çanakkale, and a negative and also insignificant trend in summer precipitation is noted in Lüleburgaz. The fact that the trend in summer precipitation is positive in almost all of the stations shows that a more notable trend is present in summer precipitation in the Thrace Peninsula compared to winter and s

3.4. Trend Analysis of Precipitation in Fall

In the fall season, a positive and significant precipitation trend is detected in Kumköy and Sarıyer stations (Table 9, Figures 6 and 8). A positive but insignificant precipitation is

Table 5: Trend values of monthly precipitation.

Meteorology Station	Test Name	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Kırklareli	Mann-Kendall	0,598	0,873	0,877	0,427	0,991	0,182	0,717	0,396	0,644	0,031	0,618	0,257
	Kendall's Tau	0,046	0,014	-0,014	-0,069	-0,002	0,116	0,032	-0,074	0,040	0,187	0,044	-0,098
	Sen's Slope	0,185	0,026	-0,027	-0,118	-0,005	0,283	0,046	-0,088	0,069	0,529	0,139	-0,405
Edirne	Mann-Kendall	0,788	0,749	0,808	0,543	0,612	0,693	0,144	0,546	0,887	0,475	0,510	0,792
	Kendall's Tau	0,022	-0,027	0,020	-0,050	-0,042	-0,033	0,120	0,050	-0,012	0,059	-0,054	0,022
	Sen's Slope	0,070	-0,049	0,052	-0,091	-0,119	-0,079	0,194	0,057	-0,014	0,209	-0,178	0,069
Lüleburgaz	Mann-Kendall	0,384	0,713	0,799	0,649	0,910	0,677	0,436	**0,001**	0,426	0,788	0,074	0,299
	Kendall's Tau	-0,073	-0,031	0,022	0,038	0,010	-0,035	-0,066	-0,290	-0,067	0,024	-0,150	-0,087
	Sen's Slope	-0,227	-0,070	0,042	0,100	0,023	-0,071	-0,087	-0,288	-0,109	0,059	-0,463	-0,320
Uzunköprü	Mann-Kendall	0,522	0,731	0,836	0,449	0,620	0,491	0,601	0,720	0,885	0,655	0,055	0,433
	Kendall's Tau	0,059	-0,032	-0,019	-0,07	-0,046	0,063	0,048	-0,033	0,014	0,041	-0,175	-0,072
	Sen's Slope	0,259	-0,107	-0,045	-0,191	-0,121	0,166	0,056	-0,022	0,013	0,161	-0,874	-0,421
Kumköy	Mann-Kendall	0,800	0,475	0,939	0,400	0,530	0,423	0,367	0,364	0,147	0,325	0,757	0,516
	Kendall's Tau	-0,021	0,059	0,007	0,069	0,052	0,066	0,074	0,075	0,119	0,081	0,026	0,053
	Sen's Slope	-0,072	0,152	0,008	0,125	0,087	0,078	0,095	0,107	0,420	0,302	0,079	0,242
Çorlu	Mann-Kendall	0,505	0,899	0,972	0,945	0,391	0,092	0,835	1,000	0,566	0,075	0,411	0,066
	Kendall's Tau	-0,058	0,011	0,003	0,006	0,074	0,145	0,018	0,000	0,050	0,153	-0,071	-0,158
	Sen's Slope	-0,192	0,029	0,007	0,021	0,154	0,407	0,024	0,000	0,108	0,419	-0,187	-0,541
Sarıyer	Mann-Kendall	0,914	0,168	0,626	0,642	0,414	**0,012**	0,582	0,363	0,211	**0,014**	0,426	0,927
	Kendall's Tau	0,009	0,116	0,041	-0,039	0,069	0,211	0,047	0,077	0,105	0,205	0,067	-0,008
	Sen's Slope	0,042	0,321	0,125	-0,069	0,117	0,313	0,059	0,119	0,364	0,788	0,273	-0,031
Florya	Mann-Kendall	0,899	0,626	0,705	0,625	0,393	0,162	0,671	0,920	0,624	0,905	0,358	0,391
	Kendall's Tau	-0,010	0,036	-0,028	0,036	0,064	0,104	-0,032	-0,008	-0,037	0,009	-0,069	-0,064
	Sen's Slope	-0,016	0,083	-0,054	0,050	0,061	0,116	-0,011	0,000	-0,060	0,012	-0,161	-0,164
Tekirdağ	Mann-Kendall	0,234	0,321	0,493	0,981	0,608	0,838	0,634	0,416	0,583	0,363	**0,028**	0,234
	Kendall's Tau	-0,090	0,075	-0,052	-0,002	0,039	0,016	0,036	0,062	0,042	0,069	-0,165	-0,051
	Sen's Slope	-0,209	0,167	-0,096	-0,003	0,063	0,025	0,040	0,032	0,050	0,171	-0,443	-0,150
İpsala	Mann-Kendall	0,742	**0,013**	0,904	0,634	0,825	0,717	0,200	0,177	0,243	0,215	0,469	0,515
	Kendall's Tau	0,030	-0,225	-0,012	-0,044	-0,021	0,033	0,116	0,123	-0,106	0,113	-0,066	-0,059
	Sen's Slope	0,142	-0,705	-0,025	-0,110	-0,033	0,062	0,208	0,100	-0,230	0,445	-0,227	-0,308
Malkara	Mann-Kendall	0,530	0,269	0,828	0,957	0,721	0,410	0,182	0,845	**0,011**	0,089	0,087	0,488
	Kendall's Tau	0,069	0,120	0,024	-0,007	0,040	0,090	-0,145	0,022	0,275	0,184	-0,185	-0,075
	Sen's Slope	0,527	0,496	0,067	-0,017	0,141	0,300	-0,217	0,004	0,738	1,008	-1,311	-0,496
Gökçeada	Mann-Kendall	0,899	0,296	1,000	0,938	0,238	0,189	0,146	0,205	0,932	0,055	0,400	0,719
	Kendall's Tau	-0,012	-0,097	0,000	0,008	-0,109	0,122	-0,138	-0,121	0,008	0,177	-0,078	-0,034
	Sen's Slope	-0,090	-0,499	0,000	0,029	-0,189	0,146	-0,056	-0,003	0,000	0,680	-0,436	-0,246
Çanakkale	Mann-Kendall	0,155	0,694	0,61	0,494	0,932	**0,027**	1.000	0,861	0,737	0,449	0,221	0,299
	Kendall's Tau	-0,106	-0,030	-0,038	0,051	-0,007	0,165	0,000	-0,014	0,025	0,057	-0,091	-0,077
	Sen's Slope	-0,395	-0,083	-0,074	0,089	-0,012	0,163	0,000	0,000	0,010	0,122	-0,282	-0,329

found in Kırklareli, Edirne, Çorlu, Florya, Malkara, Gökçeada, and Çanakkale stations. Moreover, a negative and insignificant precipitation is noted in Lüleburgaz, Uzunköprü, Tekirdağ, and İpsala stations. Kırklareli and Edirne, which show a negative trend in spring, have a positive trend in fall.

Meteorology Station	Test Name	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Kırklareli	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	+	+	−	−	−	+	+	−	+	+	+	−
	Sen's Slope	+	+	−	−	−	+	+	−	+	+	+	−
Edirne	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	+	−	+	−	−	−	+	+	−	+	−	+
	Sen's Slope	+	−	+	−	−	−	+	+	−	+	−	+
Lüleburgaz	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🔴	🔴	🔴
	Kendall's Tau	−	−	+	+	+	−	−	−	−	+	−	−
	Sen's Slope	−	−	+	+	+	−	−	−	−	+	−	−
Uzunköprü	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	+	−	−	−	−	+	+	−	+	+	−	−
	Sen's Slope	+	−	−	−	−	+	+	−	+	+	−	−
Kumköy	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	−	+	+	+	+	+	+	+	+	+	+	+
	Sen's Slope	−	+	+	+	+	+	+	+	+	+	+	+
Çorlu	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	−	+	+	+	+	+	+	+	+	+	−	−
	Sen's Slope	−	+	+	+	+	+	+	+	+	+	−	−
Sarıyer	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🔴	🔴	🟢	🔴	🔴
	Kendall's Tau	+	+	+	−	+	+	+	+	+	+	+	−
	Sen's Slope	+	+	+	−	+	+	+	+	+	+	+	+
Florya	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	−	+	−	+	+	+	−	−	−	+	−	−
	Sen's Slope	−	+	−	+	+	+	−	+	−	+	−	−
Tekirdağ	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🔴
	Kendall's Tau	−	+	−	−	+	+	+	+	+	+	−	−
	Sen's Slope	−	+	−	−	+	+	+	+	+	+	−	−
İpsala	Mann-Kendall	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	+	−	−	−	−	+	+	+	−	+	−	−
	Sen's Slope	+	−	−	−	−	+	+	+	−	+	−	−
Malkara	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🔴	🔴
	Kendall's Tau	+	+	+	−	+	+	−	+	+	+	−	−
	Sen's Slope	+	+	+	−	+	+	−	+	+	+	−	−
Gökçeada	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	−	−	+	+	−	+	−	−	+	+	−	−
	Sen's Slope	−	−	+	+	−	+	−	−	+	+	−	−
Çanakkale	Mann-Kendall	🔴	🔴	🔴	🔴	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴
	Kendall's Tau	−	−	−	+	−	+	+	−	+	+	−	−
	Sen's Slope	−	−	−	+	−	+	+	+	+	+	−	−

🟢 Significant 🔴 Insignificant − Decrease + Increase

Figure 3: Trend values of monthly precipitation.

Table 6: Trend values of precipitation in winter.

Meteorology Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,780	🔴	-0,025	➖	-0,083	➖
Edirne	0,765	🔴	0,025	➕	0,065	➕
Lüleburgaz	0,124	🔴	-0,129	➖	-0,873	➖
Uzunköprü	0,393	🔴	-0,061	➖	-0,177	➖
Kumköy	0,656	🔴	0,037	➕	0,088	➕
Çorlu	0,215	🔴	-0,107	➖	-0,241	➖
Sarıyer	0,566	🔴	0,048	➕	0,120	➕
Florya	0,648	🔴	-0,034	➖	-0,053	➖
Tekirdağ	0,662	🔴	-0,033	➖	-0,067	➖
İpsala	0,341	🔴	-0,087	➖	-0,250	➖
Malkara	0,965	🔴	0,006	➕	0,011	➕
Gökçeada	0,385	🔴	-0,081	➖	-0,324	➖
Çanakkale	0,094	🔴	-0,124	➖	-0,741	➖

● Significant 🔴 Insignificant ➖ Decrease ➕ Increase

Table 7: Trend values of precipitation in spring season.

Meteorology Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,731	🔴	-0,030	➖	-0,040	➖
Edirne	0,843	🔴	-0,017	➖	-0,027	➖
Lüleburgaz	0,720	🔴	-0,030	➖	-0,120	➖
Uzunköprü	0,863	🔴	-0,016	➖	-0,028	➖
Kumköy	0,757	🔴	0,026	➕	0,046	➕
Çorlu	0,451	🔴	0,065	➕	0,081	➕
Sarıyer	0,983	🔴	0,002	➕	0,003	➕
Florya	0,637	🔴	0,035	➕	0,029	➕
Tekirdağ	0,701	🔴	-0,029	➖	-0,031	➖
İpsala	0,979	🔴	-0,003	➖	-0,003	➖
Malkara	0,879	🔴	0,017	➕	0,033	➕
Gökçeada	0,697	🔴	0,036	➕	0,065	➕
Çanakkale	0,920	🔴	0,008	➕	0,024	➕

● Significant 🔴 Insignificant ➖ Decrease ➕ Increase
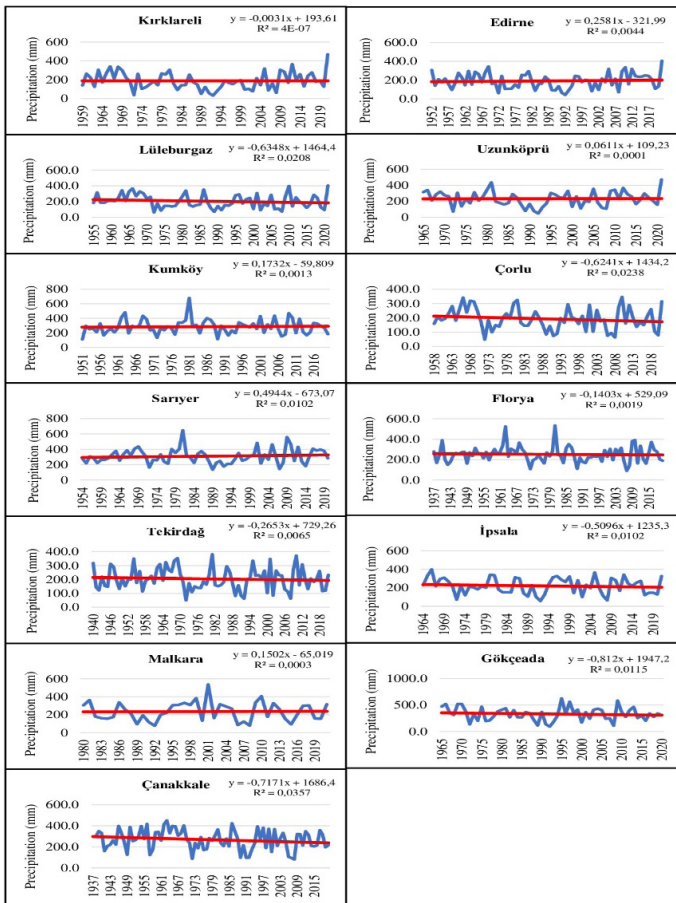
Figure 4: Year by year change in winter precipitation.

3.5. Trend Analysis of Precipitation During the October–March Period

In the Thrace Peninsula, no statistically significant upward or downward trend is observed in any of the meteorological stations in the October–March period (Table 10, Figures 9 and 11). On
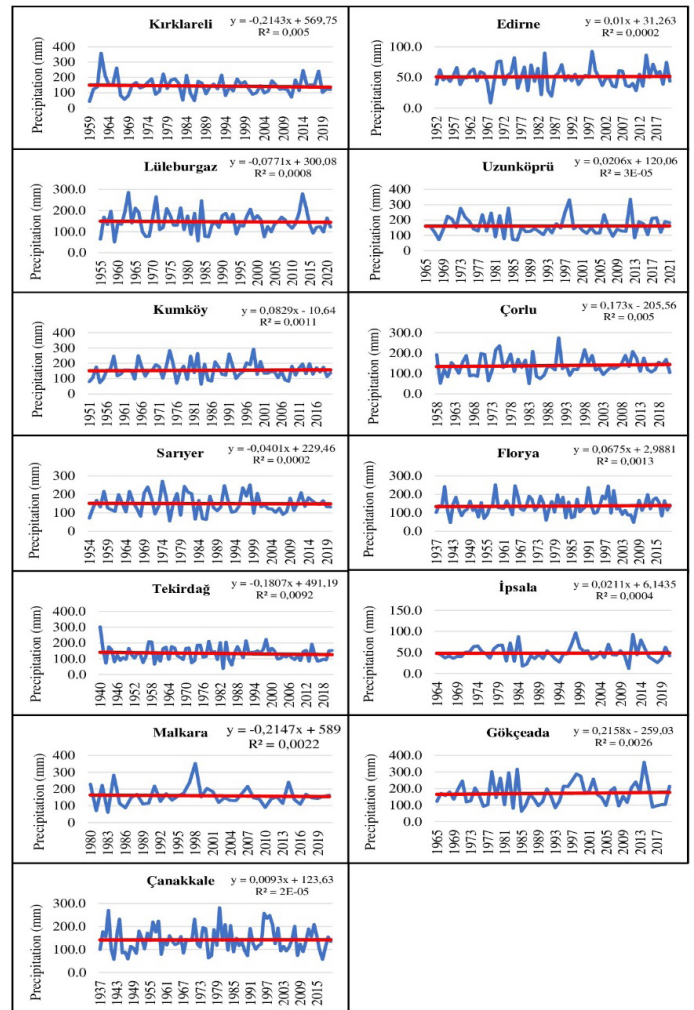
Figure 5: Trend graphs of precipitation in spring season.

the other hand, an insignificant positive trend is observed in Kırklareli, Edirne, Kumköy, Çorlu, Sarıyer, and Florya stations,

Table 8: Trend values of precipitation in summer.

Meteoro-logy Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,370	●	0,078	✚	0,122	✚
Edirne	0,453	●	0,062	✚	0,085	✚
Lüleburgaz	0,574	●	-0,047	▬	-0,207	▬
Uzunköprü	0,587	●	0,050	✚	0,064	✚
Kumköy	0,400	●	0,069	✚	0,098	✚
Çorlu	0,107	●	0,138	✚	0,174	✚
Sarıyer	**0,016**	●	0,202	✚	0,275	✚
Florya	0,629	●	0,036	✚	0,023	✚
Tekirdağ	0,433	●	0,059	✚	0,049	✚
İpsala	0,222	●	0,111	✚	0,119	✚
Malkara	0,803	●	0,028	✚	0,041	✚
Gökçeada	0,235	●	0,110	✚	0,102	✚
Çanakkale	0,406	●	0,062	✚	0,112	✚

● Significant ● Insignificant ▬ Decrease ✚ Increase

Table 9: Trend values of precipitation in fall.

Meteorology Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,137	●	0,129	✚	0,217	✚
Edirne	1,000	●	0,000	✚	0,000	✚
Lüleburgaz	0,274	●	-0,092	▬	-0,422	▬
Uzunköprü	0,125	●	-0,140	▬	-0,325	▬
Kumköy	**0,010**	●	0,211	✚	0,438	✚
Çorlu	0,407	●	0,071	✚	0,125	✚
Sarıyer	**0,005**	●	0,234	✚	0,558	✚
Florya	0,985	●	0,002	✚	0,001	✚
Tekirdağ	0,911	●	-0,009	▬	-0,015	▬
İpsala	0,629	●	-0,044	▬	-0,114	▬
Malkara	0,278	●	0,117	✚	0,271	✚
Gökçeada	0,977	●	0,003	✚	0,009	✚
Çanakkale	0,948	●	0,005	✚	0,023	✚

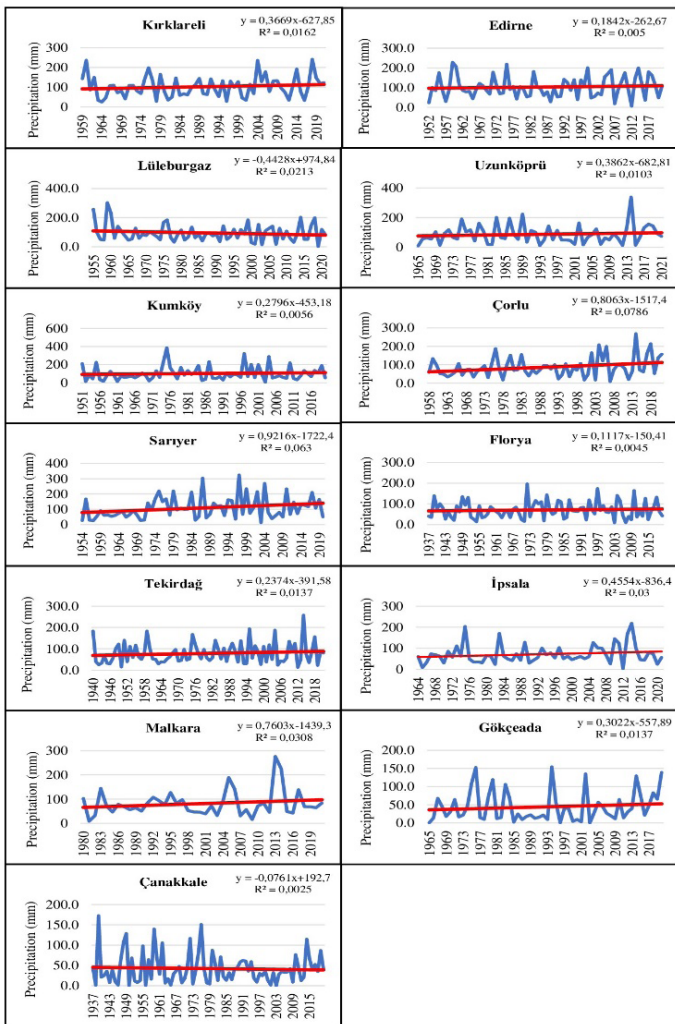● Significant ● Insignificant ▬ Decrease ✚ Increase

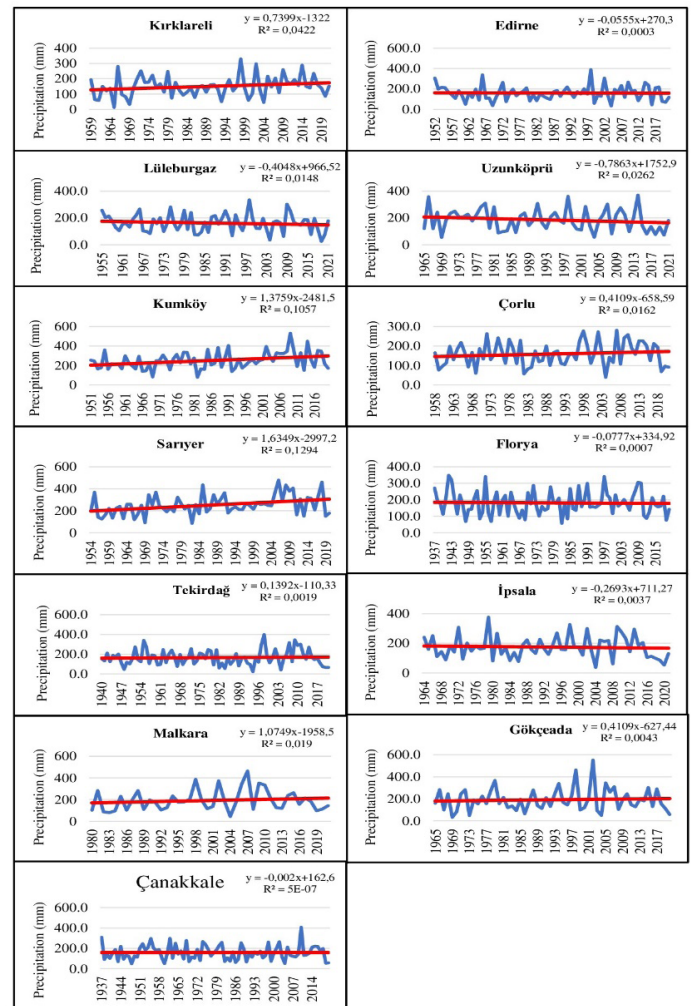**Figure 6:** Trend graphs of precipitation in summer.

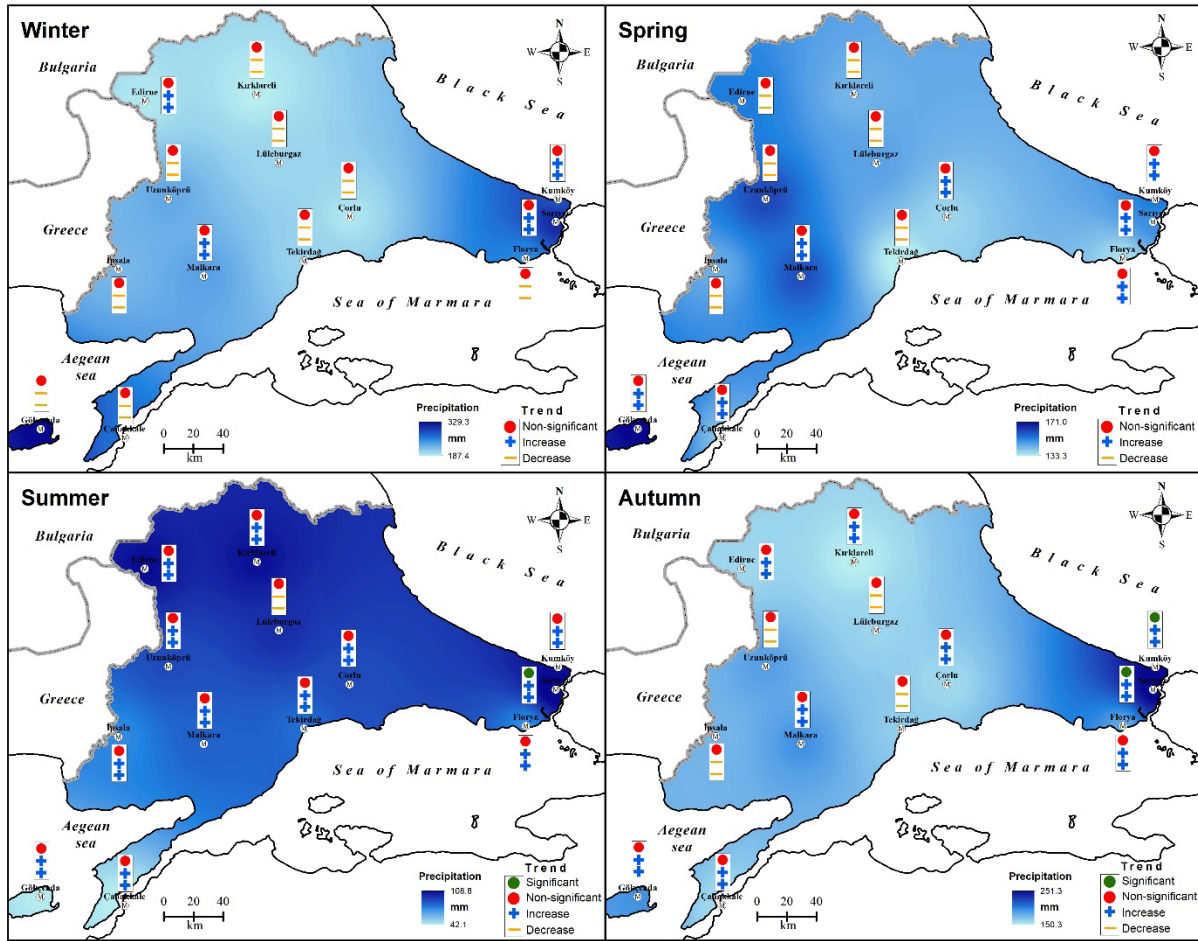**Figure 7:** Trend graphs of precipitation in fall.

Figure 8: Results of trend analysis for (a) winter, (b) spring, (c) summer and (d) autumn precipitation totals.

Table 10: Trend values of precipitation during the October-March period.

Meteorology Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,700	🔴	0,034	➕	0,046	➕
Edirne	0,693	🔴	0,033	➕	0,058	➕
Lüleburgaz	0,225	🔴	-0,102	➖	-0,955	➖
Uzunköprü	0,640	🔴	-0,043	➖	-0,091	➖
Kumköy	0,626	🔴	0,040	➕	0,064	➕
Çorlu	0,451	🔴	0,065	➕	0,081	➕
Sarıyer	0,122	🔴	0,130	➕	0,190	➕
Florya	0,637	🔴	0,035	➕	0,029	➕
Tekirdağ	0,309	🔴	-0,077	➖	-0,092	➖
İpsala	0,687	🔴	-0,037	➖	-0,075	➖
Malkara	0,931	🔴	-0,010	➖	-0,022	➖
Gökçeada	0,783	🔴	-0,026	➖	-0,071	➖
Çanakkale	0,137	🔴	-0,111	➖	-0,871	➖

🟢 Significant   🔴 Insignificant   ➖ Decrease   ➕ Increase

and a negative trend is observed in Lüleburgaz, Uzunköprü, Tekirdağ, İpsala, Malkara, Gökçeada, and Çanakkale stations.

3.6. Trend Analysis of Precipitation During the April–September Period

A statistically significant and positive trend in precipitation is observed in Kumköy, Çorlu, and Sarıyer stations in the April–September period (Table 11, Figures 10 and 11). A positive and insignificant trend is observed in Kırklareli, Edirne, Florya, Tekirdağ, İpsala, Malkara, Gökçeada, and Çanakkale, and a negative and insignificant trend is observed in Lüleburgaz and Uzunköprü.

3.7. Trend Analysis of Annual Precipitation

Based on the trend analysis of the total annual precipitation values of the stations in the Thrace Peninsula, a significant and positive trend is found in Kumköy and Sarıyer (Table 12, Figures 12 and 13). On the other hand, positive and insignificant trends are observed in Kırklareli, Çorlu, and Malkara stations, and negative and insignificant trends are detected in Edirne, Lüleburgaz, Uzunköprü, Florya, Tekirdağ, İpsala, Gökçeada, and Çanakkale stations.
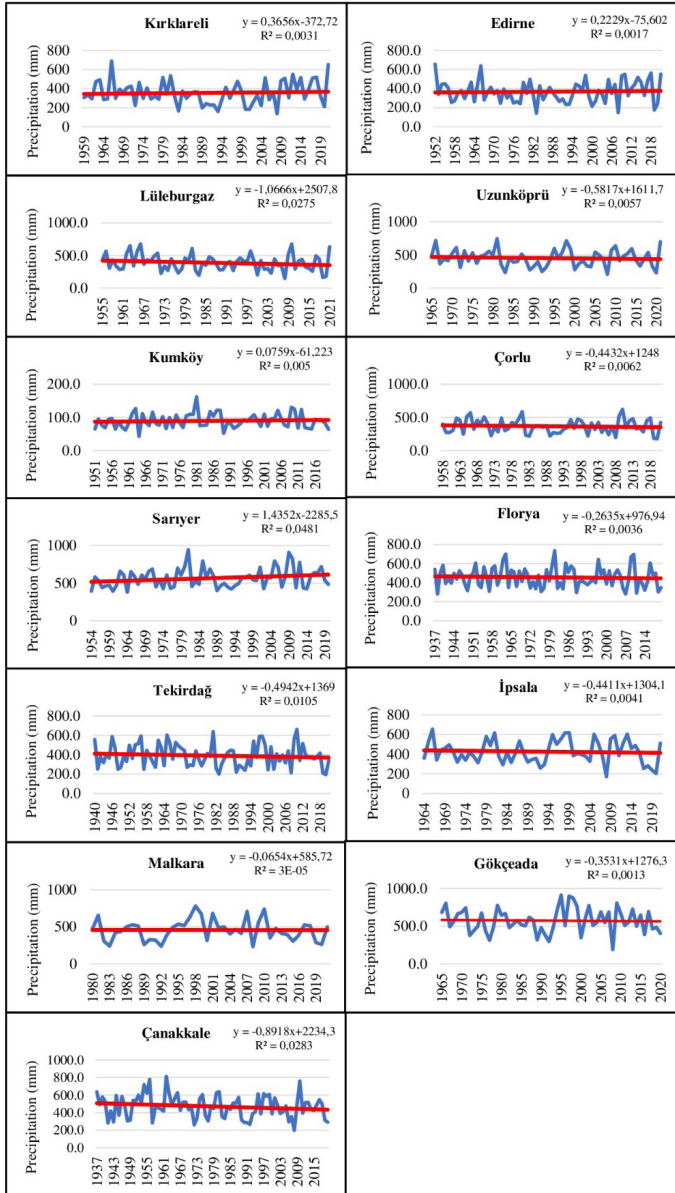
Figure 9: Trend graphs of precipitation during the October-March period.

3.10. Trend Analysis of Monthly Maximum Precipitation

In the trend analysis of monthly maximum precipitation, a positive and significant trend is found in Kumköy, Çorlu, Sarıyer, and Malkara stations located on the Thrace Peninsula (Table 13, Figure 14). Among the stations where a statistically insignificant trend was determined, the trend in monthly maximum precipitation in Lüleburgaz, Uzunköprü, and Florya stations follows a negative direction, whereas the trend in Kırklareli, Edirne, Tekirdağ, İpsala, Gökçeada, and Çanakkale stations follows a positive direction.
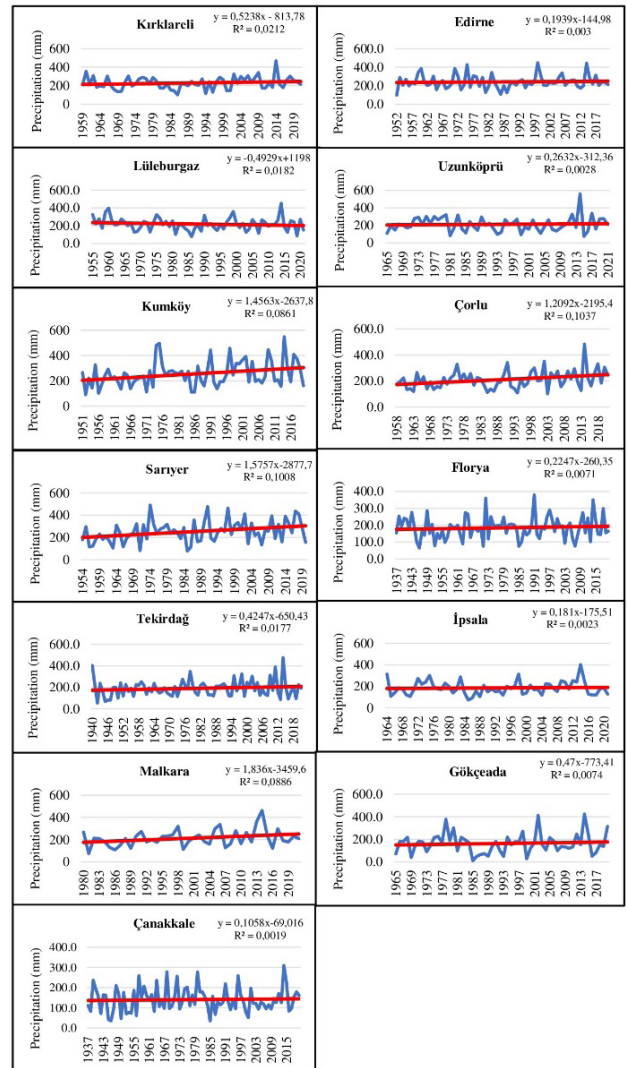
Table 11: Trend values of precipitation during the April-September period.

Meteoro-logy Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,308	🔴	0,089	➕	0,077	➕
Edirne	0,570	🔴	0,047	➕	0,031	➕
Lüleburgaz	0,221	🔴	-0,103	➖	-0,509	➖
Uzunköprü	0,956	🔴	-0,006	➕	-0,011	➕
Kumköy	**0,035**	🟢	0,172	➕	0,219	➕
Çorlu	**0,021**	🟢	0,198	➕	0,180	➕
Sarıyer	**0,010**	🟢	0,216	➕	0,273	➕
Florya	0,985	🔴	0,002	➕	0,001	➕
Tekirdağ	0,476	🔴	0,054	➕	0,035	➕
İpsala	0,648	🔴	0,042	➕	0,028	➕
Malkara	0,083	🔴	0,187	➕	0,270	➕
Gökçeada	0,821	🔴	0,021	➕	0,017	➕
Çanakkale	0,743	🔴	0,025	➕	0,096	➕

🟢 Significant 🔴 Insignificant ➖ Decrease ➕ Increase

Figure 10: Trend graphs of precipitation during the April-September period.
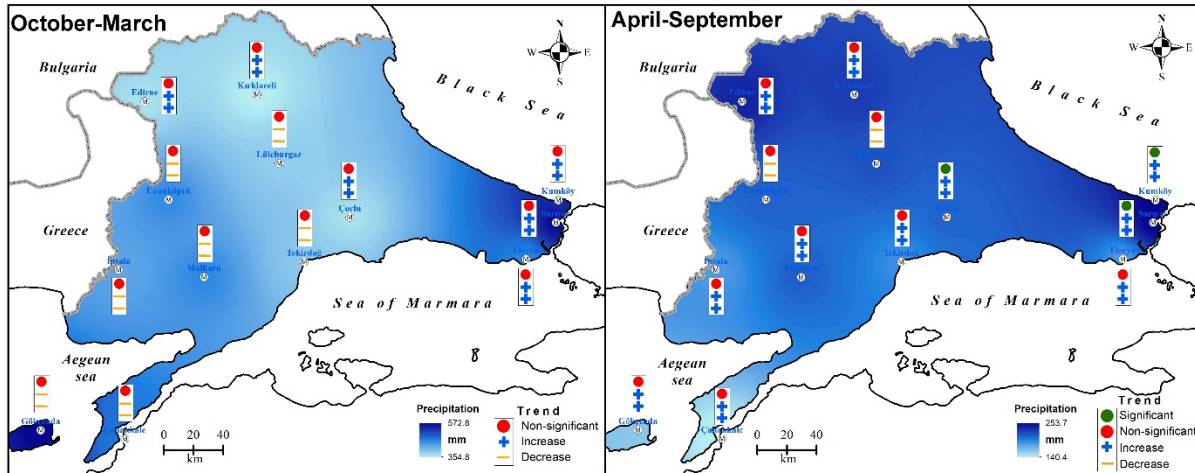
Figure 11: Trend maps of precipitation during the October-March and the April-September periods.

Table 12: Trend values of annual precipitation.

Meteoro-logy Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,644	🔴	0,040	➕	0,600	➕
Edirne	0,911	🔴	-0,010	➖	-0,106	➖
Lüleburgaz	0,096	🔴	-0,140	➖	-1,697	➖
Uzunköprü	0,615	🔴	-0,046	➖	-0,742	➖
Kumköy	**0,014**	🟢	0,201	➕	1,971	➕
Çorlu	0,434	🔴	0,067	➕	0,675	➕
Sarıyer	**0,002**	🟢	0,262	➕	3,498	➕
Florya	0,802	🔴	-0,019	➖	-0,126	➖
Tekirdağ	0,958	🔴	-0,004	➖	-0,025	➖
İpsala	0,511	🔴	-0,060	➖	-0,848	➖
Malkara	0,308	🔴	0,110	➕	2,376	➕
Gökçeada	0,916	🔴	-0,010	➖	-0,115	➖
Çanakkale	0,233	🔴	-0,089	➖	-0,820	➖

🟢 Significant 🔴 Insignificant ➖ Decrease ➕ Increase

4. DISCUSSION and CONCLUSION

According to the Mann–Kendall test, Kendall's tau, and Sen's slope test, a significant negative trend in monthly precipitation values in the Thrace Peninsula is found in August, November, and February in Lüleburgaz, Tekirdağ, İpsala, respectively. Moreover, a significant positive trend is observed in June and October in Sarıyer, September in Malkara, and June in Çanakkale. Regarding the seasons, a positive and statistically significant trend is detected in Sarıyer in summer and Kumköy and Sarıyer in autumn. In addition, positive and statistically significant trend is noted in Kumköy, Çorlu, and Sarıyer in the April–September and in Kumköy and Sarıyer in annual precipitation. No significant trend in precipitation is detected between the winter and spring seasons and during the October–March period. An insignificant decreasing trend is also found in winter, during October–March, and annual precipitation, whereas an insignificant increasing trend is found in spring, summer, fall,
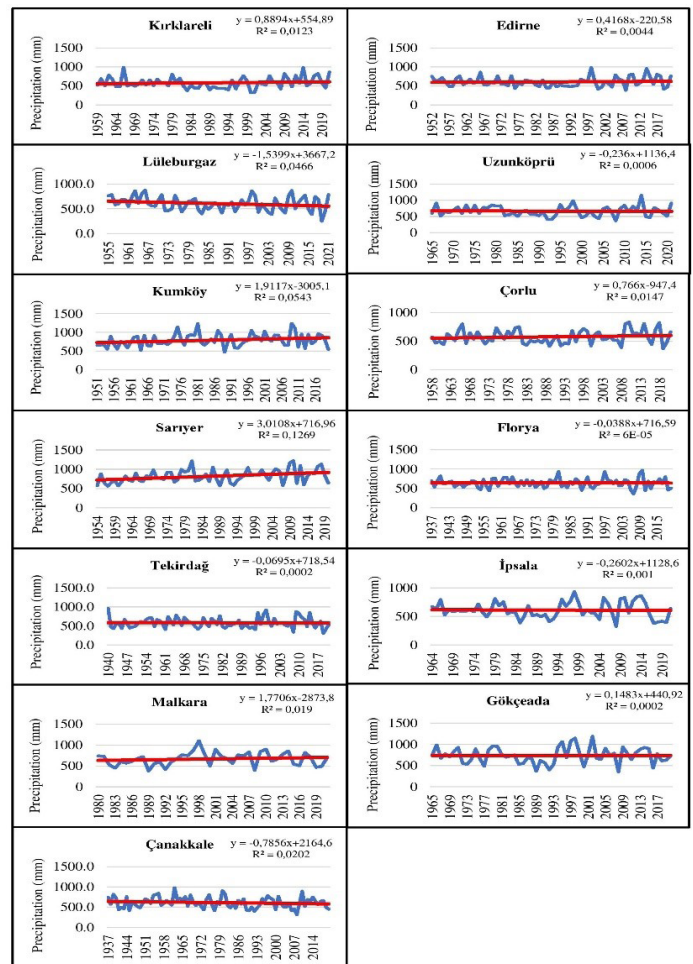

Figure 12: Trend graphs of annual precipitation.

and during April–September precipitation. In terms of monthly maximum precipitation, a positive and significant trend is found in Kumköy, Çorlu, Sarıyer, and Malkara.

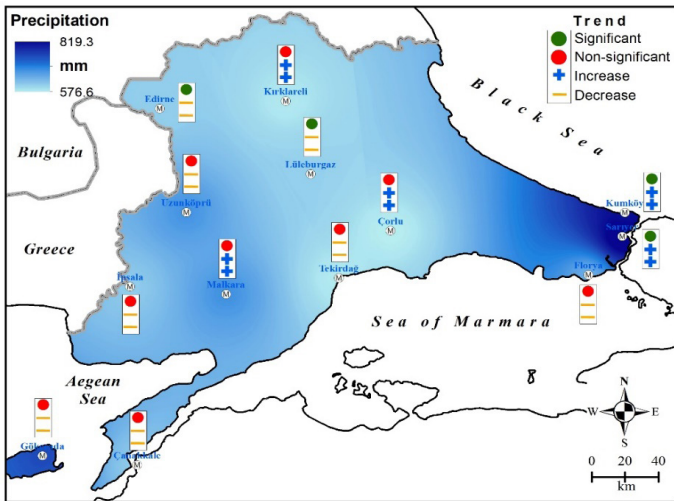The findings obtained in this study are mostly consistent with

Figure 13: Trend map of annual precipitation.

Table 13: Trend values of monthly maximum precipitation.

Meteorology Station	Mann-Kendall P (Value) (α=0,05)		Kendall's Tau		Sen's Slope	
Kırklareli	0,865	🔴	0,015	➕	0,017	➕
Edirne	0,070	🔴	0,150	➕	0,161	➕
Lüleburgaz	0,795	🔴	-0,022	➖	-0,043	➖
Uzunköprü	0,713	🔴	-0,034	➖	-0,035	➖
Kumköy	**0,001**	🟢	0,278	➕	0,379	➕
Çorlu	**0,012**	🟢	0,219	➕	0,235	➕
Sarıyer	**0,020**	🟢	0,197	➕	0,298	➕
Florya	0,383	🔴	-0,066	➖	-0,057	➖
Tekirdağ	0,224	🔴	0,092	➕	0,090	➕
İpsala	0,409	🔴	0,076	➕	0,144	➕
Malkara	**0,026**	🟢	0,243	➕	0,639	➕
Gökçeada	0,117	🔴	0,146	➕	0,349	➕
Çanakkale	0,147	🔴	0,109	➕	0,135	➕

🟢 Significant   🔴 Insignificant   ➖ Decrease   ➕ Increase

those of previous studies. Alexandrov et al. (2004) stated that the trends in annual precipitation in Bulgaria for the 1901–2000 period were insignificant at the 95% probability level. Topuz et al. (2020) found no statistically significant trend in annual and winter precipitation in Turkey for the 1955–2013 period. Türkeş (2012) found an increasing trend in annual total precipitation in Tekirdağ and İstanbul regions. Furthermore, Gönençgil (2012) found that annual total precipitation showed a decreasing trend at all stations, except Edirne and Kirecburnu. In this study, no statistically significant trend in winter precipitation was found, but a significant positive trend in annual precipitation was observed only in Kumköy and Sarıyer.

Gönençgil (2012) concluded that the July precipitation series showed an increasing trend at Edirne (significant) and Kırklareli stations and a decreasing trend at Tekirdağ, Kirecburnu, and
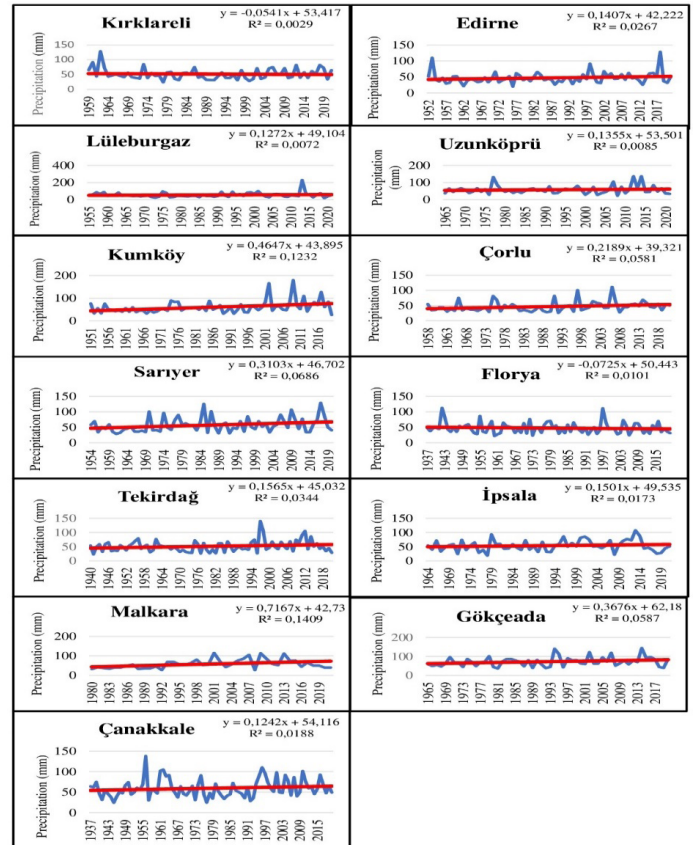

Figure 14: Trend graphs for monthly maximum precipitation.

Çorlu stations, especially after the 1990s. In this study, although the trend direction of summer precipitation is increasing, a statistically significant increase is observed only in Sarıyer station.

In the periodic trend analysis of annual precipitation averages in the Meriç River Basin Eroğlu (2021) determined that there was a significant negative trend at Ipsala in the 1965–1990 period, a significant positive trend at Kırklareli station in the 1991–2015 period, and no statistically significant trend at any station in the basin area in the 1965–2015 period. No statistically significant trend was also found in annual average precipitation at any station in the Meriç River Basin in this study.

From the analysis of precipitation trends in the Thrace Peninsula within the scope of meteorological stations, significant positive trends are detected in Sarıyer, Kumköy, Çorlu, Malkara, and Çanakkale stations, whereas significant negative trends are found in Lüleburgaz, Tekirdağ, and İpsala stations only in monthly precipitation. Moreover, no statistically significant results are found in Kırklareli, Edirne, Uzunköprü, Florya, and Gökçeada stations.

Out of 117 analyses performed for 13 meteorological stations in the Thrace Peninsula to determine the effects of global climate change on temperature averages, 107 (91.5%) were found to have a statistically positive and significant trend (Eroğlu, 2022). This trend in air temperatures would cause an increase in the amount of evapotranspiration (ET). Due to population growth, urbanization, and industrialization, the need for water and water resources in this area is increasing day by day. It is also emphasized the change in the global climate has resulted in the escalation of problems, such as flooding and water insufficiency, water quality deterioration, and ecosystem problems in the Thrace Peninsula in recent years (Turoğlu and Uludağ, 2013), where water resources and groundwater are important (Aykut, 2021).

On the other hand, the average rainy days in Sarıyer, Kumköy, Çorlu, Florya, Edirne, Uzunköprü, Kırklareli, Tekirdağ, Malkara, Ipsala, Lüleburgaz, Gökçeada, and Çanakkale are 131, 124, 123, 118, 108.5, 99, 98.5, 98, 98, 96, 90, 88, and 86 days, respectively. Accordingly, the number of rainy days in the Thrace Peninsula varies between 131 and 86 days. Sarıyer and Çanakkale are the stations with highest and lowest number of rainy days, respectively. The rainfall Trakya is distributed according to precipitation intensity classes, where light rains below 10 mm constitute 80% of the total rainfall. On the other hand, the proportion of heavy and very heavy rain showers is <1% (Erlat, 2000).

The maximum monthly precipitation during the observation periods of the meteorological stations was 227.4 mm, 179.4 mm, 144.4 mm, 140.1 mm, 137.8 mm, 131.8 mm, 128.9 mm, 128.5 mm, 128.3 mm, 115.1 mm, 112.5 mm, 111.3 mm, and 93.2 mm in Lüleburgaz (2013, April), Kumköy (2009, September), Gökçeada (2014, May), Tekirdağ (1997, October), Çanakkale (1956, November), Uzunköprü (1977, December), Sarıyer (2017, September), Edirne (2018, November), Kırklareli (1960, January), Malkara (2001, December), Florya (1942, November), Çorlu (2006, July), and Ipsala (1979, November), respectively. From these data, it can be understood that the monthly maximum rainfall in Edirne, Sarıyer, Gökçeada, Lüleburgaz, Kumköy, Çorlu, Malkara, and Tekirdağ decreased between 1997 and 2018. Similarly, the monthly maximum rainfall in İpsala, Uzunköprü, Kırklareli, Çanakkale, and Florya decreased during the period from 1942 to 1979.

This study examined the impact of global climate change on precipitation trends in the Thrace Peninsula. The data obtained contribute to the future planning of water resources, water use, and management. Nevertheless, it is relevant to note that a large number of detailed scientific studies are necessary to reach more diverse findings regarding the climatological and precipitation characteristics of the Thrace Peninsula.

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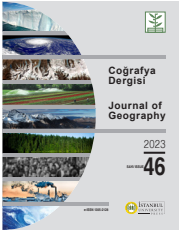
Çoklu Analiz Yöntemlerinin Işığında Tarsus (Berdan) Ovasının Paleocoğrafyası ve Gözlükule Höyüğünün Jeoarkeolojisi

Paleogeography of the Tarsus Plain and Geoarchaeology of Gözlükule Mound in Light of a Multi-Proxy Analysis

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ÖZ

Gözlükule Höyüğü, günümüzdeki Tarsus (Berdan) Ovası'nın kuzey kenarında bulunmaktadır. Bu çalışmada, Tarsus Ovası'nın paleocoğrafik gelişimini ve bölgede yer alan Gözlükule Höyüğü'nün doğal çevre değişimlerinden nasıl etkilendiğini ortaya koymak amacıyla, 2001 ve 2002 yıllarında yörede yapılmış olan 19 adet delgi sondaja ait sedimanlar yeni analizler ışığında değerlendirilmiştir. Sedimanlar, granülometrik, element özellikleri ve paleontolojik açıdan analiz edilmiştir. Bu analizlerin sonuçlarına göre Tarsus Ovası ile Gözlükule Höyüğü çevresinin Holosen'deki doğal çevre değişmeleri yorumlanmıştır. Bu gelişmelerin belli bir kronolojiye bağlanabilmesi için Ege Üniversitesi Bilimsel Araştırma Projeleri SHD - 2021 - 22452 ve SYL - 2020 - 22305 numaralı iki proje desteği ile toplam 5 adet RC14 analizi yaptırılmıştır. Sediman örnekleri paleontolojik, sedimantolojik, element analizleri ve tarihleme sonuçları birlikte değerlendirilerek yeni verilere göre yörenin paleocoğrafik gelişimi ortaya konmuştur.
Anahtar kelimeler: Tarsus (Berdan) Ovası, Gözlükule Höyüğü, paleocoğrafya

ABSTRACT

Gözlükule Mound is located in the northern Tarsus Plain . This study aims to reconstruct the paleoenvironment of Gözlükule Mound and the paleogeographic development of the Tarsus Plain. Core sediments taken from 19 drillings made between 2001-2002 are used to reveal the effects of natural environmental changes, with granulometric analyses, elemental analyses, and paleontological analyses being done for this purpose. In light of these analyses, the study interprets the natural environmental changes to the Tarsus Plain and the surroundings of Gözlükule Mound that occurred in the Holocene. In order to connect these developments to a certain chronology, a total of five radiocarbon-14 analyses were made with the support of Ege University Scientific Research Project Nos. SHD-2021-22452 and SYL-2020-22305. The paleontological, sedimentological, and elemental analyses, as well as the dating results of the sediment samples, were reevaluated, with the paleogeographic development of the region being revealed in accordance with the new data.
Keywords: Tarsus (Berdan) Plain, Gözlükule Mound, paleogeography

EXTENDED ABSTRACT

Tarsus Plain is a part of the Çukurova Deltas Complex and is located in a region bounded by the Mediterranean Sea to the south, the Bolkar Mountains to the north and northwest, and the Misis Mountains to the east. With a historical past dating back to 7,000 BC, Cilicia was one of the most important settlements of the region in the ancient period, and Gözlükule Mound is located on the northern edge of the Tarsus Plain. In order to reveal the paleogeographic development of the Tarsus Plain and how the Gözlükule Mound in the region was affected by natural environmental changes, the study reevaluates within its scope sediment samples that had been taken from core drillings in the region.

A laser-diffraction grain-size analysis was carried out over 300 sediment samples taken from different depths, as well as an elemental analysis using the x-ray fluorescence (XRF) method on 145 sediment samples. In addition, a carbon-nitrogen-sulfur (CNS) analysis, total organic carbon (TOC) and total inorganic carbon (TIC) analysis, and paleontological analysis were also conducted on 150 sediment samples. A total of five radiocarbon-14 (RC-14) analyses were conducted with the support of Ege University Scientific Research Project Nos. SHD-2021-22452 and SYL-2020-22305.

To determine the delta development in the Tarsus Plain as well as in the old lagoon and marsh areas in the region, XRF, CNS, and carbon-to-nitrogen (C/N ratio) elemental analyses were performed on 150 sediment samples. In addition to the calcium-to-potassium (Ca/K) ratio in the sediment content, the high TIC ratio explains the dominance of marine sediments. The high zirconium-to-rubidium (Zr/Rb) ratio indicates the accumulation of sandy material. However, the sediment samples that were determined to be marine were also seen to have high levels of titanium (Ti), manganese (Mn), and strontium (Sr). The environment is explained to have been lagoonal through the high chlorine (Cl), sulfur (S), and calcium (Ca) ratios found in the sediment. The analysis results determined that coastal dunes had provided the formation of the lagoon and reflect the transition. Accordingly, the Ca/K, Cl, S, and TOC ratios decreased, The Si and TIC ratios increased due to the formation of dunes. A high K ratio is also identified in flood plain sediments.

The granulometric analysis of 300 samples from drilling sediments graded the grain size poorly or very poorly at depths reflecting the flood plain sediments. However, the average grain size was seen to range between 3-10 microns. Due to the flooding present in river dynamics, average grain size reaches up to 39 microns at some levels. At the depths determined as the old river bed, the average particle size distribution reached up to 800 microns, with the sediment structure showing very poor grading. These levels contain coarse grains as well as all sizes of sand, silt, and clay. At levels reflecting the marine environment, the average grain size of the sediment is 50 microns, with the sediment being coarse, silty, and poorly graded. In the lagoon environment, this took on a very fine sandy structure with an average grain size of 200 microns.

The fossils in the sediment samples taken from the boreholes made significant contributions to the research in terms of their habitats. The macro- and micro-fossils found in the sediment samples taken from the boreholes in the Tarsus Plain and around the Gözlükule Mound prove the environmental characteristics that were interpreted from the sedimentological point of view. The changes in the coastline in the Holocene in particular provided indicators for determining whether the Gözlükule Mound and the city of Tarsus had been coastal settlements during these periods; whether the Rhegma (Rhegmoi) Lagoon, whose existence appears in historical narratives, had also existed as the plain developed, and whether a harbor town called Aulai had also existed.

The natural environment around the Gözlükule Mound has changed considerably from the Neolithic era to the present. This change occurred mostly in the alluvial area and along the shoreline. The Tarsus Plain and Gözlükule Mound were never located on the coast, nor did the sea penetrate inland this far. The sea had risen rapidly and transgressed around Tarsus. It must have advanced on the old plain surface, which had been shaped under terrestrial conditions compared to the pre-Holocene floor level, and is now located under today's alluvium area. According to the results on the drillings, the sea had penetrated up to 5 km south of the Gözlükule Mound during this period.

Over the course of time, the settlement that started in Gözlükule Mound expanded to the present city area. Meanwhile, a lagoon began to develop in the south, and the port city of Tarsus, called Rhegma as well as Aulai, was established on the shore of this lagoon. In this

period, Tarsus became the most important city of the region with its geographical location and inner harbor. As the Rhegma lagoon filled with alluvium and turned into a lake and then into a large swamp, Tarsus being 15-16 km away from the coast ceased to be a city connected to the sea.

According to the results of the multiple analysis methods that were carried out, the coastline had intruded to the north in the direction of Tarsus and Gözlükule Mound via transgression in the Early Holocene; it moved towards the plain again in the Middle and Late Holocene alongside the alluvia carried by the Tarsus Stream and the Seyhan and Ceyhan rivers in the region. Based on the processes that developed in the Middle and Late Holocene, a lagoon (Rhegma) was formed to the south of Gözlükule Mound. With the continued accumulation, the lagoon environment gradually turned into a lake before then becoming a wetland in the delta-flood plain. Wetlands in the form of swamps remain as current traces of these processes over the plain except where they were dried by drainage works. Today, the Karabucak swamp in the south Tarsus Plain is the last remnant of these environments.

1. GİRİŞ

Gözlükule Höyüğü, İçel il sınırları içinde Çukurova (antik adıyla Kilikya Ovası) ve Tarsus (Berdan) çayının batısında bulunur (Şekil 1). Modern Tarsus kentinin güneydoğusunda yer alan Gözlükule Höyüğünde ilk arkeolojik kazılar Hetty Goldman başkanlığında 1935 yılında başlamış, II. Dünya savaşı sırasında ara verilmesi dışında 1948 yılına kadar sürmüştür. 2000 yılına kadar verilen aradan sonra Boğaziçi Üniversitesi Tarih Bölümünden Prof. Dr. Aslı Özyar başkanlığında Gözlükule Höyüğünde yeniden başlayan arkeolojik araştırmalar, 2007 yılından itibaren kazılara dönüşerek günümüze kadar devam etmiştir (Özyar, Danışman, Gürbüz ve Özener, 2003; Özyar ve Danışman, 2009; Özyar, Danışman, Ünlü ve Kuruçayırlı, 2009; Özyar vd., 2014; Özyar, Ünlü, Pancaroğlu ve Volkaer, 2017).

Tarsus'un (Tarsos), Gözlükule Höyüğündeki çalışmalarla, Neolitik'e kadar uzanan yerleşme tarihine sahip olduğu ortaya konmuştur. Tarsus kentinin kurulduğu yer olan Gözlükule Höyüğünde, Hetty Goldman çalışmalarında, Neolitik'ten İslam dönemine kadar süren bir yerleşimin olduğu belirlenmiş ve yedi kültür katı saptanmıştır (Goldman, 1935, 1956; Goldman ve Jones, 1963). Höyüğün en alt kısmında bulunan bazı keramik ve obsidyen aletler M.Ö. 6000-5500 yılları arasına yani Neolitik'e tarihlenmiştir. Neolitik Dönemde başlayan bu yerleşme, Kalkolitik ve Tunç Çağı'nın tüm evrelerini geçirerek hiç terkedilmeden, Demir Çağı'nda da değişen tüm koşullara uyum sağlayarak var olmayı sürdürmüştür. Höyükte en fazla birikim oluşturan yapı katlarının 20 m'yi bulan kalınlığı ile Tunç Çağı'na ait olduğu belirtilmektedir (Özyar vd., 2003). Doğu Akdeniz'deki konumu ve Neolitik'e kadar uzanan yerleşme tarihi, Gözlükule Höyüğü'nün içinde bulunduğu Kilikya Bölgesinin yerleşme tarihi açısından daha da önemli kılmaktadır.

Gözlükule Höyüğünde, 2000 yılından itibaren interdisipliner bir arkeoloji projesi başlamıştır. Gözlükule Höyüğünde yeni dönem arkeoloji çalışmalarında Neolitik'ten günümüze kadar Tarsus yöresinde doğal çevrede meydana gelen değişmeler ve bu
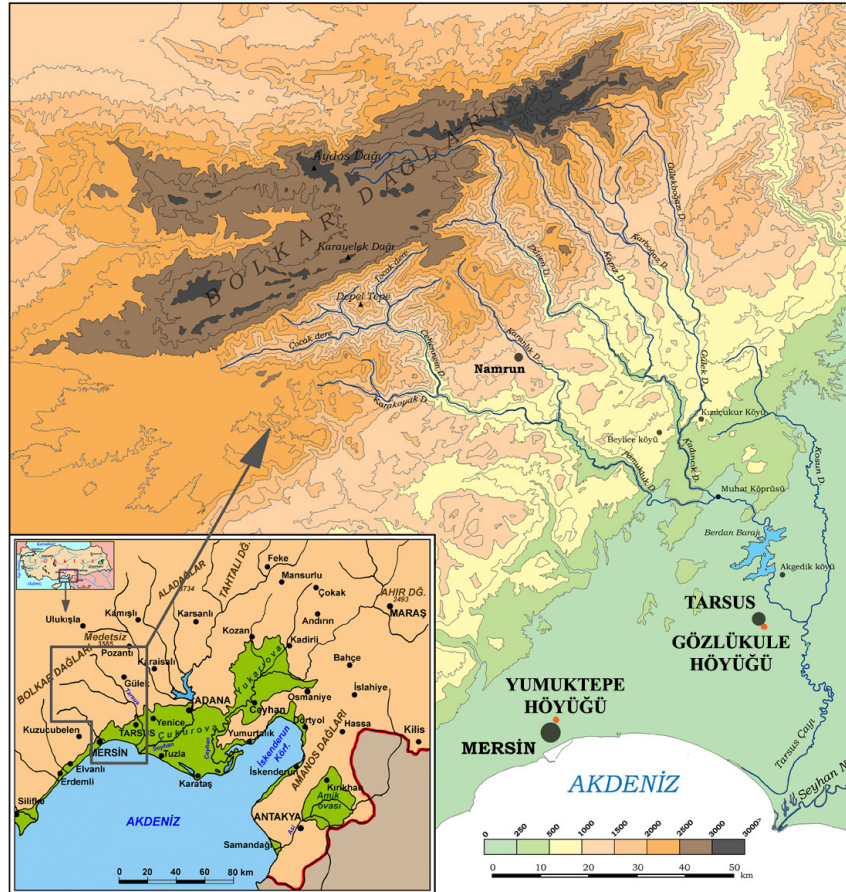
Şekil 1: Tarsus Ovası ve Gözlükule Höyüğünün konumu (Hocaoğlu, 2003; Öner, Uncu ve Hocaoğlu, 2002a, Öner, Uncu ve Hocaoğlu, 2002b).
Figure 1: *The location of the Tarsus Plain and the Gözlükule Mound*
(Hocaoğlu, 2003; Öner, Uncu ve Hocaoğlu, 2002a, Öner, Uncu ve Hocaoğlu, 2002b).

değişmelerin insan faaliyetleri ve yerleşme tarihine etkilerinin belirlenmesi önemli görülmüştür (Özyar vd., 2003). Bu amaçla 2000'li yılların başında Gözlükule Höyüğü arkeolojik kazı projesi kapsamında yörede paleocoğrafya çalışmaları başlamıştır (Hocaoğlu, 2003; Öner vd., 2002a; Öner vd., 2002b; Öner, Uncu ve Hocaoğlu, 2003; Öner, Hocaoğlu ve Uncu, 2005a; Öner, Hocaoğlu ve Uncu, 2005b; Öner, 2016a; Öner, 2016b; Öner, Vardar, Karadaş ve İlhan, 2019).

Bu çalışmalarda öncelikle alüvyal alanlarda DSİ tarafından yapılmış olan sondajlar değerlendirerek ovayı oluşturan genç pekişmemiş sedimanların genel stratigrafisi belirlenmiştir. Sonrasında gerek höyük çevresinde gerekse ova tabanında Cobra MK1 delgi (çakma) sondaj makinasıyla 19 adet delgi sondaj yapılmıştır (Şekil 2). Sondajlardan alınan örnekler sedimantolojik olarak incelenmiş ve sedimanların ortam özellikleri belirlenmiştir. Tarihsel verilerden de yararlanılarak alanın son 7000 yıllık dönemine ait paleocoğrafya haritaları oluşturulmuştur (Hocaoğlu, 2003; Öner vd., 2002a, Öner vd., 2002b; Öner vd., 2003; Öner vd., 2005a; Öner vd., 2005b; Öner, 2016a; Öner, 2016b; Öner vd., 2019). Bu çalışmada delgi sondajlardan alınan sediman örneklerin sedimantolojik (granülometrik ve element analizleri) ve paleontolojik analizlerinin yapılması ve Gözlükule Höyüğü çevresinde meydana gelen coğrafi çevre değişikliklerinin bu analizler ışığında yeniden değerlendirilmesi amaçlanmıştır.

2. MATERYAL VE YÖNTEM

Tarsus Ovası ve Gözlükule Höyüğünün doğal çevresi büyük ölçüde son buzul maksimumundan (20.000 yıl öncesi) günümüze kadar meydana gelen deniz seviyesi-kıyı çizgisi değişmeleri ve Orta Holosen'den itibaren ön plana geçen alüvyal boğulma süreçleri ile zaman içinde değişikliğe uğramıştır. Gerek deniz seviyesi-kıyı çizgisi değişmeleri gerekse de alüvyal boğulma ile kıyı bölümünde meydana gelen ortam değişmelerinin belirlenmesi ancak genç sediman birikimlerinin iç özelliklerinin incelenmesiyle mümkün olabilmektedir. Bu amaçla Gözlükule Höyüğü arkeoloji projesi kapsamında önceki yıllarda (Hocaoğlu, 2003; Öner vd., 2002a, 2002b, 2002c, 2003, 2005a, 2005b) Tarsus Ovası ve Gözlükule Höyüğü çevresinde yapılmış (Şekil 2) sondajlardan alınan ve bölüm laboratuvarımızda hassas bir şekilde korunan sediman örnekleri yeni analizler için kullanılmıştır.

Sondajların farklı derinliklerden 300 adet örneğin lazer kırınımlı tane boyu analizi, 145 adet örneğin X-Işını Floresansı yöntemiyle element analizleri, Karbon-Nitrojen-Sülfür analizleri, Toplam Karbon ve Toplam İnorganik Karbon analizleri ile 140 adet örneğin paleontolojik analizleri yapılmıştır. Ayrıca EÜ BAP projesi desteği ile Tübitak MAM tarafından farklı derinliklere ait 5 kavkı örneğinin RC14 tarihlendirmesi yapılmıştır (Tablo 1). Bu analizlerin sonuçları yukarıda sözü
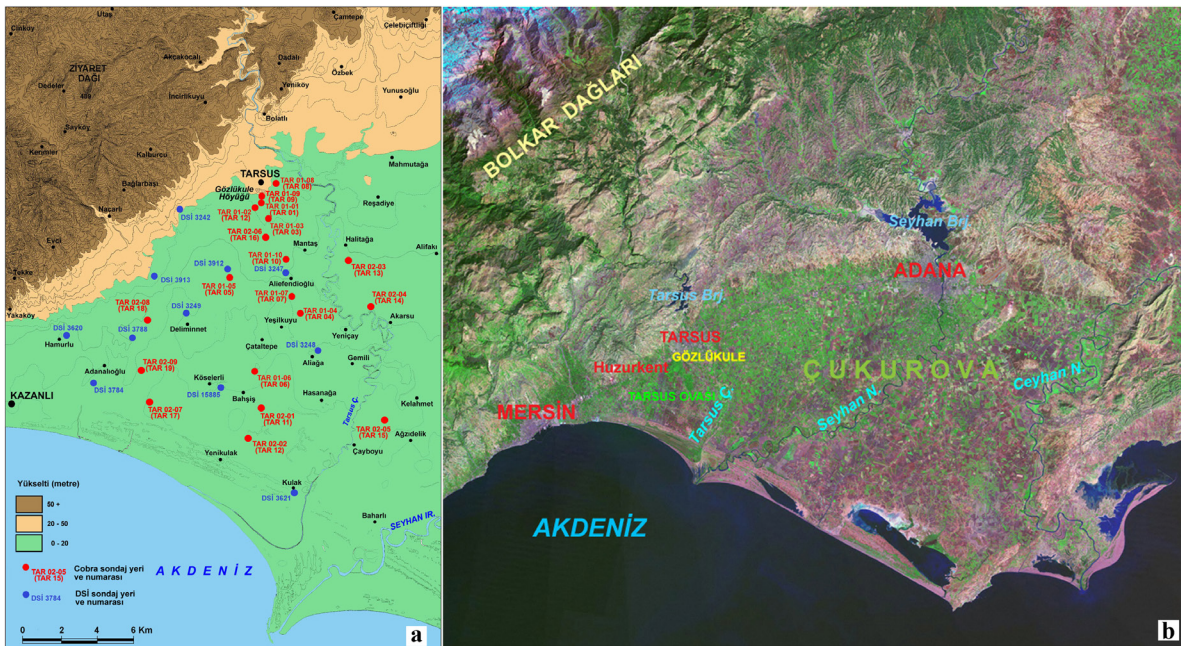
Şekil 2: Tarsus Ovası ve Gözlükule çevresindeki DSİ ve Cobra sondaj yerleri (a); Çukurova, Tarsus ve Gözlükule çevresinin uydu görüntüsü (b) (Öner vd., 2002a, Öner vd., 2002b, Öner vd., 2003).

Figure 2: DSI and Cobra drilling locations around Tarsus Plain and Gözlükule (a); Satellite image of Cukurova, Tarsus and Gözlükule surroundings (b) (Öner vd., 2002a, 2002b, 2003).

edilen önceki çalışmalarda elde edilmiş bulgular ile birlikte değerlendirilerek bölgenin Holosen Paleocoğrafyası ile Gözlükule ve Tarsus'un jeoarkeolojisine yeni bilimsel katkılar sağlanmıştır.

Örnek No	Örnek Derinliği (m)	14C Yaşı (G.Ö.)	Örnek Türü
Tarsus-04	15,2 - 15,4	8104±34	Kavkı
Tarsus-06	5,5 - 5,7	6345±33	Kavkı
Tarsus-06	12,35 - 12,5	6482±31	Kavkı
Tarsus-11	3,5 - 3,7	4968±30	Kavkı
Tarsus-11	14,9 - 15	5611±33	Kavkı

3. SEDİMANTOLOJİK VE PALEONTOLOJİK ANALİZLER

3.1. Element Analizleri

Element analizleri paleocoğrafya-paleoklimatoloji çalışmalarında paleo-ortam yorumlamaları amacıyla sıklıkla kullanılmaktadır (Shang, Daidu, Yin, Burr, Zhang ve Wang, 2018). Tarsus Ovası'nda delta gelişimini ve bölgede yer alan eski lagün ve bataklık alanlarını belirlemek amacıyla 19 sondaja ait 150 örneğe XRF, CNS ve CN element analizleri yapılmıştır.

Çeşitli çalışmalarda belirtildiği gibi sedimanlar içindeki Ti, Fe ve Si gibi elementler karasal, Ca ise denizel koşulları temsil etmektedir (Shang vd., 2018; Zabel, Schneider, Wagner, Adegbie, de Vries ve Kolonic, 2001; Adegbie, Schneider, Röhl ve Wefer, 2003; Hanebuth ve Lantzsch, 2008). Bu çalışmada element analizi yapılan örneklerde Ca/K oranının, Toplam İnorganik Karbon (TIC) oranının ve Ti, Mn ve Sr içeriklerinin yüksek olduğu seviyeler denizel birikim ortamları olarak yorumlanmıştır. Bununla birlikte Cl ve Na'un yüksek konsantrasyonlarda bulunması tamamen denizel değil fakat deniz suyu etkileri ile (lagün) açıklanmaktadır (Vött, Brückner, Handl ve Schriever, 2006; Tjallingii, Röhl, Kölling ve Bickert, 2007; Pechlivanidou vd., 2014). Buna göre örneklerde Ca, Cl ve S oranlarının yüksek olduğu seviyeler lagüner olarak değerlendirilmiştir.

Lagüner ortamlar zaman içinde karadan taşınan sedimanların etkisiyle ortam koşulları bakımından değişime uğrayarak kıyı bataklıklarına dönüşmektedir. Kıyı bataklığı ortamlarında Fe, Mn, Al ve TOC konsantrasyonu fazladır; Ca ise azdır ve bu, deniz suyu girişinin azaldığı anoksik koşulların oluştuğu

anlamına gelmektedir (Stock vd., 2016; Laermanns vd., 2017; Laermanns vd., 2021; Elschner vd., 2021). Yüksek oranda Fe, Mn, Al ve TOC içeren seviyeler kıyı bataklıkları olarak değerlendirilmiştir. Lagüner ortamlarda Ca/K, Cl, S, TOC oranlarının azaldığı, Si ve TIC oranlarının arttığı seviyeler kumul oluşumu ile ilişkilendirilmektedir (Piva vd., 2008; Koster, Vött, Mathes-Schmidt ve Reicherter 2015; Pint vd., 2015; Seeliger vd., 2013; Shang vd., 2018; Laermanns vd., 2017, 2021; Elschner vd., 2021). Buna göre element analizleri sonuçlarına göre Ca/K, Cl, S, TOC oranlarının azaldığı, Si ve TIC oranlarının arttığı seviyeler lagün oluşumunu sağlayan, kıyı kumulları olarak belirlenmiştir.

Flüvyal ortamlarda taşkın ovası sedimanları yüksek K oranı ve yüksek Si/Ti oranını ile karakterize edilmektedir. Ayrıca bu çevrelerde Zr/Rb oranının yüksek olması kaba taneli sediman taşınımını (akarsu yatağını) yansıtmaktadır (Turner, Jones, Brewer, Macklin ve Rassner, 2015). Bununla birlikte arkeolojik materyalin olduğu kültür katmanı seviyelerinde ise sediman içindeki TOC, Sr ve Fe konsanstrasyonu artmaktadır. Holosen öncesi kırmızı paleosollerde ise toprak içindeki Fe, Mn, Al, Si ve Ti oranlarının yüksek, TOC, TIC ve Ca oranlarının da düşük olduğu görülmektedir (Stock vd., 2016; Laermanns vd., 2021; Shang vd., 2018; Altmeyer, Seeliger, Ginau, Schiestl ve Wunderlich, 2020; Riddick vd., 2022; Laermanns vd., 2017; Elschner vd., 2021; Turner vd., 2015; Pint vd., 2015).

3.2. Sedimantolojik Analizler

Delta, taşkın ve kıyı ovalarında, akarsularla taşınan sedimanlar, farklı ortamları temsil edecek şekilde birbirleri üzerinde istiflenmektedir. Bu nedenle aynı kesit üzerindeki farklı derinliklerde denizel, bataklık ve karasal ortamı yansıtan birimlerin varlığı mümkündür. Sedimandaki fasiyes değişimini belirlemek ve paleo-ortamsal yorum yapılabilmek amacıyla bölgede gerçekleştirilen sondaj çalışmalarından elde edilen sediman örnekleri üzerinde granülometrik analizlerin yapılması gerekmektedir.

Sondajlardan alınan 300 adet örneğin yapılan granülometrik analizlerinde (Şekil 3), taşkın ovası sedimanlarını yansıtan derinliklerde tane boyu kötü ve çok kötü derecelenmiştir. Bununla birlikte ortalama tane boyu 3 mikron ile 10 mikron arasında değiştiği görülmektedir. Ancak akarsu dinamiğindeki taşkınlar nedeniyle bazı seviyelerde ortalama tane boyu 39 mikrona kadar çıkmaktadır (Şekil 3). Eski akarsu yatağı olarak belirlenen derinliklerde ortalama tane boyu dağılımı 800 mikrona kadar çıkmakta ve sediman yapısı çok kötü derecelenme göstermektedir. Bu seviyelerde kaba tanelerin yanı sıra her boy kum, silt ve kil
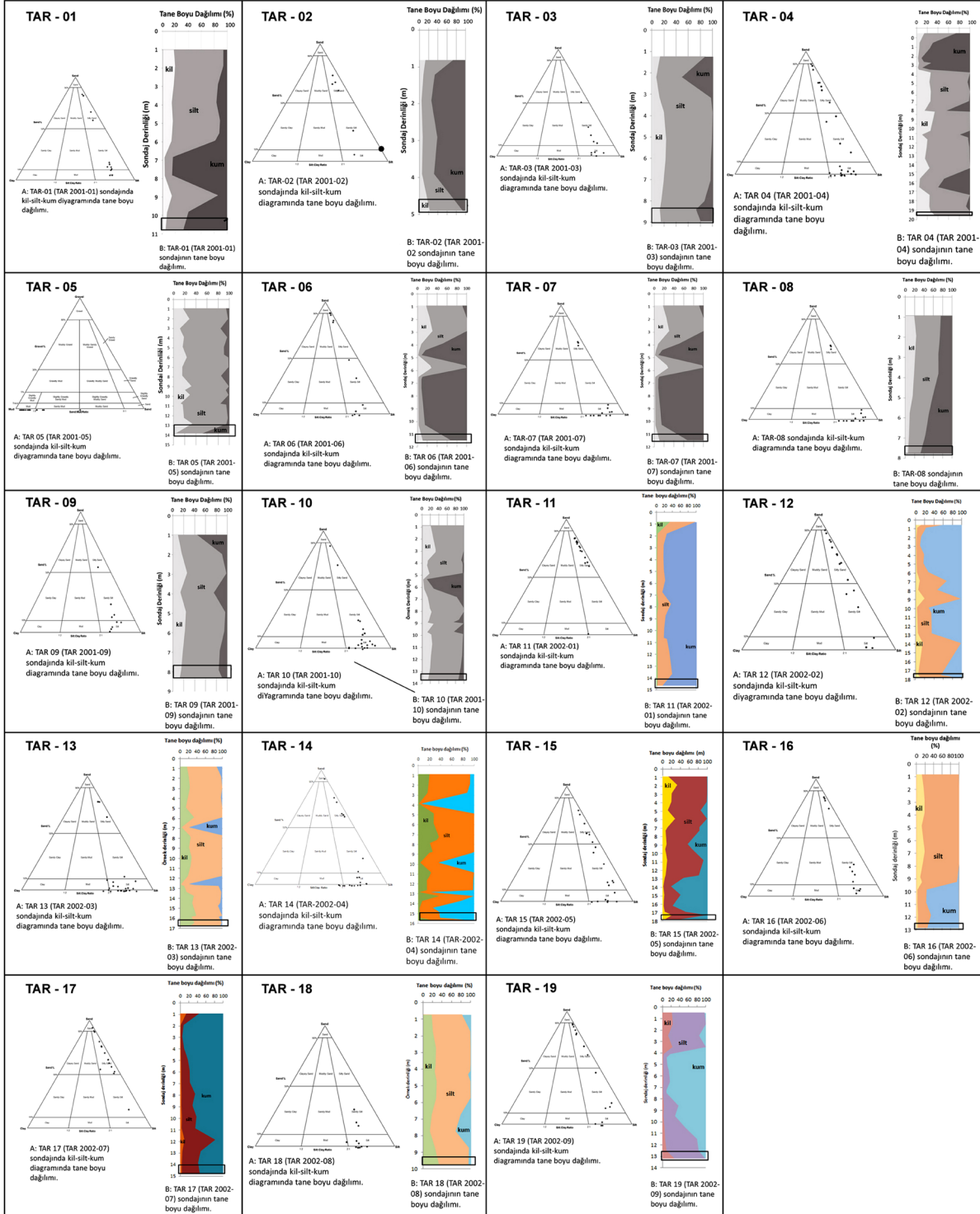
Şekil 3: Tarsus Ovasında yaptığımız delgi sondajlara (Cobra sondajları) ait sedimanların tane boyu analiz sonuçlarına ait grafikler (Kırallı, 2022).
Figure 3: Graphs of the grain size analysis results of the sediments of the core drillings (Cobra drillings) in the Tarsus Plain (Kırallı, 2022).

bulunmaktadır. Bununla birlikte sediman örneklerinin içinde 2 mm'den büyük granül boyutunda taş ve akarsu çakılları da tespit edilmiştir. Turba katmanıyla temsil edilen m'lerde ortalama tane boyu 4 mikronla killi/siltli özelliktedir (Şekil 3).

Denizel ortamı yansıtan seviyelerde sedimanın ortalama tane boyu 50 mikron olup sediman kaba siltli yapıda ve kötü derecelenme göstermektedir (Şekil 3). Lagüner ortamda ise ortalama tane boyu 200 mikronla çok ince kumlu bir yapıya bürünmektedir. Bununla birlikte sedimandaki kötü derecelenme
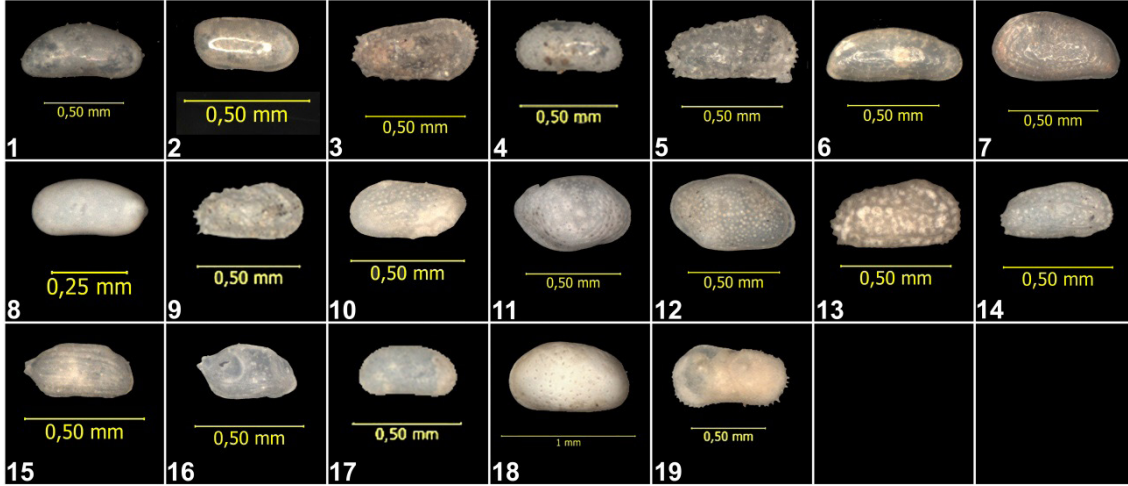
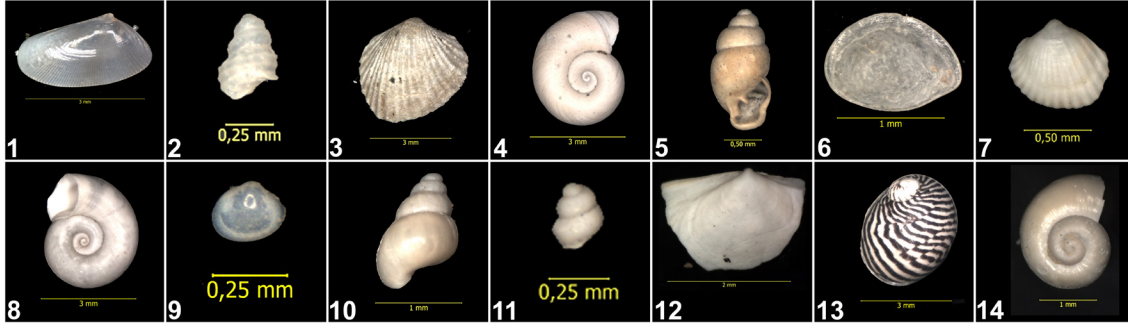**Şekil 4:** Paleontolojik analizler sonucunda bulunan baskın ostrakodlar.
Figure 4: Ostracod species determined as a result of paleontological analysis.
(1.*Argilloecia* sp.; 2.*Basslerites berchoni*; 3.*Carinocythereis carinata*; 4.*Candona parallela pannonica*; 5.*Carinocythereis rhombica*; 6.*Cyprideis torosa;* 7.*Cytheridea neapolitana*; 8.*Cytherois* sp.; 9.*Cytheretta adriatica*; 10.*Hemicyterura* sp.; 11.*Loxoconcha bairdi*; 12.*Loxoconcha elliptica*; 13.*Hiltermannicythere rubra*; 14.*Hiltermannicythere turbida;* 15.*Semicytherura incongruens*; 16.*Semicytherura* sp.; 17.*Pseudocandona* sp.; 18.*Loxoconcha* sp.; 19.*Ilyocypris* sp.) (Kırallı, 2022).
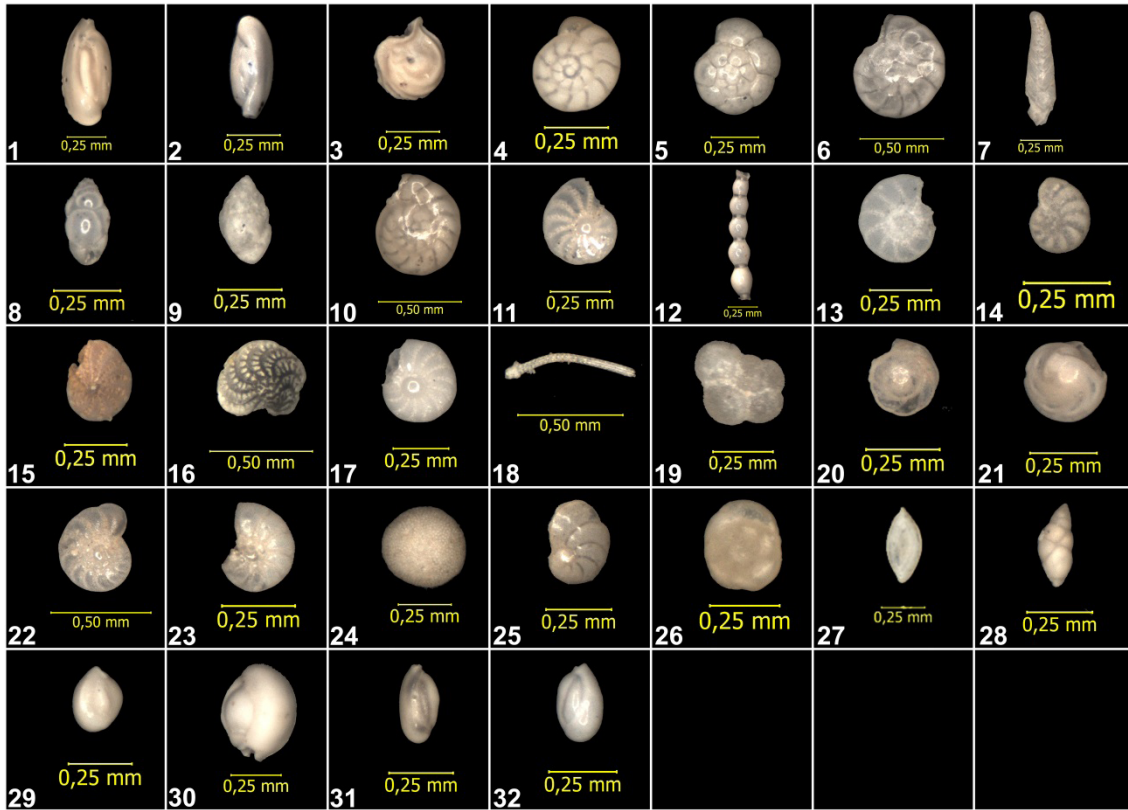
Şekil 5: Paleontolojik analizler sonucunda bulunan baskın foraminiferler.
Figure 5: Foraminiferal species determined as a result of paleontological analysis. (1.*Adelosina cliarensis;* 2.*Adelosina mediterranensis;* 3.*Adelosina* sp.; 4.*Ammonia compacta;* 5.*Ammonia* sp.; 6.*Ammonia tepida;* 7.*Bolivina* sp.; 8.*Brizalina* sp.; 9.*Bulimina* sp.; 10.*Challengerella bradyi;* 11.*Cribroelphidium* sp.; 12.*Dentalina* sp.; 13.*Elphidium advenum;* 14.*Elphidium complanatum;* 15.*Elphidium crispum;* 16.*Elphidium macellum;* 17.*Elphidium* sp.; 18.*Echinoid* sp.; 19. *Globigerina* sp.; 20.*Neoponides bradyi;* 21.*Neoponides* sp. 22.*Nonion depressulum;* 23.*Nonion* sp.; 24.*Orbulina* sp.; 25.*Peneroplis* sp.; 26.*Rosalina bradyi;* 27.*Spiroloculina* sp.; 28.*Textularia* sp.; 29.*Triloculina* sp.; 30.*Triloculina marioni;* 31.*Quinqueloculina* sp.; 32.*Quinqueloculina seminula*) (Kırallı, 2022).

Şekil 6: Paleontolojik analizler sonucunda bulunan baskın mollusklar.
Figure 6: Mollusc species determined as a result of paleontological analysis
(1.*Abra* sp.; 2.*Bittium* sp.; 3.*Cardium* sp.; 4.*Gyraulus* sp.; 5.*Hydrobia* sp.; 6.*Operculum;* 7.*Parvicardium* sp.; 8.*Planorbis* sp.; 9.*Pisidium* sp.; 10.*Rissoa* sp.; 11.*Setia* sp.; 12.*Tellina* sp.; 13.*Tricolia* sp.; 14.*Valvata* sp.) (Kırallı, 2022).
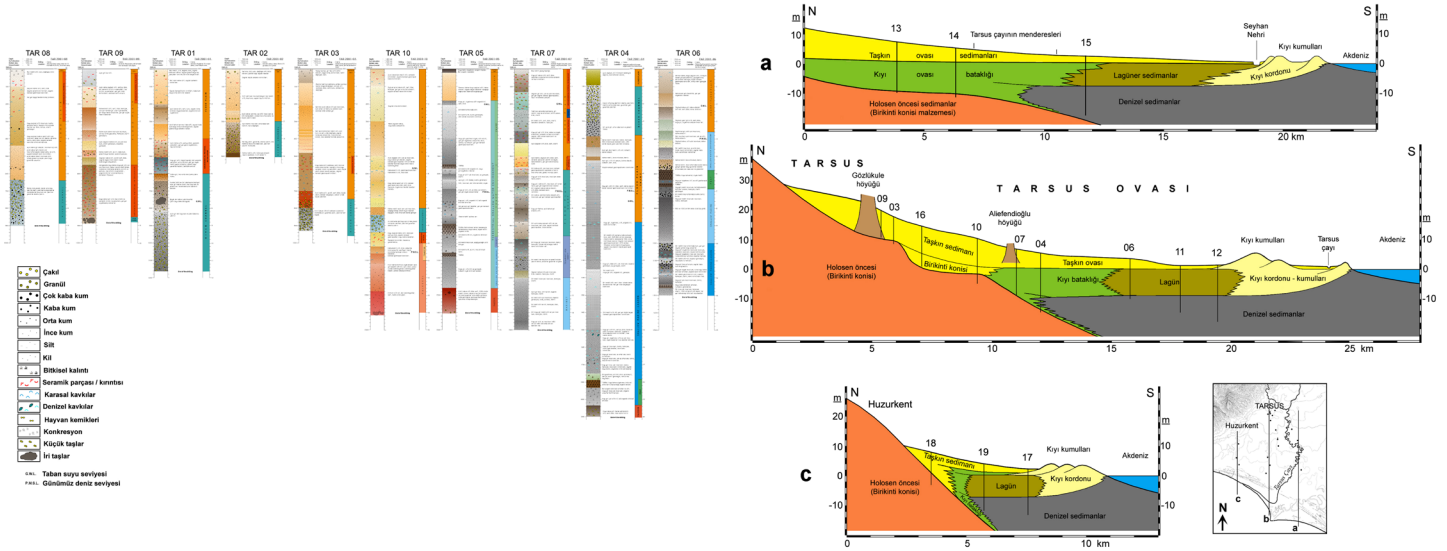
Şekil 7: Tarsus Ovasında yaptığımız sığ sondaj logları (Cobra sondajları) (solda) ve ovanın alüvyal stratigrafisini gösteren kuzey-güney doğrultulu kesitleri (Öner vd., 2005a; Öner vd., 2005b'den alınarak güncellenmiştir).
Figure 7: Shallow core drilling logs (Cobra boreholes) (left) we made in the Tarsus Plain and north-south stratigraphy of the plain showing the alluvial stratigraphy (Updated from Öner vd., 2005a; 2005b).

devam etmektedir. Lagüner ortamı temsil eden siltli-killi laminalar sondaj logunda görülmekte, ancak bunlar analiz sonuçlarına yansımamaktadır. Laminalardaki farklılığın belirlenmesi için daha sık aralıklarla örneklerin incelenmesi gerekmektedir.

3.3. Paleontolojik Analizler

Sondajlardan alınan sediman örnekleri fosil içerikleri bakımından birikme ortamlarını yansıttığı için paleo-ortam çalışmalarına önemli katkılar sağlamaktadır. Özellikle delta alanlarında ve akarsu ağızlarına karşılık gelen bölgelerde denizel ve karasal koşullara ait süreçler ardışık olarak devam etmektedir. Bu nedenle fasiyes değişimlerini belirlemede paleontolojik analizlerin önemi oldukça fazladır (Sür ve Öner, 2014).

Bu çalışmada sondajlardan alınan 150 adet sediman örneği makro ve mikro fosil içeriği açısından ayrıntılı olarak incelenmiştir. İncelenen seviyelerde bulunan Foraminifer, Ostrakod ve Molluskların ortam belirlemedeki rollerinden yararlanılmıştır (Şekil 4, 5 ve 6).

4. DELGİ SONDAJLARIN DEĞERLENDİRİLMESİ

4.1. TAR 01; TAR 02; TAR 03; TAR 08 ve TAR 09 Numaralı Sondajlar

Gözlükule yakın çevresinde yapılan sondajlarda karasal sedimanlar gözlenmiş olup höyüğün oturduğu yüzey ve ilk yerleşme yüzeyleri belirlenmiştir. Höyüğün güneyinde yapılan TAR 01, 02, 03 ve 09 ile doğusunda yapılan TAR 08 numaralı

sondajlarda karasal sedimanlar kat edilmiştir. Bütün bu sondajlarda en altta çakıllı akarsu yatak sedimanları üzerinde siltli taşkın sedimanları yer almıştır. Çakıllı birim üzerine gelen taşkın sedimanları içinde TAR 09 sondajında olduğu gibi yer yer 3 m kalınlıktaki katman içinde seramik parça ve kırıntıları yer almış olup bunlar kültür katmanı olarak Gözlükule höyüğünün yerleşildiği ve yaşamın devam ettiği seviyelerle korele edilmiştir. Çakıllı yatak sedimanları ise höyüğün akarsu yakınlarında ve aynı zamanda kaliş karakterli bir zeminde kurulduğunun ifadesidir (Şekil 3 ve 7).

4.2. TAR 10; TAR 13; TAR 14; TAR 16 ve TAR 18 Numaralı Sondajlar

Gözlükule höyüğünün biraz uzak çevresindeki ova alanında yapılan bu sondajlarda da yine karasal ortamlar yer almıştır. Bunların bazılarında, TAR 10 ve 18 numaralı sondajlarda olduğu gibi taşkın ovası sedimanları ve çakıllı seviyelerin altında kırmızı killi paleosoller ya da birikinti konisi materyalleri bulunmuştur. Bu birimler yüksek kesimlerin eteklerinde ve kuzeye doğru ova sedimanlarının üzerinde yüzeyde gözlenmektedir. Bunun yanında Tarsus Ovası doğusunda yapılan TAR 13 ve 14 sondajlarında 17 m'lere kadar inilmesine karşılık taşkın ovası ve kıyı bataklığı sedimanları geçilmiştir. Bu kesimde kıyı çizgisi TAR 14 sondaj noktasının güneyinde bulunmuş olmalıdır (Şekil 3 ve 7).

4.3. TAR 04 Nolu Sondaj

TAR 04 nolu sondajdan elde edilen sedimanlara lazer kırınım yöntemi kullanılarak tane boyu analizi, XRF ve CNS/CN analizleri yapılmıştır. Buna ek olarak ortam yorumlamasının yapılabilmesi için paleontolojik analizler gerçekleştirilmiştir. Bunun yanında sondajın 15,2-15,4 m derinliğinden alınan kavkı örneklerine RC14 tarihleme analizi yaptırılmıştır (Tablo 1).

Analiz sonuçlarına göre 20 m ile 19,3 m arası birim, Holosen öncesi birikinti konileri üzerinde yer alan kırmızı paleosollerdir. Bu seviyeye ait herhangi bir fosile rastlanılmamıştır. Sondajın 19,3 m ile 17,9 m aralığında, turba katmanıyla temsil edilen derinliklerde başta TOC değerinde ve daha sonra sediman içindeki Fe, Al, Mn ve Ni oranlarında artış gözlenmiştir. Ortalama tane boyu 4 mikrondur. Paleontolojik analizlerin sonucunda taşınmış olduğunu belirlediğimiz *Bolivina* sp. ve *Globigerina* sp. fosilleri tespit edilmiştir. *Ilyocypris* sp., *Candona parallela pannonica*, *Rissoa* sp., *Elphidium* sp., *Cyprides torosa*, Rissoa sp., *Operculum*, *Ventrosia ventrosa* belirlenen diğer fosillerdir (Şekil 8).

Bu noktada, 17,9 m ile 15 m arasındaki sedimanlar sığ denizel ortamı yansıtmaktadır. Turba katmanından sığ denizel katmana geçiş özelliği yansıtan, acı su ortamında yaşayan *Cyprides torosa* ve denizel ortamda yaşayan *Ventrosia ventrosa* fosilleri dikkati çekmektedir. *Elphidium complanatum*, *Ammonia tepida*, *Ammonia* sp., *Ammonia tepida*, *Ammonia* sp. *Nonion* sp., *Dentalina* sp., *Karreriella* sp., *Neoponides* sp., *Quinqueloculina seminula*, *Elphidium* sp., *Nonion depressulum, Ammonia beccarii*, *Ammonia compacta*, *Textularia* sp., *Lobaluta lobaluta*, *Leptocythere* sp., *Valvata* sp., *Ventrosia ventrosa* fosilleri saptanmıştır. Aynı şekilde bu birimde de römaniye fosiller olarak pelajik kökenli *Bolivina* sp., *Globigerina* sp., *Orbulina* sp. gibi örneklere rastlanmıştır. Sediman içeriğindeki Ca/K oranının yanı sıra TIC oranının da yüksek olması denizel sedimanların hakim olduğunu açıklamaktadır. Zr/Rb oranının yüksek olması ise kumlu materyalin biriktiğini göstermektedir. Sediman 4,5 mikron değeri göstermiştir (Şekil 3). Radyokarbon analiz sonuçlarına göre günümüzden 8100 yıl önce burada 15 m'ye kadar sığ denizel bir ortamın var olduğu anlaşılmıştır (Tablo 1; Şekil 8).

Sondajın 15 m'den 6 m'ye kadar olan derinlik, kıyı bataklığı şeklinde bir sulak alanın varlığını göstermiştir. Ca/K oranı düşük olmasına karşın TOC, Fe, Ni, Ti ve Mn oranlarının yüksek olması buradaki sedimanların bataklık karakterinde olduğunu göstermektedir. Birim içinde *Ammonia tepida*, *Ammonia* sp., *Ammonia beccarii*, *Candona parallela pannonica*, *Candona* sp., *Cypridopsis* sp., *Leptocythere* sp., *Cyprides torosa*, *Leptocythere bituberculata*, *Operculum*, *Valvata* sp., *Rissoa* sp., *Gyraulus* sp., *Chara oogonium*, *Setia* sp., *Ventrosia ventrosa* fosilleri tanımlanmıştır (Şekil 3 ve 8). Denizel-acı ve tatlı su karakterli canlıların yaşamış olduğu bu sulak alanın kıyıya yakın ya da denizel süreçlerden hala etkilenen bir ortam olduğunu göstermiştir. Bu birimde *Globigerina* sp., *Orbulina* sp. gibi taşınmış römaniye fosillere de rastlanmıştır.

Sondajın 6. m'sinden yani yaklaşık günümüz deniz seviyesinden bugünkü yüzeye kadar olan derinlik taşkın ovası sedimanlarını yansıtmaktadır. Ancak 3,8 m'den 1 m'ye kadar olan derinliğin eski akarsu yatağını temsil ettiği anlaşılmaktadır. Bu birim içinde de acı su ve denizel fosillerin yer alması, hala kıyıdaki sulak alanın etkilerinin zaman zaman burayı da etkilemiş olduğunun işaretidir. Yakın zamana kadar Aynaz bataklığının ovadaki varlığı, sulak alanın uzun süre bu noktada da devam ettiğini göstermektedir (Şekil 3 ve 8).
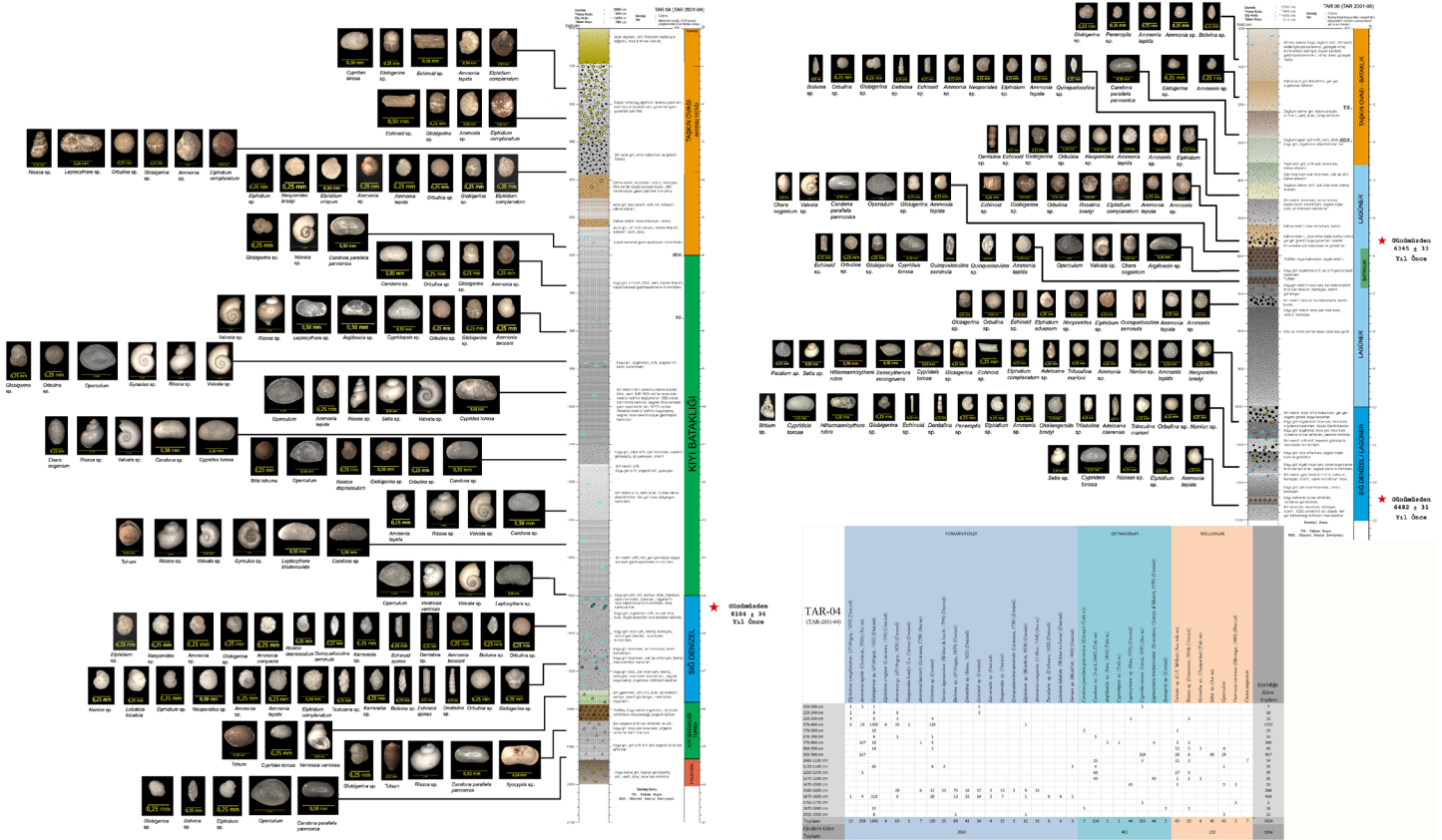
Şekil 8: TAR 04 ve TAR 06 numaralı sondajlara ait sedimanlar, ortam yorumu ve incelenen derinliklerde bulunmuş fosiller (Öner vd., 2002a; Öner vd., 2002b; Öner vd., 2003; Kırallı, 2022).

Figure 8: Sediments, environment interpretation and fossils found at the investigated depths of core drilling TAR 04 and TAR 6 (Öner vd., 2002a; Öner vd., 2002b; Öner vd., 2003; Kırallı, 2022).

4.4. TAR 05 Nolu Sondaj

Sondajın 14 m ile 12,5 m arası Holosen öncesi birikinti konileri üzerinde oluşan kırmızı paleosol katmanıdır. Ortalama tane boyu 40 mikrondur ve 3,5 mikron ile kötü derecelenmiştir. Ayrıca bu derinlikte herhangi bir fosil tespit edilmemiştir. Bunun yanında 12,6 m'den itibaren içinde yer yer turba birimlerin bulunduğu sulu bataklık özelliğinde bir ortamın varlığı gözlenmiştir. Bataklık karakterindeki karasal sığ su ortamı 1,8 m'ye kadar devam etmiştir. Bu birimde *Ammonia tepida*, *Textularia* sp., *Dentalina* sp., *Globigerina* sp., *Echinoid* sp., *Candona parallela pannonica*, *Pseudocandona* sp., *Ilyocypris bradyi*, *Argilloecia* sp., *Candona* sp., *Hydrobia* sp., *Valvata* sp., *Rissoa* sp., *Gyraulus* sp., *Operculum*, *Chara oogonium* fosilleri belirlenmiştir. *Textularia* sp., *Globigerina* sp., *Dentalina* sp. gibi rastladığımız fosiller, daha önce fosilleşen ve ayrışan anakayadan buraya taşınmış römaniye fosillerdir. *Ammonia* sp.de her türlü tuzluluk şartına uyabilir. Bunların dışındaki diğerleri kıyı bataklığı, acı su, tatlı su ortamını temsil etmektedir. Daha sonraki

1,8 m ile yüzeye kadar olan derinlik taşkın ovası sedimanlarını temsil etmektedir. Tarsus Ovasının kuzeyindeki bu sondaj noktasına Holosen Transgresyonu ile yükselen denizin sokulamadığı anlaşılmış olup, kıyı çizgisi bu noktanın güneyinde kalmıştır.

4.5. TAR 06 Nolu Sondaj

TAR 06 sondajından alınan sediman örneklerinin yapılan analiz sonuçlarına göre 13 m'den 10 m'ye kadar sediman sığ denizel/lagüner ortamı yansıtmaktadır (Şekil 3 ve 8). Yüzeyden 5,5-5,7 m ile 12,35-12,5 m seviyelerinden yapılan RC14 analiz sonuçlarına göre günümüzden yaklaşık 6480 yıl öncesinde denizin bu noktaya ilerlemiş olduğu anlaşılmıştır (Tablo 1). TIC ve Ca oranında bir artış görülmektedir. Ayrıca bu seviyelerde *Ammonia* sp., *Ammonia tepida*, *Adelosina cliarensis*, *Globigerina* sp., *Echinoid* sp., *Dentalina* sp., *Adelosina* sp., *Challengerella bradyi*, *Elphidium* sp., *Elphidium advenum*, *Elphidium complanatum*, *Nonion* sp., *Neoponides* sp., *Neoponides bradyi*, *Orbulina* sp., *Peneroplis* sp., *Triloculina* sp., *Triloculina marioni*,

Ouinqueloculina seminula, *Setia* sp., *Hiltermannicythere rubra*, *Cyprideis torosa*, *Semicytherura incongruens*, *Bittium* sp. *Pisidium* sp. fosilleri tespit edilmiştir (Şekil 8).

Sondajın 10 m'den 3,6 m'ye kadarki sediman özellikleri lagüner ortamı yansıtır. Bu seviyelerde denizel ortamda yaşayan fosillerle beraber acı su ortamında yaşayan fosillerin bir arada bulunduğu tespit edilmiştir. Bu seviyede Ca oranı yüksektir olup *Ammonia* sp., *Ammonia tepida*, *Ouinqueloculina seminula*, *Elphidium* sp., *Neoponides* sp., *Elphidium advenum*, *Cyprideis torosa*, *Ouinqueloculina* sp., *Echinoid* sp., *Globigerina* sp., *Orbulina* sp., *Argilloecia* sp., *Chara oogonium*, *Operculum*, *Valvata* sp. fosilleri belirlenmiştir (Şekil 8). Bunula birlikte 6,75 m ile 5,75 m arasında bulunan turba karakterli bol organik içerikli sedimanın varlığı bataklık ortamı yansıtır ve olası bir deniz seviyesi alçalmasını ve karalaşmayı ifade eder. Bu birimde *Argilloecia* sp., *Chara oogonium*, *Valvata* sp., *Globigerina* sp., *Ammonia tepida*, *Candona parallela pannonica* fosilleri bir arada bulunmaktadır. Bununla birlikte bu seviyelerde sediman içindeki TOC, S, Fe ve Mn konsantrasyonunun fazla olması anoksik koşulların oluştuğu anlamına gelmektedir. Sonraki 5,75 ile 3,6 m arasında lagüner ortamın yeniden devam etmesi deniz seviyesinin yeniden yükseldiğini gösterir. RC14 analiz sonuçlarına göre bu dönem günümüzden yaklaşık 6340 yıl öncesi tarihi vermiştir. Bu seviyede, K oranı azalmakta ve Ca ve TIC oranları denizel ortamın etkisiyle artış göstermektedir. Denizel/Lagüner süreci *Ouinqueloculina* sp., *Elphidium* sp., *Neoponides* sp., *Ammonia* sp., *Ammonia tepida*, *Elphidium complanatum*, *Rosalina bradyi* fosilleri ifade etmektedir (Şekil 8). Sondajın 3,6 m'den yüzeye kadar taşkın ovası sedimanları bulunmaktadır. *Ammonia* sp., *Ammonia tepida*, *Peneroplis* sp., *Bolivina* sp., *Candona parallela pannonica*, *Globigerina* sp. fosilleri bulunmuş olup yakın zamana kadar mevcut Aynaz bataklığına ait sulak alanı yansıtmaktadırlar (Şekil 9).

4.6. TAR 11 Nolu Sondaj

TAR 11 sondajından elde edilen sediman örneklerinin analiz sonuçlarına göre 15 m'den 11,25 m'ye kadar olan derinlik sığ denizel ortamı temsil etmektedir (Şekil 3). RC14 analiz sonuçlarına göre günümüzden yaklaşık 5600 yıl önce bu nokta denizel bir ortamdır (Şekil 7, 12; Tablo 1). Sediman içindeki TIC, Zr, Ti, Mn ve Sr içerikleri yüksektir. Sedimanın ortalama tane boyu 50 mikronla kaba siltli bir yapıdadır (Şekil 9). Bu seviyelerdeki sedimanlar içinde *Adelosina mediterranensis*, *Ammonia* sp., *Ammonia tepida*, *Bulimina* sp., *Challengerella bradyi*, *Dentalina* sp., *Elphidium advenum*, *Elphidium macellum*, *Elphidium* sp., *Globigerina* sp., *Neoponides bradyi*, *Neoponides* sp., *Nonion depressulum*, *Nonion* sp., *Orbulina* sp., *Quinqueloculina seminula*,

Quinqueloculina sp., *Textularia* sp., *Triloculina marioni*, *Uvigerina* sp., *Basslerites berchoni*, *Cyprideis torosa*, *Loxoconcha* sp., *Semicytherura incongruens*, *Semicytherura* sp., *Bittium* sp., *Echinoid* sp. fosil türleri tespit edilmiştir (Şekil 9).

TAR 11 nolu sondajın 11,25 m'sinden 3,6 m'ye kadar lagüner ortam mevcuttur. Sedimanlardaki Cl ve Ca oranları ise lagün ortamının oluştuğunu desteklemektedir. Sondajın 7,6 ile 8 m'leri arasında bataklık oluşmuştur ki bu seviyede S, Fe ve TOC oranları en yüksek seviyeye ulaşmaktadır.

4.7. TAR 12 Nolu Sondaj

TAR 12 nolu sondajın analizleri sonucunda 18 m'den 11,45 m'ye kadar olan derinlik sığ denizel ortamdır (Şekil 3). Denizel etki nedeniyle TIC oranı yüksektir. Bu seviyelerde *Adelosina mediterranensis*, *Ammonia* sp., *Ammonia tepida*, *Bulimina* sp., *Echinoid* sp., *Nonion* sp., *Triloculina marioni*, *Quinqueloculina seminula*, *Carinocythereis carinata*, *Semicytherura incongruens* ve *Setia* sp. fosilleri tespit edilmiştir.

Denizel fosillerle birlikte acı su ortamında yaşayan fosiller bir arada bulunmaktadır. *Adelosina cliarensis*, *Adelosina mediterranensis*, *Ammonia compacta*, *Ammonia* sp., *Ammonia tepida*, *Bolivina* sp., *Brizalina* sp., *Bulimina* sp., *Challengerella bradyi*, *Cribroelphidium* sp., *Dentalina* sp., *Elphidium advenum*, *Elphidium complanatum*, *Elphidium crispum*, *Elphidium macellum*, *Elphidium* sp., *Fissurina* sp., *Globigerina* sp., *Karrerialla* sp., *Neoponides bradyi*, *Neoponides* sp., *Nonion depressulum*, *Nonion* sp., *Orbulina* sp., *Peneroplis* sp., *Quinqueloculina seminula*, *Quinqueloculina* sp., *Rosalina bradyi*, *Textularia* sp., *Triloculina marioni*, *Triloculina* sp., *Uvigerina* sp., *Basslerites berchoni*, *Carinocythereis carinata*, *Carinocythereis rhombica*, *Cyprideis torosa*, *Hemicytherura* sp., *Hiltermannicythere rubra*, *Hiltermannicythere turbida*, *Loxoconcha bairdi*, *Semicytherura incongruens*, *Semicytherura* sp., *Bittium reticulatum*, *Bittium* sp., *Chrysallida* sp., *Gyraulus* sp., *Planorbis* sp., Rissoa sp., *Tricolia* sp., *Valvata* sp., *Abra* sp., *Cardium* sp. bu seviyede saptanan fosillerdir (Şekil 9).

Sondajın 11,45 m'den 3,45 m'ye kadar olan derinlikte lagüner ortama ait sedimanlar mevcuttur. Lagünün varlığını gösteren önemli unsurlardan biri sediman içeriğindeki Cl oranıdır. Buna ek olarak S, Fe ve TOC konsantrasyonları bölgede anoksik koşulların yaşandığını göstermektedir. Bu seviyelerde saptanan fosiller bölgede lagün varlığını kanıtlamaktadır. Hem acı suda hem de denizel ortamda yaşayan fosiller belirlenmiştir ki bu da bölgenin stabil kalmadığını göstermektedir. *Adelosina*
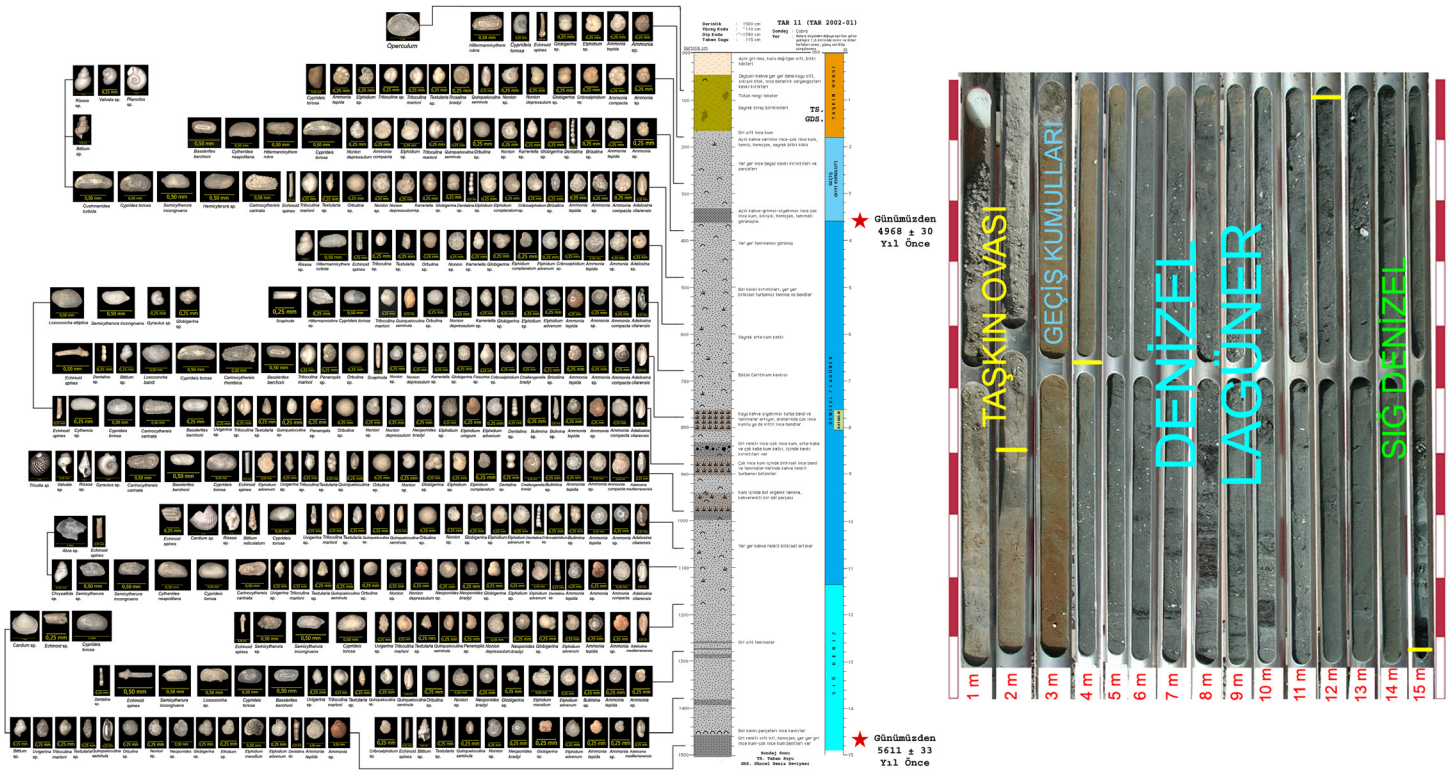
Şekil 9: TAR 11 numaralı sondaja ait sedimanlar, ortam yorumu ve incelenen derinliklerde bulunmuş fosiller (Öner vd., 2002a; Öner vd., 2002b; Öner vd., 2003; Kırallı, 2022).

Figure 9: Sediments of drilling TAR 11, interpretation of the environment and fossils found at the investigated depths (Öner vd., 2002a, Öner vd., *2002b; Öner vd., 2003; Kırallı, 2022).*

cliarensis, *Ammonia* sp., *Ammonia tepida*, *Dentalina* sp., *Echinoid* sp., *Nonion* sp., *Nonion depressulum*, *Triloculina marioni*, *Quinqueloculina seminula*, *Basslerites berchoni*, *Cyprideis torosa*, *Hiltermannicythere turbida*, *Dosinia lupinus* fosilleri belirlenmiştir.

Sondajda 3,45 m'den 1,4 m'ye kadar olan derinlikte eski kıyı kumulları yer alır. Cl, S, TOC oranları azalmakta, Si ve TIC oranları artmaktadır. Ortalama tane boyu 220 mikronla ince kumludur (Şekil 3). Bu seviyelerde tespit edilen fosiller şunlardır: *Ammonia* sp., *Ammonia tepida*, *Cyprideis torosa*. Yüzeyden 1,4 m'ye kadar olan derinlikte ise taşkın ovası sedimanları bulunur. Bu seviyede *Cyprideis torosa* ve taşınarak geldiği düşünülen *Setia* sp. fosilleri belirlenmiştir. Bu sondajının bulunduğu noktada Holosen Transgresyonu ile birlikte denizel ortam haline geldiği, önce açık denizle bağlantılı sığ denizel ortam, daha sonra kıyı oklarının gelişmesine bağlı lagüner ortam olduğu ve kıyı kordonları ve bunların gelişerek lagüner ortamın kapanmasına kadar varlığını koruduğu, son aşamada ise ince bir taşkın sedimanı altında kıyı kumullarının bu noktayı kapladığı anlaşılmıştır. Taşkın sedimanları ise Aynaz bataklığı olarak yakın zamana kadar var olan sulak alanın drenajı ile yüzeyde kalan alüvyonlardır.

4.8. TAR 15 Nolu Sondaj

Sondajın analiz sonuçlarına göre 18 m'den 9 m'ye kadar olan derinlik sığ denizel ortamdır. Ortalama tane boyu 50 mikronla kaba siltli ve 70 mikronla çok ince kumlu bir yapıdadır (Şekil 3). *Ammonia* sp., *Adelosina cliarensis*, *Adelosina mediterranensis*, *Ammonia tepida*, *Challengerella bradyi*, *Dentalina* sp., *Echinoid* sp., *Elphidium* sp., *Elphidium advenum*, *Elphidium complanatum*, *Neoponides bradyi*, *Nonion depressulum*, *Nonion* sp., *Globigerina* sp., *Orbulina* sp., *Triloculina* sp., *Triloculina marioni*, *Ouinqueloculina* sp., *Ouinqueloculina seminula*, *Carinocythereis carinata*, *Leptocythere* sp., *Cyprideis torosa*, *Basslerites berchoni*, *Hiltermannicythere rubra*, *Semicytherura incongruens*, *Loxoconcha* sp., *Bittium* sp. *Bittium reticulatum* ve *Rissoa* sp. paleontolojik analizler sonuncunda tanımlanan fosillerdir (Şekil 10).

TAR 15 nolu sondajın 4 m'lere kadar olan üst bölümü ise lagüner ortam özelliğinde olup 10,6 m, 9,4 m ve 8,8 m'lerinde bataklık sedimanları geçilmiştir. Bu seviyeler arasında; *Ammonia* sp., *Ammonia tepida*, *Adelosina* sp., *Challengerella bradyi*, *Dentalina* sp., *Echinoid* sp., *Elphidium advenum*, *Nonion*

depressulum, *Nonion* sp., *Neoponides bradyi*, *Globigerina* sp., *Orbulina* sp., *Triloculina marioni*, *Ouinqueloculina seminula*, *Quinqueloculina* sp., *Carinocythereis carinata*, *Cyprideis torosa*, *Loxoconcha* sp., *Loxoconcha elliptica*, *Semicytherura incongruens*, *Bittium* sp., *Bittium reticulatum*, *Rissoa* sp., *Vermetid*, *Valvata* sp., *Setia* sp. ve *Cardium* sp. fosilleri saptanmıştır (Şekil 10).

Yüzeye doğru 4 m ile 2 m'ler arasında ortam kıyı bataklığına dönüşmüştür. Bu seviyeler arasında belirlenen fosiller *Nonion depressulum*, *Ammonia tepida*, *Loxoconcha* sp., *Candona* sp. *Ilyocypris* sp., *Ilyocypris gibba*, *Pseudocandona* sp., *Valvata* sp., *Chara oogonium* ve *Operculum* olup acı su ortamını yansıtırlar (Şekil 10). Yüzey ile 2 m arasındaki birim taşkın ovası sedimanlarıdır. Ortalama tane boyu 5 mikronla siltlidir. Bu seviyede *Ilyocypris* sp., *Valvata* sp., *Chara oogonium* ve *Candona parallela pannonica*, *Candona* sp., *Operculum* fosilleri belirlenmiştir. Buna göre Tarsus çayının günümüzdeki yatağının doğusundaki kesimde de denizel ve lagüner ortamların var olduğu anlaşılmaktadır. Yakın zamanlara doğru ise Seyhan Irmağının akışının batıya doğru yönelmesiyle bu ortamların nispeten bu kesimde daha hızlı alüvyal boğulmaya uğrayıp kapandığı düşünülebilir (Şekil 10).

4.9. TAR 17 Nolu Sondaj

Sondajın analiz sonuçlarına göre 15 m ile 9,45 m arası sığ denizel ortamı yansıtmaktadır. Ortalama tane boyu 50 mikronla kaba siltlidir. Bu seviyelerde *Ammonia* sp., *Ammonia tepida*, *Adelosina cliarensis*, *Challengerella bradyi*, *Dentalina* sp., *Elphidium* sp., *Nonion depressulum*, *Elphidium advenum*, *Neoponides* sp., *Textularia* sp., *Bacuniella* sp., *Cytheretta adriatica*, *Carinocythereis carinata*, *Hiltermannicythere rubra*, *Hiltermannicythere turbida*, *Semicytherura* sp., *Semicytherura incongruens*, *Gyraulus* sp., *Setia* sp. fosilleri tespit edilmiştir. Sondajın 9,45 ile 2,75 m'si arası bitkisel organik laminaların bulunduğu lagüner ortamı temsil etmektedir. Bu seviyelerde denizel ortamda yaşayan canlıların yanı sıra acı su ortamında
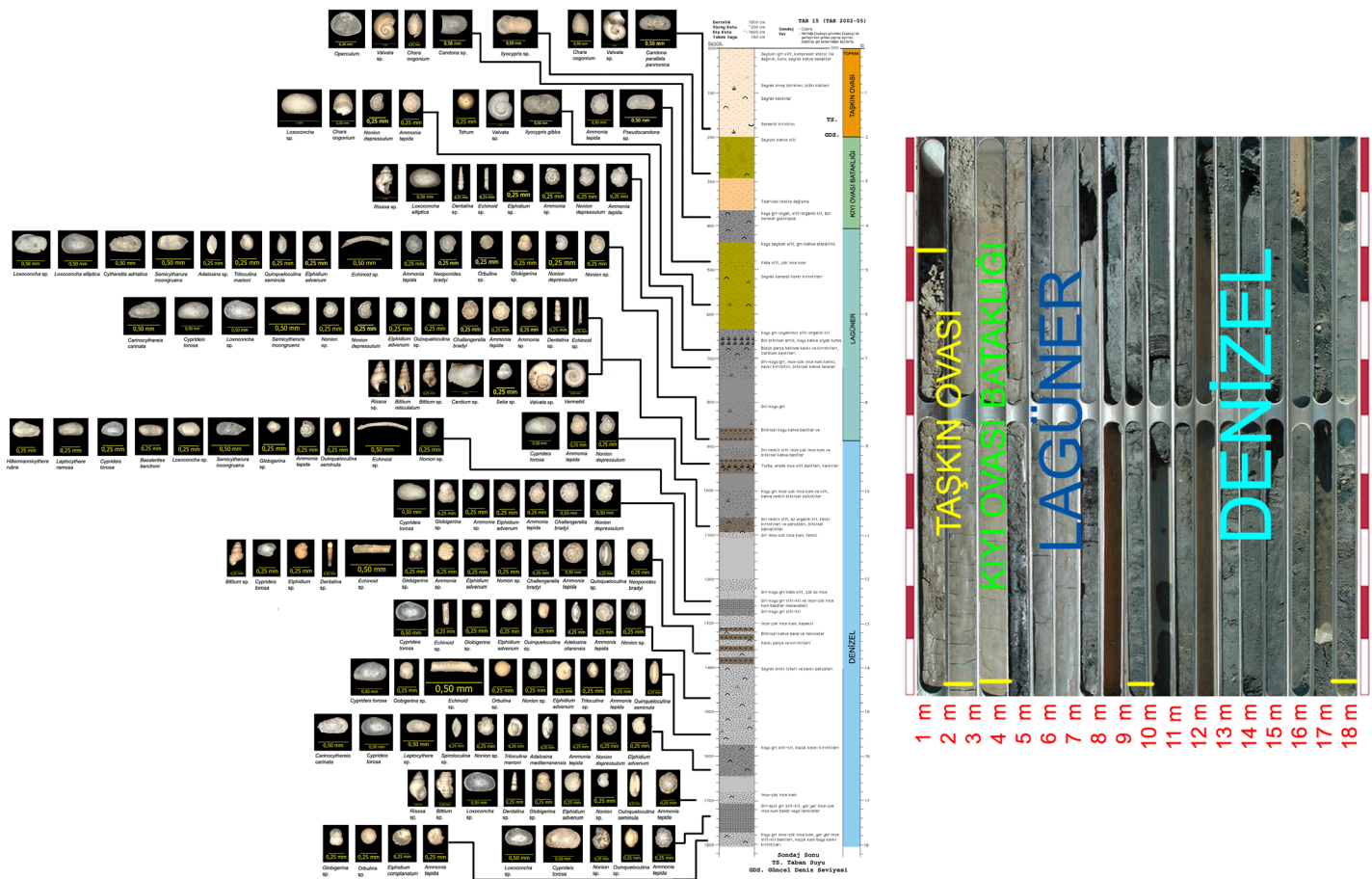
Şekil 10: TAR 15 numaralı sondaja ait sedimanlar, ortam yorumu ve incelenen derinliklerde bulunmuş fosiller (Öner vd., 2002a; Öner vd., 2002b; Öner vd., 2003; Kırallı, 2022).

***Figure 10**: Sediments of drilling TAR 15, interpretations of the environment and fossils found at the investigated depths (Öner vd., 2002a; Öner vd., 2002b; Öner vd., 2003; Kırallı, 2022).*

yaşayan canlıların fosilleri de bulunmaktadır. Bu durum lagün ortamının değişken yapısına uygundur. *Ammonia tepida*, *Adelosina cliarensis*, *Challengerella bradyi*, *Elphidium* sp., *Elphidium advenum*, *Globigerina* sp., *Neoponides* sp., *Nonion depressulum*, *Quinqueloculina* sp., *Quinqueloculina* sp., *Cyprideis torosa* fosilleri saptanmıştır. Sondajın yaklaşık bugünkü deniz seviyesinden yüzeye kadar olan kısım gri-kahverenkli ince-çok ince kumlu kısmı kıyı kumulları ve üst 1 m'lik bölümü ise siltli taşkın ovası sedimanlarıdır. Gerek eoliyen olarak taşınan taneler şeklinde gerekse eski sulak Aynaz bataklığı sulak alanının Tatlısu fosilleri olarak *Valvata* sp., *Ammonia* sp., *Globigerina* sp. ve Orbulina sp. fosilleri tespit edilmiştir.

TAR 17 sondajı da diğer TAR 11 ve TAR 12 sondajları gibi Holosen Transgresyonu ile birlikte denizel ortam haline gelen, daha sonra kıyı oklarının gelişmesine bağlı lagüner ortama dönüşen bir yerdir. Lagüner ortamın kapanmasına kadar varlığını koruyan ve son aşamada kıyı kumullarının bu noktayı kapladığı anlaşılmıştır. Taşkın sedimanları da Aynaz bataklığı sulak alanın drenajı ile yüzeyde kalan alüvyonlardır.

4.10. TAR 19 Nolu Sondaj

TAR 19 sondajında 14 m ile 10,65 m arası sığ denizel ortamla temsil edilmektedir. Bu seviyede *Adelosina* sp., *Adelosina cliarensis*, *Ammonia* sp., *Ammonia tepida*, *Echinoid* sp., *Elphidium* sp., *Elphidium advenum*, *Nonion* sp., *Neoponides bradyi*, *Nonion depressulum*, *Spiroloculina* sp., *Triloculina marioni*, *Textularia* sp., *Ouinqueloculina* sp., *Aurila speyeri*, *Basslerites berchoni*, *Cyprideis torosa*, *Carinocythereis carinata*, *Cytheretta adriatica*, *Cytheretta adriatica*, *Hiltermannicythere rubra*, *Ilyocypris* sp., *Loxoconcha* sp., *Semicytherura* sp., *Semicytherura incongruens*, *Tellina* sp., *Bittium* sp. fosilleri bulunmuştur. Sondajın 10,65 m ile 4,5 m arasındaki sedimanlar lagüner ortamı temsil etmektedir. Bu birim içinde *Adelosina* sp., *Adelosina cliarensis*, *Ammonia* sp., *Ammonia tepida*, *Bolivina* sp., *Bulimina* sp., *Challengerella bradyi*, *Dentalina* sp., *Elphidium* sp., *Elphidium advenum*, *Elphidium complanatum*, *Neoponides bradyi*, *Nonion* sp., *Nonion depressulum*, *Spiroloculina* sp., *Triloculina* sp., *Triloculina marioni*, *Textularia* sp., *Quinqueloculina* sp., *Quinqueloculina seminula*, *Aurila speyeri*, *Basslerites berchoni*, *Cyprideis torosa*, *Carinocythereis carinata*, *Cytheretta adriatica*, *Cushmanidea turbida*, *Cytheretta adriatica*, *Hiltermannicythere rubra*, *Ilyocypris bradyi Ilyocypris* sp., *Loxoconcha elliptica*, *Loxoconcha* sp., *Semicytherura* sp., *Semicytherura incongruens*, *Abra* sp., *Cardium* sp., *Parvicardium* sp., *Rissoa* sp., *Setia* sp., *Tellina* sp., *Vermetid*, *Valvata* sp., *Bittium* sp. fosilleri tespit edilmiştir.

Sondajın 4,5 m ile 2,2 m arası ise kıyı bataklığı ortamını temsil etmektedir. Üst bölümde 2,4 m'den yüzeye kadar olan derinlik ise taşkın ovası sedimanlarıdır (Şekil 3).

TAR 19 nolu sondajının bulunduğu noktada sığ denizel ve lagüner ortamlarını içerdiği gözlenmiştir. Bu kesimde yaptığımız TAR 6, TAR 11, TAR 12, TAR15, TAR 17 ve TAR 19 sondajları, Tarsus ya da diğer adıyla Berdan Ovasının bu bölümünü Holosen Transgresyonu ile ilerleyen denizin kapladığını ve sonrasında tarihsel anlatım ve çeşitli kaynaklarda ifade edilen bir lagüne dönüştüğünü kanıtlamıştır. Bu lagünün alüvyal boğulma, kıyı kordonlarının gelişmesi, buradan da beslenen eoliyen unsurlarla giderek önce bir göl ve sulak alana sonra da direne edilerek bugünkü görünüme kavuştuğu anlaşılmıştır (Şekil 11).

4.11. TAR 07 Nolu Sondaj

TAR 07 sondajda hemen yüzeyden başlayan seramik parçaları 6 m derinliğe kadar devam etmiştir. Buna göre Aliefendioğlu Höyüğünde ilk yerleşim başladığı dönemde çevredeki yüzeyin bugünkü deniz seviyesinden ancak 1 m kadar yüksekte olduğu anlaşılmaktadır. Biraz güneydeki TAR 04 sondajında denizel ortama ulaşıldığı düşünüldüğünde, höyüğün kıyıya çok yakın bir konumda olduğu da anlaşılır (Şekil 7).

5. SONUÇ VE DEĞERLENDİRME

Gözlükule, Tarsus'un ilk kuruluş yeri olup yerleşme tarihi Neolitik'e kadar uzanmaktadır. Yaklaşık son 10.000 yıllık dönemde bölgedeki deniz seviyesi ve deniz seviyesine bağlı kıyı çizgisi değişmeleri, alüvyal boğulma süreçleri ile yöredeki akarsu yataklarındaki kaymalar bu yerleşmelerin doğal çevrelerini önemli ölçüde değiştirmiştir. Kuşkusuz bu yerleşmeler ve oradaki insanların faaliyetleri bu değişmelerden etkilenmiştir. Alanda yaptığımız ve yukarıda analiz sonuçlarıyla birlikte açıklanan delgi sondajlarla doğal çevredeki değişmelerin belirlenmesi mümkün olabilmiştir (Şekil 13).

Gözlükule Höyüğü, kıyıdan yaklaşık 5-6 km daha kuzeyde ve muhtemelen bir seki ya da kaliş birimi üzerinde kurulmuştur (Şekil 7). Höyüğün batısında ise kuzey-güney doğrultuda Tarsus Çayı akmaktaydı (Şekil 13A ve 13B). Höyük çevresinde gerçekleştirilen sondajlarda taşkın ovası sedimanlarının altında rastlanılan çakıllı birimler zaman zaman yer değiştiren, sel karakterli bir akarsuya ait yatak sedimanlarıdır.

Holosen Transgresyonu sonlarında Orta Holosen'de yani günümüzden 7-6 bin yıl öncesinde kıyı çizgisi kuzeye doğru Gözlükule-Tarsus yönünde ulaşabildiği en uç noktalara

gelmiştir. Ancak ne var ki, bu dönemde bile kıyı çizgisi Gözlükule ve Tarsus kentinin yerleşim alanlarının oldukça güneyinde kalmıştır. Yani Tarsus ve Gözlükule yerleşmeleri hiçbir zaman direk kıyıda olan yerleşmeler olmamıştır (Şekil 13A ve 13B). Orta Holosen'den itibaren deniz seviyesi yükselmesinin yavaşlayıp durmasıyla birlikte, akarsuların taşıdıkları alüvyonlarla denizi doldurma süreci hızlanmıştır. Bu ilk aşamada kıyı bölümü nispeten sığ olduğu için alüvyonlarla denizin giderek dolmuş olması gerekir (Şekil 13A ve 13B). Ancak uzun süre Seyhan nehrinin günümüzde olduğu gibi batıya Tarsus çayına doğru akış göstermemesi gerekir. Bununla birlikte gerek Tarsus Çayı gerekse daha büyük akarsular olan Seyhan ve Ceyhan ırmaklarının taşkınları ve kıyıya taşıdığı sedimanların denizel süreçlerle işlenmesi sonucu kıyı oklarının ilk temelleri denizel ortamda oluşmaya başlamış olmalıdır. Çünkü tarihsel kaynaklarda ovanın güneyinde bir lagünün varlığı anlatılmaktadır. Örneğin, Strabon'un ifadelerinde, milât yıllarında Tarsus'un güneyinde bir lagün bulunmaktadır (Pekman, 1991; Pişmanlık ve Köroğlu, 2012). Rhegma adı

verilen bu lagünün kuzey kenarında yine aynı adla bilinen bir liman kenti kurulmuştur (Pekman, 1991; Şekil 13C). Ramsay'ın Aulai olarak belirttiği bu limana gemiler yanaşır yüklerini boşaltırlardı. Yine Ramsay'a göre daha küçük tekneler kent merkezine (Tarsus) ulaşabiliyordu (Zoroğlu, 2000). Buradan anlaşılıyor ki, denizin en fazla karaya ilerlediği günümüzden önce 6000'li yıllardan 4000 yıl sonra bile Tarsus güneyinde büyükçe bir lagün vardı (Öz, 1998; Özükan, 2013; Şekil 11, 12 ve 13C). Eğer günümüzdeki şekliyle Seyhan nehri de bu yöne aksaydı söz konusu lagün ya da daha sonraki gölün milât yıllarına kadar çoktan dolması gerekirdi. Bu denizel ve lagüner ortamların sedimanlarına TAR04; TAR06; TAR11; TAR12; TAR15; TAR17 ve TAR19 numaralı delgi sondajlarımızda rastlamaktayız. Gerek sondajlar (Şekil 2) sırasındaki gözlemlerimizle, gerekse granülometrik (Şekil 3) ve paleontolojik analiz sonuçlarına (Şekil 4, 5, 6 ve 8) göre bu ortamlar ayrıntılı olarak belirlenmiştir (Şekil 7, 8, 9, 10 ve 13).
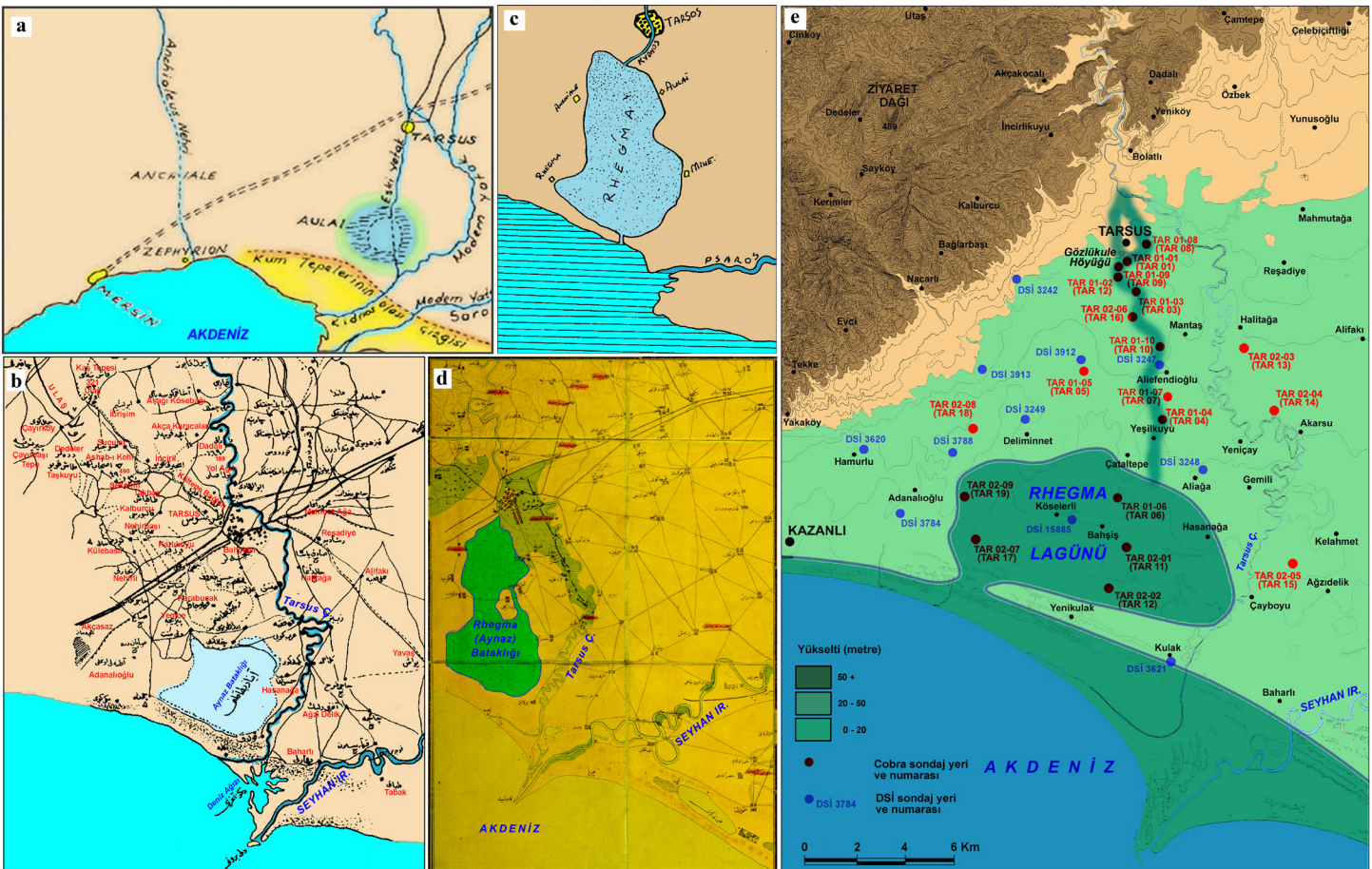
Şekil 11: Tarihi kaynak ve haritalarda Tarsus Ovası ve Rhegma Lagününün gösterilişi [(Zoroğlu'nun (2000) Ramsay haritasından düzenleme (a) ve Öz (1998) haritaları (b, c, d) ile sondaj sonuçlarımıza göre Tarsus Çayının ovadaki eski yatak yerleri ve Rhegma Lagününün rekonstrüksiyonu (e)].
Figure 11: Representation of Tarsus Plain and Rhegma Lagoon in historical sources and maps (Zoroğlu's arrangement from Ramsay's map 2000 (a), Öz, 1998 maps (b, c, d) and the old bed locations of the Tarsus Stream in the plain and the reconstruction of the Rhegma Lagoon (e)).
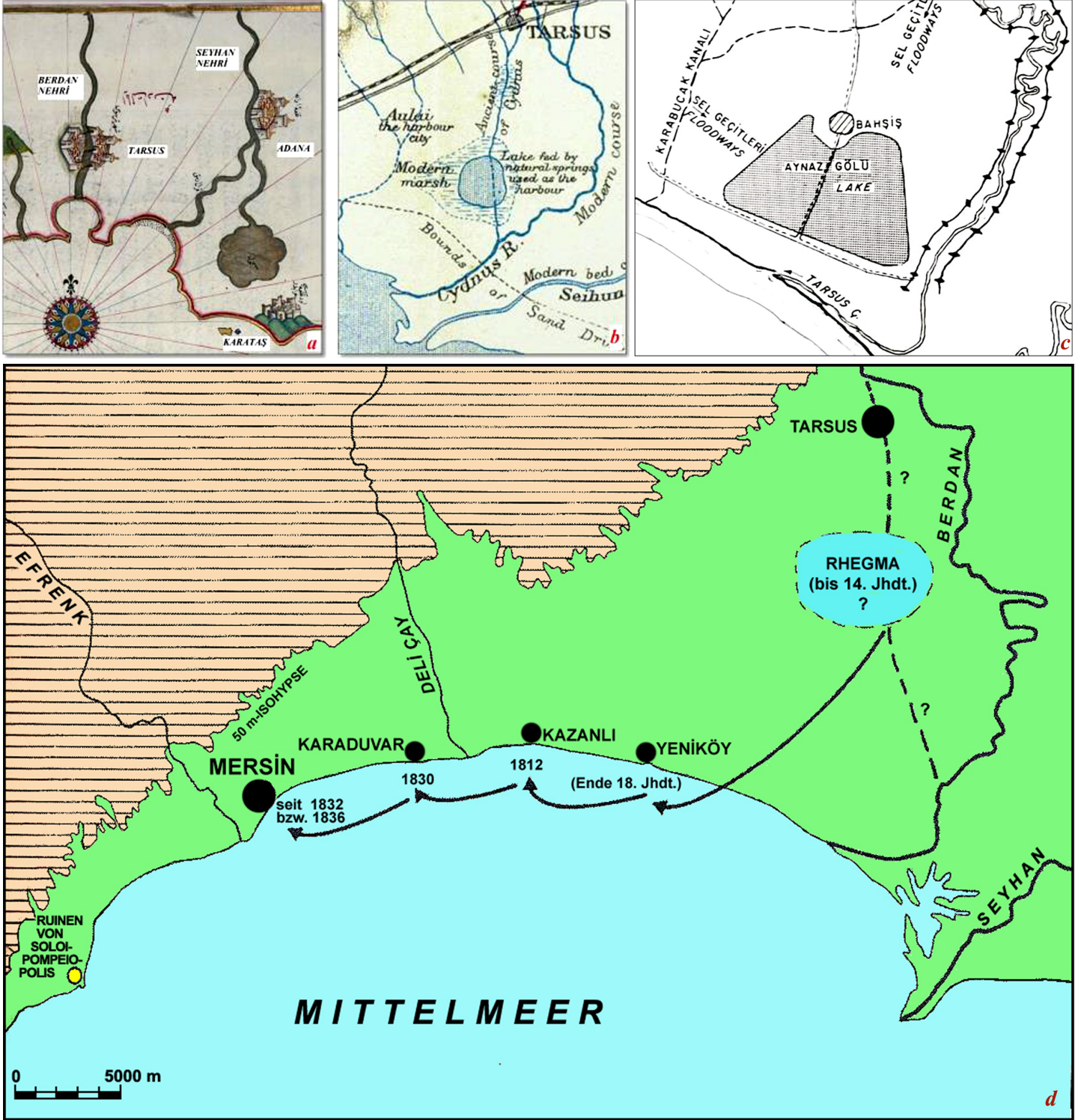
Şekil 12: Rhegma Lagünü ve Tarsus Ovasının Piri Reis (1525 tarihli) (a) ve Ramsay (1903 tarihli) (b) haritalarda gösterilişi. Rhegma Lagününün kalıntısı olan ve DSİ tarafından 1958-1969 yılları arasında kurutulup tarıma açılan aynaz bataklığı/gölünün IECO firması raporundaki haritası (c). Eski Tarsus'un limanı olarak ifade edilen Rhegma'dan bugünkü modern Mersin limanına doğru olan gelişim süreci (Rother, 1997'den düzenleme) (d).
Figure 12: Representation of Rhegma Lagoon and Tarsus Plain on maps by Piri Reis (dated 1525) (a) and Ramsay (dated 1903) (b). Map (c) of the IECO company report of the marsh swamp/lake, which is the remnant of the Rhegma Lagoon and was dried and opened for agriculture by DSI between 1958-1969. The development process from Rhegma, which is expressed as the port of old Tarsus, to today's modern Mersin harbor (edit from L. Rother, 1997) (d).
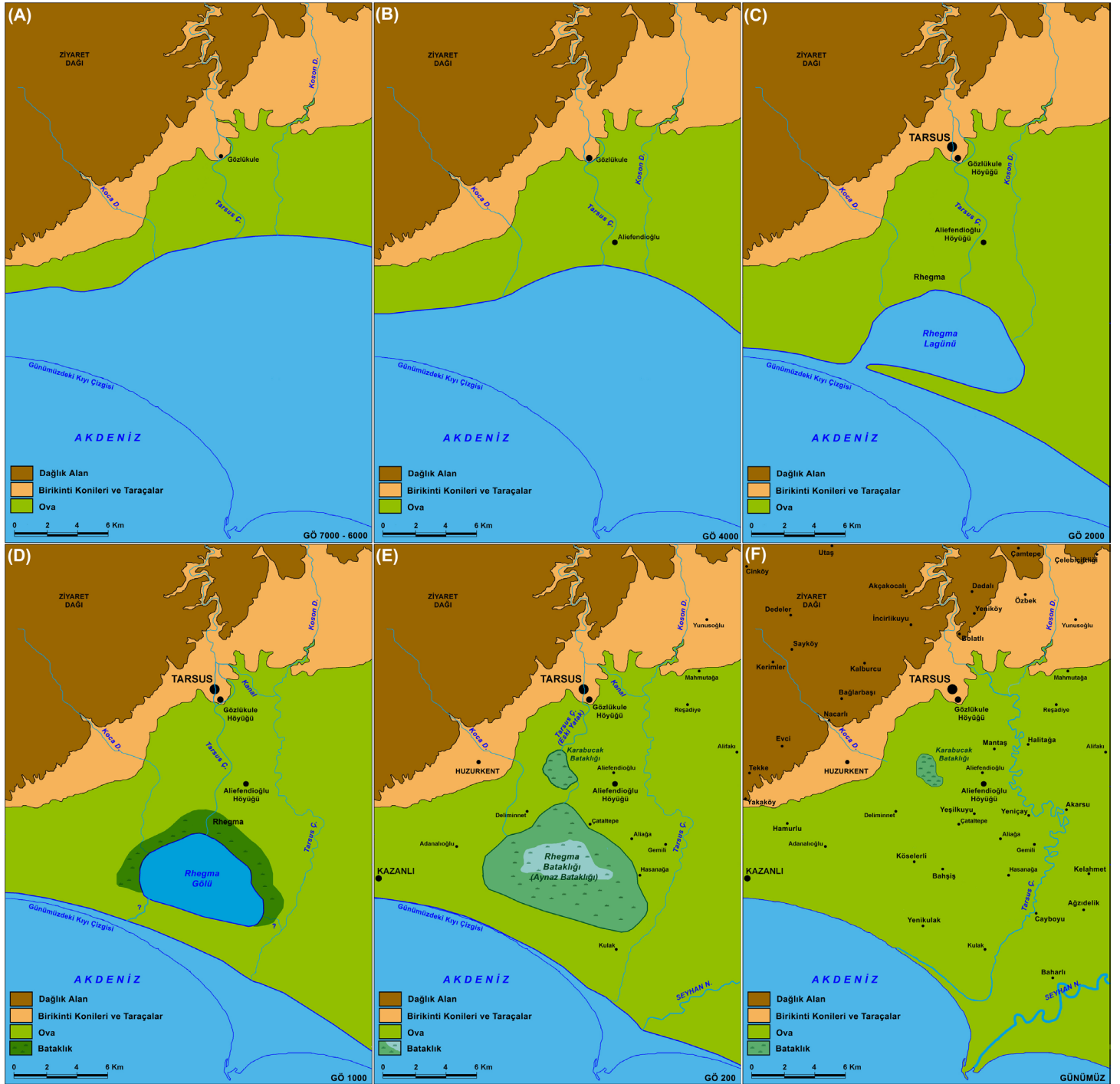
Şekil 13: Tarsus Ovası ve yakın çevresinde günümüzden önce 7000-6000 (A), 4000 (B), 2000 (C), 1000 (D), 200 (E) yılları ile günümüze ait kıyı çizgisi rekonstrüksiyonları (Öner vd., 2003; Rhegma yeri simgesel olarak konmuştur).

Figure 13: Coastline reconstructions of the Tarsus Plain and its immediate surroundings between the years 7000-6000 (A), 4000 (B), 2000 (C), 1000 (D), 200 (E) and today (Öner vd., 2003). (The Rhegma place is symbolically placed).

Höyük çevresinde ve ovada yapılan TAR 01; 02; 03; 04; 06; 08; 09; 10 ve 16 numaralı sondajlarda çeşitli derinliklerinde rastladığımız akarsu yatak sedimanları, bize eski Tarsus çayının izlediği yolu kabaca göstermiş ve şimdiye kadar sadece tasviri anlatımlarda ifade edilen akarsu yatağı belirlenmiştir (Şekil 13). Büyük olasılıkla Orta Holosen'deki kıyı çizgisine bağlı akarsu

ağız bölümü, kıyı çizgisi ilerlemelerine uyumlu olarak geliştiği için, yatağın izlediği yol Rhegma lagünü var olduğu sürece gözlenmekte, yatak değişikliği sonrası ulaştığı son nokta da lagün kıyı çizgisi hakkında fikir vermektedir.

Rhegma Lagünü, kuzeydeki yüksek alanlardan ovaya inen küçük derelerle ve eski Tarsus çayının taşıdığı alüvyonlarla giderek dolmuş ve zamanla denizle olan ilişkisi özellikle Tarsus Çayının yeni yatağından ve Seyhan Irmağının taşıdığı sedimanlarla kıyı kordonlarının genişlemesiyle kesilmiştir (Şekil 13D). Aynı zamanda doğuda akışının sürdüren yeni yatağındaki Tarsus çayının da taşkınları bu alana ulaşmıştır. Hatta bu tarafa yönelen Seyhan Irmağının daha büyük akarsu olması sonucu taşkınları sırasında Rhegma Lagünü'ne de sedimanlar ulaşmıştır. Bunun sonucunda derinliği azalan Rhegma Lagünü kapalı bir tatlısu gölü haline dönüşmüştür (Şekil 13D).

Roma döneminde, Rhegma Lagünü çevresinin bakımlı tutulduğu bilinmektedir (Zoroğlu, 2000). Bununla birlikte doğal çevre değişmelerden dolayı Rhegma Lagünü'nün derinliğin azalması gemilerin girişlerini güçleştirmiştir. Bunun sonucunda limanın giderek işlevini yitirip çevre doğal şartlara teslim olduğunda bataklık alanlar genişlemiş olmalıdır. Nitekim Tarsus Ovasının güneyinde yapılan sondajda, denizel sedimanlar üzerine gelen karasal sedimanlar içinde turba katmanlarının varlığı bunun işaretidir. Lagünün zaman içerisinde sığlaşıp kapanmasıyla, Rhegma limanı da önemini kaybetmiş olmalıdır (Şekil 13D; 13E). Bu durum Tarsus kentinin bölgedeki etkinliğini büyük ölçüde azaltmıştır. Zamanla Tarsus Ovası taşınan alüvyonlarla dolmakla birlikte, Rhegma lagünü ve gölünün bulunduğu yerde 20. yüzyıl ortalarına kadar geniş bir sulak alan varlığını sürdürmüştür (Şekil 13E). Büyük ölçüde bataklık halindeki bu sulak alana Aynaz bataklığı denilmiştir.

Söz konusu bataklık 1950'li yıllardaki çalışmalarla kurutularak tarıma açılmıştır (Şekil 13F). Tarsus güneyindeki lagünün giderek liman işlevini kaybetmesi sonucu, yöredeki bu ihtiyacı karşılayacak şekilde liman etkinlikleri giderek batıya doğru geçiş göstermiş, sırasıyla Yeniköy, Kazanlı, Karaduvar ve günümüzde de yörenin en önemli limanı olan Mersin bu gereksinmeyi karşılayan noktalar olmuştur (Rother, 1997; Şekil 12d).

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The Resilience of Sustainable Climate-Sensitive Cities in the COVID-19 Pandemic

Sürdürülebilir İklim Duyarlı Kentlerin Pandemideki Dirençlilikleri

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ABSTRACT

Cities that are the nodal points of global networks have been hit hardest by The COVID-19 pandemic. Cities are also one of the most significant actors in fighting against the climate crisis, which is similar to the effects of the crisis created by the pandemic and carries even more devastating risks. Therefore, it is crucial for them to implement sustainability policies to increase their resilience against these risks and combat the climate crisis. In implementing sustainability policies, many global networks offer various supports to both global climate-sensitive policies and city governments. In this study, the "urban sustainability and urban resilience" dimensions were discussed on the socio-spatial structure of cities during the pandemic, and inferences were made regarding the resilience and sustainability of the cities according to their sizes during the pandemic process. Cities were selected from five different countries which have different government types and are members of three different global sustainability networks. The study contributes to the the literature by showing whether efficiently applied sustainability policies of a global sustainability membership matter for different-sized cities in increasing their resilience or not. It is found that the sustainability and resilience targets determined by the global urban networks are not applied in the cities participating in these networks, under the risk conditions created by the pandemic. In addition, many member cities do not sufficiently consider the "social dimension" in their sustainability and resilience policies such as health systems. It is surprising to see their insufficiency socio-spatial injustice and vulnerability in disaster periods.

Keywords: COVID-19, Urban sustainability, Urban Resilience

ÖZ

Bir küresel kriz olarak nitelendirilebilen COVID-19 pandemisi, küresel ağların düğüm noktaları olan kentlerde daha çok görülmektedir. Bu sebeple kentler, pandemi ile mücadelede en önemli aktör olarak öne çıkmaktadır. Pandeminin yaratmış olduğu krizin etkilerine benzer nitelikte olan ve hatta daha yıkıcı riskleri taşıyan iklim krizi ile mücadelede de kentler, en önemli role sahip aktörlerden biridir. Dolayısıyla kentlerin, bu riskler karşısında dirençliliğini artırabilmesi ve iklim krizi ile mücadele edebilmesi için sürdürülebilirlik politikalarını uygulamaları önem taşımaktadır. Sürdürülebilirlik politikalarının uygulanması hususunda birçok küresel ağ, hem küresel iklim politikalarına hem de kent yönetimlerine çeşitli destekler sunmaktadırlar. Bu çalışmada, pandemi ile birlikte kentlerin sosyo-mekânsal yapısına yönelik tartışmaları, "kentsel sürdürülebilirlik ve kentsel dirençlilik" boyutları ele alınarak, üç farklı küresel sürdürülebilirlik ağlarının üçüne de üye olan, farklı yönetim biçimlerine sahip 5 ülkeden seçilen, farklı ölçeklerdeki kentlerin pandemi sürecindeki dirençliliğine ve sürdürülebilirliği değerlendirilmiştir. Çalışmada küresel kentsel ağların belirlediği sürdürülebilirlik ve dirençlilik hedeflerinin, pandeminin yarattığı koşullar altında seçilen kentlerde yeterince bağlayıcı olmadığı tespit edilmiştir. Bu bağlamda birçok kentin sürdürülebilirlik ve dirençlilik politikalarında "sosyal boyutu" yeterince dikkate almadığı, birçok kentte sağlık sistemlerinin hala yetersiz olduğu ve sosyo-mekânsal adaletsizliğin afet dönemlerinde kırılganlığı artırdığı bu çalışmanın temel sonuçlarından bazılarıdır.

Anahtar kelimeler: COVID-19, kentsel dirençlilik, kentsel sürdürülebilirlik

INTRODUCTION

When the number of COVID-19 cases increased and mutation viruses became widespread, discussions criticizing the policies that restrict "spatial mobility" came to the fore. In these discussions, it is emphasized that urban resilience is weak, and it is imperative to increase the resilience of cities in the post-pandemic period. The issues that came to the fore when the restrictions were lifted and the gradual/unstaged opening processes started are as follows: the need for green and open spaces, concerns about public transport use, density in common areas, revitalizing economic activity, and increase the sustainability of cities in to struggle for the climate crisis, which is another global problem (Jasiński, 2022).

As we look at the international solution proposals regarding sustainability and resilience, the 11th objective among the Sustainable Development Goals (SDGs) was defined as "Creating Sustainable Cities and Communities" and under this heading, it was emphasized that cities and human settlements should be made inclusive, safe, resilient, and sustainable (Croese et al., 2020). It is possible to examine the objectives determined under these objectives under four headings: *Ensuring everyone's access to basic services, eliminating social inequalities, reducing the effects of climate change, and developing urban policies compatible with nature* (Shen et al., 2011: 19). The indicators determined for these purposes are as follows (UNSTATS, 2020): *urban poverty, disaster-affected, and disaster-related deaths, urban climate data, and risk reduction policies*. With the data obtained from these indicators, evaluations can be made about whether a country or a city is sustainable or not.

To measure the resilience of a city, some features of the city and its capacity to develop, improve, and provide flexibility against risks are evaluated (Zabanioutou, 2020: 18). On resilience, the UN Disaster Risk Reduction III. World Conference, commitments were made to create more resilient cities with the Sendai Framework for Disaster Risk Reduction. In the document, the scope of disaster risk is discussed as environmental, technological, and biological disasters, hazards, and risks that occur because of natural and human activities (Kelman, 2015: 121). From the point of view of the holistic approach of the Sendai Framework Convention, epidemics can be evaluated under the category of biological disasters. To qualify a disease as a disaster, the number of cases, the rate of transmission, and the high rate of death caused by the disease are considered. Therefore, the diseases and deaths caused by the COVID-19 virus make it possible to qualify this virus as a disaster (Özden, 2020: 27).

In this study, the cities with varying sizes that undertake to implement the principles of urban sustainability and create policies for this are examined to measure whether their sustainability and resilience to pandemic conditions are better or not. The cities examined within the scope of the study were selected from the cities that are members of ICLEI, C40 Cities, and GCoM organizations that aim to achieve urban sustainability goals and establish a dynamic network between cities. The main reason for choosing these three global organizations is that they establish ties with cities from different regions and adopt principles such as low emissions, resilience, and fair transition among their targets. While selecting a country that is a member of all three of these global networks we put emphasis firstly on the government type difference and secondly on size difference between cities. By paying attention to the different sizes of the selected cities, the importance of the scale in terms of sustainability-pandemic-resilience will be compared. Lastly, the relationship between sustainability and resilience in the pandemic process of the cities will be revealed by examining their local struggle process that varies according to countries' governmental differences in type.

LITERATURE REVIEW

Urban Sustainability, Urban Resilience and the Pandemic

56% of the world's population lives in cities; this rate is predicted to increase to 68% by 2050 (UN, 2020). It is known that cities are open to extreme weather events, heat waves, and the effects of changing precipitation regimes, both with their populations and built environments, because of the climate crisis (Uncu, 2019: 17). Therefore, it becomes a necessity for cities that are open to all these risks to be sustainable and resilient.

The concept of sustainability provides a normative framework that can provide interaction between human communities and the environment and can apply the concept of resistance to every aspect of this framework. Urban sustainability is a concept that requires social solidarity, provides economic empowerment without destroying nature, and aims to raise awareness of the urban environment (Cohen, 2017; Weichselgartner and Kelman, 2014: 29). The concept of urban resilience, on the other hand, has a meaning that expresses the capacity of a city to manage the uncertainties that may be created by risks such as economic, social, and environmental changes, natural disasters, and epidemics, and to adapt to these processes (Ribeiro ve Gonçalves, 2019).

The COVID-19 pandemic, which can be described as a biological disaster, is seen in urban areas at a rate of 95% (UNDP, 2020). Thus, cities are in serious trouble in the face of the spreading COVID-19 virus is at risk, because of the density of people, buildings, and services, and the interconnected infrastructures (Elmqvist, et al., 2019: 267). In resilience discussions, sudden and non-linear dynamics are generally considered. The COVID-19 virus also emerged as a dynamic that emerged suddenly and shook resilience. The following solutions are at the center of the discussions in the urban area with COVID-19: reconsidering urban density planning, replanning urban open and green spaces, replanning urban transportation, reconsidering urban infrastructure and services by increasing the efficiency, deforestation in the urban area and combating biodiversity loss, ensuring urban climate justice, reorganizing urban water and food security, creating sustainable solutions in urban energy, reorganizing urban public health services, increasing smart urban systems (Manzanedo and Manning, 2020; Tuğaç, 2020; SDG Report, 2020).

In these discussions on the sustainability and resilience of cities with COVID-19, four dimensions come to the fore in general (Shulla, et al., 2021: 11): *resilient communities, ecosystem balance, economic sustainability, and global health*. In the first dimension, sustainable cities will be able to create communities that are more resilient to risks. Because sustainability goals include reducing poverty, ensuring gender equality, and creating a healthier environment (Barbier and Burgess, 2020). A balanced and protected ecosystem, which is considered in the second dimension, expresses the environmental dimension of sustainability. In a balanced ecosystem, it will be easier to control the disease and pathogens can be controlled (Yin et al., 2021: 70). Thirdly, economic sustainability refers not only to a growth-oriented economic policy but also to the importance of a resilient economy that can be "self-sufficient" during the disaster and post-disaster recovery (Leach, et al., 2021). In the fourth dimension, some discussions argue that health should be seen as a global crisis. With the pandemic, the health systems of many countries that have committed to implementing sustainability policies have had difficulty adapting to the process. Along with the pandemic, which is a global problem, it has been seen that health has a global dimension (Hakovirta and Denuwara, 2020:3).

Associated with the health risk posed by the COVID-19 pandemic, the issue of public health was discussed in detail in April 2020 with the supplementary document of the "Cities Disaster Resilience Risk Scorecard" prepared by the United Nations Office for Disaster Risk Reduction (UNDRR, 2020). It has been seen that egalitarian health management with sufficient capacity against all risks is a necessity against both climate risks and epidemics such as COVID-19(Salas, et al., 2020: 3).

METHODOLOGY

Today, approximately 600 cities in Europe and 9,400 cities around the world act together by being a member of global sustainability-themed networks to achieve their sustainability goals (Uncu, 2019: 50). In this study, three different global urban networks are taken into consideration in designing our research as they include principles such as low emissions, resilience, and fair transition, have memberships of cities from all regions of the world, and present inspections and reports at regular intervals. The selected urban networks are: "*Local Governments for Sustainability (ICLEI)", "C40 Cities" and "The Global Covenant of Mayors for Climate and Energy (GCoM)"* organizations. It is important to examine the economic, social, and environmental policies and different management styles of the countries and selected cities, which are seen as important pillars of sustainability and resilience, as they are critical factors in fighting against the pandemic.

In this context, the applications of global urban networks regarding sustainability goals are as follows: *ICLEI (Local Governments for Sustainability)* is a global network of cities made up of more than 1,750 local and regional governments. It is an organization that helps create productive cities with low emissions, an equitable, green economy (advocating equitable, flexible, and circular economy policies), and sustainable transportation within the framework of the principles of "ICLEI Holistic and Integrated Environmental Management" (ICLEI, 2021). *C40 Cities* is a global network established by mayors to implement climate action plans, bringing together 96 cities representing a quarter of the global economy and more than 700 million citizens. The C40 has undertaken the mission of helping its member cities achieve the goals of reducing emissions, investing in clean energy, conserving natural resources, and ensuring a just transition for all (with particular attention to the disadvantaged) to provide the Green New Deal (C40 Cities, 2020). *The Global Covenant of Mayors for Climate and Energy (GCoM)* is a global network of approximately 13,000 city members and their mayors make joint commitments in this network. The main goal of the GcoM is to reduce emissions and promote the building of local climate resilience. In line with these goals, GCoM has undertaken missions such as implementing the principles of the Paris Agreement, supporting local

governments in line with these principles, and encouraging local governments to adopt participatory policies to create fair urban resilience (GCoM, n.d.).

RESEARCH DESIGN

To reach our aim, the pandemic policies and policies of sustainability and resilience of different cities from countries with different management styles, which are also members of ICLEI, C40 Cities, and GCoM networks, were examined. The main purpose here is to examine how the selected differently-sized cities follow policies to achieve their sustainability and resilience goals and evaluate whether they can provide urban resilience through these policies during the pandemic. In this context, the research was designed by choosing two cities of different sizes from countries having different governmental types and administrative structures. The cities of New York and Philadelphia were chosen from the USA, which is a federal country governed by a presidential system; The cities of Curitiba and Rio de Janeiro were chosen from Brazil, which is also a federal country governed by the presidential system; The cities of Berlin and Heidelberg were chosen from Germany, which has a federative structure; The cities of Tokyo and Yokohama were chosen from Japan, whose government is a constitutional monarchy; The cities of Johannesburg and Durban (e-Thekwini) were chosen from South Africa, which is governed by a parliamentary democracy. We tried to include cities from every region of the world in our study (See Table 1). However, we could not include some cities from countries of all different regions in the World due to not covering a membership to three global networks at the same time such as seen in Turkey's case.

The cities selected for the case study were chosen also according to their membership to ICLEI, C40 Cities, and GCoM. In the selection criteria. The size of the city (for big and small size cities we used terms of population and density (infections and deaths)), was claimed to be significant in explaining the city's reactions to resilience. By paying attention to the different scales of the selected cities, the importance of the scale in terms of sustainability-pandemic-resilience will be determined. So, this study contributes to the literature by also revealing how effective different scales and sizes of the cities in regard to sustainability.

FINDINGS

The United States of America

In addition to being the largest economy in the world, the USA is one of the countries producing the most greenhouse gas

emissions, and its attitude towards the climate crisis has an unstable quality that alternates between "taking responsibility or denying it" policies (Uysal-Oğuz, 2020). The most recent example of this situation is seen as Donald Trump's withdrawal from the Paris Agreement in 2017 when he took office and his withdrawal of many environmental protection regulations. Biden, who took office after Trump, returned to the Paris Agreement and acted regarding many environmental policy arrangements (Erensü and Şahin, 2021: 3). However, the deep inequalities created by the intensively implemented neoliberal policies in the country make it difficult to achieve sustainable development goals, which are seen as a concrete implementation tool of climate policies (Çoban, 2016: 32). With the COVID-19 pandemic, while the privatized health system came to the point of collapse because of neoliberal policies, unemployment, and poverty increased in the country with uneven growth, and it became difficult for low-income groups to reach basic needs (Munck, 2021: 17).

The USA's fight against the virus should be divided into two, Trump's presidency and the process after Joe Biden won the election. With the increase in the number of cases and deaths, the primary concern of the Trump administration was about the economy (Yıldızoğlu, 2020). The fact that health services in the USA are based on private hospitals and private health insurance companies has revealed a concrete view of the negativities created by neoliberal policies and the increase in the number of cases and deaths in the USA has been extremely rapid. Although Trump saw the pandemic as an opportunity and wanted to take over the entire executive power beyond his constitutional powers, many states, especially the governor of New York Andrew Cuomo, opposed it and Trump took a step back (Lowndes, 2020: 54). Joe Biden, a member of the Democratic Party who won the US presidential election on November 9, 2020, officially started his duty on January 20, 2021, and first promised "100 million vaccinations in 100 days" and reached this goal on the 58th day of his aim (White House, 2021). However, the increase in the number of cases with different variants and inequalities in access to health services continued during the Biden period. In addition, the problems of unemployment, income inequality, inflation, racism, and gender inequality in the country have deepened with the pandemic (Haffaje, 2021).

New York City

New York City (NYC) is one of the largest metropolitan cities in the world, as well as being a coastal city, it is faced with the devastating risks of climate change. The most important

Table 1. Selected Cities, Their Size, Density and Sustainability Policies

COUNTRY	CITIES	CITY SIZE	POPULATION	COVID-19 CASE DENSITY (DEATHS/ INFECTIONS)[1]	SUSTAINABILITY POLICIES
The United States of America	New York City	1215 km² (BIG SIZE)	8,335,897	35,151 / 1,302,064 ~%2,7 (HIGH)	•PlanNYC Climate Action Plan •Greener, Greater Buildings Plan •Green New Deal Investments
	Philadelphia	370 km² (SMALL SIZE)	1,567,258	267,342 / 4344 ~%1,7 (LOW)	•The Office of Sustainability - Greenworks •Transport Network Improvement Plans •Community Garden and Urban Forest Practices
Brazil	Curitiba	434 km² (SMALL SIZE)	1,963,730	304,384 / 7819 ~%2,6 (HIGH)	•"Best City to Live in" Award, •"Global Green City" Award, •Recognized as a "design city" in the creative cities network (thanks to Jamie Lerner), •Socio-spatial segregation that can be seen with the center-periphery separation in its urban form.
	Rio de Janeiro	1202 km² (BIG SIZE)	6,211,423	1,359,453 / 69,513 %5,1 (HIGH)	•Sustainability training through the Municipal Education Department •Electric vehicle and carbon pricing policies •High-risk area mapping for disasters (highest risk in so-called favelas slums).
Germany	Berlin	891 km² (BIG SIZE)	3,800,000	358,365 / 4038 %1,12 (LOW)	•Regional centers which are called "Regional Centers for Sustainability Strategies - Regionale Netzstellen Nachhaltigkeitsstrategien – RENN", •With the "Berlin Energy and Climate Protection Program 2030", the city will become carbon neutral by 2050, •A call to action called the "One Health Berlin Principles" in October 2019.
	Heidelberg	109 km² (SMALL SIZE)	161,257	10,609 / 81 ~%0,8 (LOW)	•The city that created and implemented the first climate action plan, •"Passivhause" project for urban energy efficiency, •Its practices in areas such as sustainable urban logistics, sustainable education, and clean energy have been awarded internationally.
Japan	Tokyo	42,143 km² (BIG SIZE)	13,960,000	389,728 / 3175 %0,8 (LOW)	•Renewable energy and disaster management policies (especially for earthquakes) are the policies that the city attaches importance, •Its goal by 2050 is to switch to zero carbon and meet its energy needs from renewable energy sources, •In this city, where seismic activity and natural events due to the climate crisis are very intense, "resilience and sustainability" come first.
	Yokohoma	560 km² (SMALL SIZE)	3,771,640	78,141 / 591 ~%0,8 (LOW)	•Since 2003, it has received an "eco-model" city award through urban waste management, •Conducts hydrogen energy investments and decarbonization policies. •It is seen as an incubation center for the smart city project.
South Africa	eThekwini (Durban)	2290 km² (BIG SIZE)	3,720,953	~410,000 / ~3000 %0,7 (LOW)	•The water resources within the city's borders have been mapped, •EWS (The eThekwini Water and Sanitation Unit) water and sanitation service expanded throughout the city, •Urban agriculture practices have been expanded both in the city center and in the city periphery.
	Johannesburg	1645 km² (SMALL SIZE)	6,065,354	1,148,889 / 20,270 ~%1,8 (HIGH)	•Focusing on energy security about climate change through the organization SALGA (South African Local Government Association), •Urban agriculture and agroecological agriculture incentive policies are carried out together with the "Green Economy Strategy".

· Highly dense cities are over %1-%25.infection density-case fatality ratio (WHO-COVID-19, 2020).[2]
· Lowly sized cities lower %0-%1 infection density-case fatality ratio (WHO-COVID-19, 2020).

1   The number of cases and deaths is the total number of February 20th, 2022. These numbers are taken from the total number of cases and deaths officially announced on the web pages of the city administrations.
2   The table shows the number of cases and deaths according to the "case fatality rate calculation" determined by the World Health Organization.
CFR (%)=(Number of deaths from disease×Number of confirmed cases of disease)×100 (WHO-COVID-19, 2020).

policies regarding the environmental aspect of sustainability goals in New York City are aimed at reducing carbon emissions. 73% of New York's carbon emissions come from buildings in the city. For this reason, the law package called "Greener, Greater Buildings Plan" was put into effect in NYC in 2009 and it was aimed to increase energy efficiency in existing buildings. Therefore, NYC increases its "Green New Deal" investments and makes global collaborations in areas such as clean energy, zero waste, zero carbon, and environmental justice (Rosan, 2011: 962). NYC aims to base its recovery strategies in the post-pandemic period on sustainability policies. As a concrete step towards this goal, NYC Mayor Bill de Blasio accepted the C40 Cities' statement of principles for a healthy, equitable, and sustainable recovery (C40 Cities, 2020).

Due to the elevated risk of COVID-19 transmission in enclosed spaces, the use of open and green spaces has increased in NYC (NYC Parks, n.d.). In a study conducted in the city, it was determined that the increase in the use of urban green space was mostly seen in the middle and high-income groups. The main point on which this determination is based is that middle and high-income groups have switched to the home working system during the pandemic process, paving the way for them to spend more time in these areas. It was concluded that low-income groups, on the other hand, could not find free time to go to green areas due to continuing their work and they were afraid of these crowded areas due to the risk of virus (Pipitone and Jovic, 2021). Another inequality situation is observed in access to the COVID-19 vaccine. The problems in the health system of the USA were also reflected in NYC, and it was seen that low-income groups and black citizens living in the city were more affected by the epidemic (Yu, et al., 2021; Truong and Asare, 2020). NYC is one of the cities that started vaccination processes early. However, it has been observed that the first places where these early vaccination processes were initiated are the neighborhoods where middle and upper-income groups live. On the other hand, it has been observed that there were problems such as vaccine supply, multiple-dose scheduling, and vaccine appointments in regions where Black and Latino groups and low-income groups live (Williams, et al., 2021). In the face of the impact of the COVID-19 pandemic, it is possible to say that NYC could not increase social resistance and the policies implemented did not have a holistic effect.

Philadelphia

There is an agent called "The Office of Sustainability" and this agent implements, monitors, and supervises policies such as accessible food, clean water, clean air, renewable energy, carbon neutral practices, social and environmental justice, and zero waste through practices under the name of "Greenworks" (Stanko and Naylor, 2018: 470). Moreover, the city's climate action plan includes practices such as urban forest initiatives to cool the city, activities to improve the transportation network plan, and community gardening (Office of Sustainability, n.d.). However, due to the increasing construction sector in the city, these gardens are also open for construction and there is a serious decrease in urban green areas. This situation carries the risk of urban food insecurity (Saffron, 2020). In addition to these problems brought about by the increase in the construction sector, there is also a serious housing problem for low-income groups. While many people live in shelters that were built for the homeless because of the high rents, a significant number of cases have been seen in these houses during the COVID-19 process (Saffron, 2020). Moreover, low-income groups faced difficulties in accessing food during the COVID-19 process (Brown, et al., 2020: 314).

The most consequential reason for poverty in Philadelphia is based on racial discrimination and the economic inequalities associated with it (Bilal, et al., 2021). Hispanics and African Americans living in the city are more exposed to these inequalities, and their vulnerability increases in the face of all crises (Adams, 2014). A study on the epidemic showed that Black and Hispanic people had 3 times higher rates of hospitalization and death due to COVID-19 than white people (Bilal, et al., 2021). Racial discrimination from the past to the present is seen as the main cause of inequalities in both the spatial structure of the city and the economic structure.

Brazil

Brazil is one of the countries that have serious shortcomings in ensuring social and economic justice and is one of the countries that are inadequate in terms of environmental sustainability policies. Although it was announced at the beginning of 2019 that there were not enough resources to respond to the fires in the Amazon region, many environmental laws were abolished in the country and many of the protective laws were abandoned (Abessa, et al., 2019: 510). Indigenous people living in the Amazon region blamed the country's president, Jail Bolsonaro, for not preventing deforestation and encouraging activities such as mining and logging in the Amazon region (Miranda, 2020). Although Brazil is among the top ten economies of the world, it is the country with the highest income inequality and poverty in the Latin American region (Uysal Oğuz and Sezek, 2020: 171).

In the early stages of the epidemic, Bolsonaro's harsh rhetoric against local rulers who supported a full shutdown and his threat to send the army offerered a concrete view of the political inconsistency in the country (de Barros, 2020: 18). In general, in Brazil, income inequality, social injustice, and spatial injustices due to the lack of delivery of public services to some parts of the country cause social fragility to rise (Uysal Oğuz, 2020: 5).

Curitiba

Architect and city planner Jaime Lerner, who was seen as the pioneer of Curitiba's sustainability steps and was mayor in different periods between 1970 and 1992, argued that urban sustainability is a holistic dimension and that reducing the use of private cars is a meaningful step for sustainability. With a design that brought the Metrobus system as it is known today to the world, he tried to show that public transportation in urban transportation creates less fuel consumption and stronger socialization areas (Cirit, 2014: 57).

In the urban form of Curitiba, while middle and high-income groups live in the center of the city, low-income groups live in the urban periphery. Housing policies that enabled low-income groups to be in the vicinity of Curitiba in the 1970s led to spatial inequality today with the COVID-19 pandemic. Most of the cases and deaths in the city consist of low-income groups living in the urban periphery (Perotti and Driessen, 2021). The city is implementing its local policies regarding the pandemic through an application called the "PlanC Project", a platform that supports both local services and more vulnerable communities. This platform, aims to minimize the risk of vulnerable and fragile communities being affected more by the COVID-19 pandemic, to cooperate with local businesses for risk reduction, and to monitor vaccination processes (World Economic Forum, n.d.).

Although Curitiba has been shown as a model proposal to other cities with the "PlanC Project" in its fight against the pandemic, it has not fully solved the problem of socio-spatial inequality. In the south of the city, public transportation services are scarce in this region, and the intensive use of existing public transportation continues despite the pandemic. Therefore, the number of cases in this region is higher when compared to the city as a whole. The fact that health services are in the city center, the population in the periphery has difficulties in reaching the urban center, and the problems experienced in accessing the COVID-19 vaccine deepen socio-spatial inequality (Souza and Bega, 2020).

Rio de Janeiro

After hosting the UNFCCC in 1992, Rio de Janeiro has been trying to carry out its sustainability policies effectively. To reduce carbon emissions, the use of light-duty electric vehicles in urban transportation has been increased and policies such as carbon pricing have been adopted (Silva et al., 2020). After the flood disaster experienced throughout the state in 2010, high-risk area assessments were made with mapping methods to increase urban resilience (Barbosa and Walker, 2020). 22% of the population of Rio de Janeiro live in slums called "favelas" and those areas have the highest value on risk maps. These regions are places with high disaster risk, high social fragility, and inadequate urban services such as housing, health, education, and lighting. With the COVID-19 pandemic, which is described as a biological disaster, serious vulnerabilities are observed in favelas, both in the field of health and socially (Bernardo et al., 2021: 596). Favelas are conducting a local solidarity process to increase their social resilience during the pandemic process (UNIC Rio, n.d.). With the solidarity networks they have established, actions are carried out through non-governmental organizations, universities, and individual initiatives in their areas such as facilitating access to information on the pandemic, ensuring food safety, creating solutions for drinking water problems, conducting free testing and treatment processes, and monitoring vaccination processes (Fernandes, ed., 2020).

The city administration had lifted the full closure measures it had taken to prevent the spread of the virus, with the trend of the number of cases falling. This situation has caused both an increase in the number of cases and the rapid spread of mutation virus species called "Brazil and Delta variants" (Ferraz, 2021). In the studies conducted in the city, it has been concluded that the deaths due to COVID-19 are higher in the densely populated low-income population (Schiray, 2021). Therefore, it is possible to say that the vulnerable communities living in the city are not resilient and therefore their local policies regarding the social dimension of sustainability goals are insufficient (Bernardo, et al., 2021; Fernandes, et al., 2020).

Germany

Germany is the country with the highest greenhouse gas emissions among European countries. Besides that, as one of the countries that assume the most responsibility, it implements projects that include actions aimed at adopting clean energy initiatives, reaching sustainability goals until 2050, and adopting "adaptation and mitigation" strategies (Scholz, et al., 2016).

However, in the elections held in 2021, a coalition government was formed in which a green party is also in the coalition, and it is stated that the "carbon-neutral" target is also included in the coalition agreement (DW, 2021).

In Germany, which has a federal structure, local policies depend on the states that make up the federative structure. For this reason, there is no central health authority in the management of the pandemic process in the country, but a local and national struggle, in which 16 states are responsible for their regions. Germany, which has enacted the National Infection Protection Law, has set three goals in the fight against the epidemic: to protect health and maintain the effectiveness of the health system, to mitigate the economic impact of the pandemic, to manage the epidemic with international cooperation (Jochen, 2020: 2).

Berlin

In Berlin, sustainability policies are carried out together with the German Sustainable Development Strategy, the Federal Government, non-governmental organizations, and all other actors. There are regional centers called "Regional Centers for Sustainability Strategies - Regionale Netzstellen Nachhaltigkeitsstrategien – RENN" to achieve sustainability goals. With the "Berlin Energy and Climate Protection Program 2030" adopted in 2018, it is aimed at the city to become carbon neutral by 2050 and to implement adaptation policies for climate change. The city has various policies and practices on many issues such as urban temperature, buildings, green space, air, water, infrastructure, and energy to adapt to climate change and climate crises (SDGs in Berlin, n.d.). Combining global sustainability principles with global health principles, Berlin prepared a call to action called "One Health Berlin Principles" in October 2019, and a short time after this call, the COVID-19 epidemic started. The "One Health Berlin Principles," consists of 10 items created by experts from different disciplines that are aimed to improve the health of people, animals, and common environments (ecosystem, biodiversity, urban green spaces, etc.) in a holistic manner and line with ethical principles. Berlin declares that it will base the post-pandemic recovery process on these principles (Gruetzmacher, et al., 2021).

The first measure taken by the municipality was to meet the "emergency childcare" and "elderly care" services for the groups that had to work during the pandemic restrictions. In addition, due to the risks posed by public transport, the number of additional bicycle lanes and bicycles belonging to the

municipality has increased. With the decisions made afterward, these bike paths were made permanent (Umwelt Bumdesamt, 2020: 18). Support was given to occupational groups, employees, and business owners affected by the epidemic (The Governing Mayor of Berlin, 2021). For the homeless living in the city, since the beginning of the pandemic, the city administration has been placed in hotels, and the testing, treatment, and vaccination processes have been followed (DW, 2020; Euro Cities, 2021). In addition to being a city that takes pioneering steps in the implementation of sustainability principles on a local and global scale, Berlin also carries out integrative policies that can set an example during the pandemic process.

Heidelberg

Heidelberg was the first city to create and implement a climate action plan for sustainability at both state and country levels (Graczyk, 2015: 211). The city's most significant application in this area, which aims to manage urban energy efficiency in a climate-sensitive manner, is the "Passivhause" project. The most outstanding feature of the "passive houses" is that the building is energy efficient, has a carbon-neutral application, and has a design suitable for the urban heat island effect (C40 Knowledge, 2021). The resistance that the city tries to provide in both its spatial structure and management strategies with a green understanding also comes to the fore during the COVID-19 pandemic process. In a city with a population of approximately 160,000, the number of COVID-19 cases and deaths is low (Coronavirus Die Lage in Heidelberg, 2022).

In Heidelberg, measures and policies regarding COVID-19 are carried out by the Baden-Württemberg state regulation to which the city is affiliated. Information about the epidemic is provided throughout the state through the web page of the local government and the "CORONA WARN-APP" mobile application (Coronavirus Die Lage in Heidelberg, 2022). For the public health crisis caused by the pandemic, the city administration offers various support to scientists from different disciplines so that they can act jointly (Allianz von Heidelberger, 2020). The effective implementation of public health policies in Heidelberg, the determined policies of the city administration towards climate, and the lack of a dense urban population ensure high resistance during the pandemic process.

Japan

Japan is one of the top five countries most responsible for global emissions. It had committed to reducing its emissions by

26% by 2030. Although Japan announced that it will increase this rate in the 2018 Green Climate Fund renewal process, it has been reported that its efforts are insufficient, and it remains below its target carbon emission rate (Climate Action Tracker Japan, 2021). Aiming for a green recovery after the COVID-19 pandemic, Japan is increasing its investments in hydrogen energy to reduce carbon emission rates (GZR, 2020).

Japan is a country where a constitutional monarchy and a parliamentary government system are run together and have a decentralized structure. Therefore, the fight of local governments against the epidemic progresses depending on the central government, but it is quite insufficient in terms of financial aid related to the epidemic (Suppasri, et al., 2021). Due to its elderly and crowded population and its proximity to China, Japan carries out the emergency action plan that it has put into effect since the beginning of the epidemic. The most essential elements in Japan's fight against the virus are early diagnosis, early intervention, improvement of intensive care services, and rapid adaptation of citizens to the measures (Iwasaki ve Grubaugh, 2020). However, as of January 2021, Japan started to have difficulties in controlling the epidemic, delays in the vaccination process that went well, and an increase in the number of cases compared to other Asian countries observed (Fritz, 2020). The period with the highest number of cases in the country is seen in July 2021, when the Summer Olympics are held (Kelly and Slodkowski, 2021).

Tokyo

The renewable energy and disaster management policies of the Tokyo Metropolitan government highlight the city in terms of sustainability. The city of Tokyo, in line with international policies, aims to switch to zero carbon and meet its energy needs from renewable energy sources by 2050 (Kishimoto and Kobari, 2020). The city government is making hydrogen energy investments to reach its carbon-neutral target (Kato and Kurosawa, 2019). The city, which is located on the ocean coast, is also faced with many risks due to its location in the earthquake zone (Akyüz, 2021: 70). In this city, where seismic phenomena and natural events due to the climate crisis are intense, "resilience and sustainability" are the policies that take first place (Gülcen Eren, 2019: 918).

Tokyo, which has a large population, is a city with a high rate of elderly population. Despite this, the most important reason for the low number of cases and death rate in the city is the experience of the Spanish flu epidemic in 1918. Thanks to this experience,

Tokyo was able to immediately implement applications such as fast and free testing, contact tracking systems, and isolation (Updates on COVID-19 in Tokyo, 2022). The highest number of cases seen in the city was experienced after the Summer Olympics in 2021. While the benefits that such organizations will provide to a city under normal conditions are high, it has led to an increase in the number of cases under pandemic conditions and the re-implementation of state of emergency decisions in the city (Kelly and Slodkowski, 2021).

The most considerable reason for the low number of cases in Tokyo is that the city administration is subject to harsh sanctions to create an emergency action plan and the society to comply with it. Although Tokyo is in a high-risk region, it has had difficulty in coping with many problems brought on by the pandemic, even though it implements resilience and sustainability policies. The pandemic process, as seen in the Tokyo example, provides some clues to the difficulties that growth may create in the future.

Yokohama

Rapidly industrializing and rapid urban development, Yokohama started a waste program in 2003 regarding its crucial environmental problem, urban waste. With this program, approximately 43% of urban waste is recycled (Ito and Reid, 2020: 1657). Within the scope of the "eco-model cities" program initiated by the Japanese government, Yokohama is seen as an "eco-model" with the best solid waste management policies in the country (Kerimova, et al., 2020: 21). In addition, the city creates regional incentives to reduce greenhouse gas emissions, carries out hydrogen energy investments and decarbonization policies, and has been expanding environmental education practices at all education levels throughout the city since 2006. The Japanese government sees Yokohama as an incubation center for the "smart city project" by the reason of its environmental policies and aims to implement smart urban systems in the city (Suwa, 2020: 393).

The Olympics held in Tokyo also affected the city of Yokohama, and a serious increase was observed in the number of cases in the city after the Olympic races. Although this increase caused strain on the city's health systems, rapid treatment processes could be provided thanks to the city's local and global networks (The Asahi Shimbun, 2021). The city administration has created a special team called Y-CERT (Yokohama Coronavirus Emergency Response Team) to respond quickly to new cases (Mayor Message, 2021). Yokohama also manages the

vaccine supply and rapid vaccination processes well, thanks to these networks and its health system (Open Yokohama, 2022).

Yokohama is a city that strives to implement sustainability policies to increase its urban resilience due to its geography. With the COVID-19 pandemic, increasing the resistance against epidemics has become one of the city's other goals.

South Africa

The Republic of South Africa, which is described as a regional actor in the African continent, is governed by a parliamentary democracy based on the presidential system. With the signing of the Paris Agreement, South Africa took decisions on renewable energy actions, decarbonized electricity, carbon tax practices, and the national adaptation process. However, South Africa needs international support to achieve these goals (Council of the EU, 2013). The existing socioeconomic inequalities, hunger, access to clean water, and diseases in the region have reached serious dimensions with the COVID-19 pandemic (Maulds, 2020). Along with the pandemic, South Africa is seen as the country that can best manage the restriction measures, vaccination, and treatment processes in the African continent. However, since South Africa is a country that provides food security and supply in the African continent, the disruptions in the supply chain by the epidemic triggered not only the virus risk but also the risk of hunger throughout the continent (Wegerif, 2020: 798).

In the country where immigrants from other countries on the African continent are concentrated, applications such as vaccines and treatments are not carried out for immigrants during the COVID-19 pandemic. This situation not only increases the rate of spread of the virus in the country but also causes an increase in the number of cases and deaths (Mukumbang, et al., 2020).

eThekwini - Durban

Insufficient water resources common in South Africa are one of the main problems of the region. Durban municipality has mapped the water resources within the city limits to solve this problem (Sim et al., 2016: 45). The water and sanitation unit called EWS (The eThekwini Water and Sanitation Unit), established by the municipality, serves water and sanitation policies throughout the country by addressing the dimensions of "economic, service and spatial differentiation" (Sutherland et al., 2014). To solve the problem of poverty and food insecurity prevalent in the African region, the municipality of Durban has expanded urban agriculture practices both in the city center and in the city periphery. However, these practices are insufficient due to the socioeconomic inequalities existing in the city (Khumalo and Sibanda, 2019: 2).

Durban, one of the biggest cities in South Africa, is weaker in sectors such as tourism, production, and logistics when compared to other big cities. Therefore, this weakness in the current economic structure of the city has deepened with the pandemic (Mantzaris ve Ngcamu, 2020: 119). Increasing unemployment rates due to the pandemic affected the service sector and a serious loss of capital was experienced in the city as investors withdrew their money from the markets. To manage this process, eThekwini Municipality established a local economic intelligence program called Durban Edge and provided support to certain levels of sectors during the mandatory shutdown periods (Maharaj and Reddy, 2020: 207).

Another situation experienced in Durban is the evacuation of unregistered city residents from their homes and the city due to COVID-19. The municipality based this application on the reasons such as providing basic services better and increasing public welfare and did not carry out any policy regarding the accommodation of people who became homeless because of evacuations (Kihato and Landaou, 2020). The deficiencies regarding basic needs in the city have deepened with the pandemic and the problems of vulnerable and disadvantaged groups have grown as a result of social exclusion.

Johannesburg

Johannesburg, which is the largest city in South Africa, unlike the national government, pays attention not only to reduction strategies but also to adaptation strategies (Mokwena, 2009: 27). In addition to policies at the national level, energy security has been focused on about climate change through the organization called SALGA (South African Local Government Association), which was established to increase cooperation and solidarity between local governments (SALGA, 2013). The municipality of Johannesburg aims to prevent food insecurity with its "Green Economy Strategy" in 2013 with urban agriculture practices and carries out policies to encourage agroecological agriculture (Kroll, 2021). Despite all these incentives and supports, Johannesburg remains far from the social goals of its sustainability goals due to problems such as gender inequality and unjust income distribution (Vyas-Doorgapersad, 2017: 173). When the COVID-19 pandemic is added to the existing vulnerabilities, both the economic and social fragility of the city increased (Ekumah, et al., 2020).

Table 2: Findings on the selected cities by their size, density, and resilience to the COVID-19 Pandemic

COUNTRY	CITIES	CITY SIZE	COVID-19 CASE DENSITY (INFECTIONS / DEATHS)	RESILIENCE IN THE PANDEMIC PERIOD
The United States of America	New York City	(BIG SIZED)	(HIGH)	•"Safe Haven" centers for the homeless, •Problems in the health system in general, •Low-income groups and blacks are more affected, •Inequalities in access to treatment (including vaccines) (Black and Latino groups and low-income groups are at a disadvantage), •Social and economic resilience is low.
	Philadelphia	(SMALL SIZED)	(LOW)	•Due to the increase in the construction sector and high rents, many people were staying in shelters and higher COVID-19 cases were observed in these houses, •The problem of racism (infections and deaths were mostly observed in Hispanics and African-American citizens), •There was an increase in layoffs, •Urban resilience is very low due to the social, economic, and growing construction sector.
Brazil	Curitiba	(SMALL SIZED	(HIGH)	•An application called "PlanC Project" for the pandemic. •Most cases and deaths are from low-income groups living in urban periphery. •Health services are in the city center, and the population in the periphery has difficulties in transportation to the urban center. •Due to the problem of socio-spatial inequality, social, environmental, and urban resilience is low.
	Rio de Janeiro	(BIG SIZED)	(HIGH)	•Case numbers were observed mostly in "favelas". •Favelas tried to resist the pandemic with their own neighborhood solidarity networks •Due to income inequality and spatial inequalities, its resilience has further decreased during the pandemic period.
Germany	Berlin	(BIG SIZED)	(LOW)	•To handle "emergency childcare" and "elderly care" services during the pandemic period, •Urban services for access to clean and healthy food, •Homeless people have been placed in hotels by the city administration since the pandemic process started, •In addition to the social and health fragilities during the pandemic process, economic fragility has been prevented to a significant extent.
	Heidelberg	(SMALL SIZED)	(LOW)	•Pandemic policies in the Baden-Württemberg state regulation are carried out, •Notifications through the "CORONA WARN-APP" mobile application, •The city administration offers various supports to scientists from different disciplines so that they can act jointly, •The determined policies of the city administration towards the climate and the lack of a dense urban population ensure high resistance during the pandemic process.
Japan	Tokyo	(BIG SIZED)	(LOW)	•Urgent action plan and harsh sanctions for society to comply with this plan, •They could not control the increase in cases during the Summer Olympics, •Due to being a large and crowded city, they had difficulty providing social resilience, •The increase in the number of cases during the international Summer Olympics, which is a critical issue in the growth of a city, paved the way for discussions on the future of growth.
	Yokohama	(SMALL SIZED)	(LOW)	•A special team named Y-CERT (Yokohama Coronavirus Emergency Response Team) has been formed, •Due to the Summer Olympics, the number of cases has increased, and the city's health systems have been challenged, •Urban resilience and sustainability are necessary in this city where seismic activity is intense. For this reason, policies have been prepared to increase resistance against epidemics.

South Africa	eThekwini (Durban)	(BIG SIZED)	(LOW)	•During the pandemic period, unemployment increased, the service sector weakened and investments in the country decreased, •Support was given to sectors at the levels determined by the Durban Edge policy, •The number of cases and deaths is not disclosed and there are doubts about the reliability of the figures announced, •Increase in social exclusion •The vulnerability of the city has increased with the pandemic due to deep income inequality, deprivations in the health system, and social exclusion. It needs outside support.
	Johannesburg	(SMALL SIZED)	(HIGH)	•Gender inequality and income distribution inequality in the city is very high and this situation has deepened with the pandemic, •There have been great difficulties in accessing water and food during the pandemic process. •The social, economic, and environmental resilience of the city is quite low. For this reason, it needs international support.

Johannesburg is a city that receives a lot of immigration because it is one of the economic centers of South Africa. For this reason, the most intense COVID-19 cases in South Africa were seen in this city (Gauteng Cases, 2021). As in other cities of South Africa, the current difficulties in accessing water and food in Johannesburg have caused an increase in social anxiety due to the full closure practices implemented due to COVID-19 (Ekumah, et al., 2020). The death of the mayor of Johannesburg, Geoff Makhubo, on 9 July 2021 due to COVID-19 has further increased this concern (Stoltz, 2021). Therefore, the state of both social and physical resistance, which existed in the current situation of the city before COVID-19, has deepened with COVID-19.

DISCUSSIONS AND CONCLUSION

The pandemic, which emerged as a global public health crisis, has turned into a social, economic, and spatial crisis experienced by the capitalist world, with all networks locked. It has also been proven that the climate crisis, another global crisis, would have the same effect. Today, states that admit that they are unprepared for the crisis created by the pandemic, in their discourse on the pandemic, list the various targets they have signed under international climate agreements and explain their post-pandemic recovery strategies. This study paves the way for discussions on whether engaging global sustainability networks are effective in achieving sustainability goals, and whether participating in these networks would be enough for economic, social, and environmental resilience of cities or not.

Findings showed that (see Table 2) although some progress has been made in terms of resilience and sustainability in small-sized cities in the USA, it is seen that there are still problems such as "poverty and homelessness" in the social dimension of sustainability in large-sized cities. This can be explained by the arms' length state policy of the USA which does not pay enough attention to social dimensions of resilience such as excluding Black and Latin groups stimulating the vulnerability of the large-sized cities in adapting the COVID-19 crisis.

The first situation encountered in cities in Brazil (see Table 2) is social income inequality and inadequacies in basic needs. Although these cities make commitments to achieve their sustainability and resilience goals, the vulnerabilities of low-income groups living on the periphery of the city are high due to income inequality. We have seen no difference between big and small-sized cities in adapting to the COVID-19 crisis. Because the inequalities have mainly caused low-income groups to be positioned intensively in the city peripheries, and it has been observed that the number of cases is high in these regions. It has been observed that existing spatial inequalities increase vulnerability more during the epidemic process which must be supported by national and local policies strongly.

In the cities of Germany, the strong local policies in adapting to COVID-19 also depend on strong national policies on sustainability issues. We have seen an important role of bottom-up policy making in the welfare state regulations which make cities adaptive to crisis regardless of their size. We have seen that each city has the flexibility to create its policies. German cities which have a strong local economy and fiscal decentralization allow them to carry out their policies on sustainability and resilience together.

We have seen that the local policies in Japan on adapting to COVID-19 are in line with the national policies. National-local integration in policies makes cities adaptive to this crisis both in big-sized and small-sized cities. The rapid adaptation of society to the restrictions related to the pandemic is perceived as a normal attitude which is in line with its authoritarian management style of the Japanese state.

Problems such as access to basic physical and social needs and unequal income distribution existed in South Africa before the pandemic reached serious dimensions . Exclusionary policies towards immigrants in the country are observed in the selected cities. We have seen a striking difference between big and small-sized cities in adapting to the COVID-19 crisis in South Africa. While small sized city, Durban, had a high density of cases during the pandemic, big-sized Johannesburg had relatively low dense cases during COVID-19. This is related to reaching the basic needs. It will not be possible to achieve the goals of resilience and sustainability without providing for basic needs and social and spatial justice in the country. So, states should consider the equal distribution of social and physical resources in adapting to be resilient during the crisis.

We have found that small-sized cities adapted to the COVID-19 crisis more than big-sized cities. However, the social infrastructure need should also be taken into consideration in adapting resilience as the Curitiba, Brazil case shows. Choosing different cities with varying sizes shows that sustainability and resilience policies of a strong state and welfare system support are important in the resilience of cities.

It is also seen that the sustainability and resilience targets determined by the global urban networks do not have an influential effect in adapting cities to resilience, under the risk conditions created by the pandemic. Sustainability targets should not remain in discourse and effective policies (such as distributing equal infrastructure and social support to cities regardless of their size but by considering the density of the population) should be considered not only at global level agreements but also by national and local policies and actors which have a significant role on designing resilient policies. Findings showed the necessity of social and physical dimensions of a multi-layered process of decision-making involving local, national, regional, and transnational actors in adapting to global environmental problems such as epidemics and climate crises.
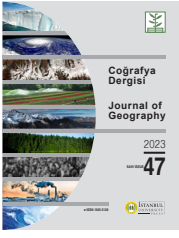
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Research Article / Araştırma Makalesi

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Relational Space: Football as a Meta Fetishism

İlişkisel Mekân: Bir Meta Fetişizmi Olarak Futbol

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ABSTRACT

The concept of space, which is constantly reshaped within the routine activity of geography, forms its contexts through the processes it undergoes, and constructs its basic relations through the "other". This relationality, which embodies all kinds of dichotomic constructs such as good-bad, beautiful-ugly, and political-apolitical, can have a natural fiction or be based on hegemonic structuralism loaded with ideology. While it can ensure the continuity of individual and collective culture, identity, and memory, it can also commodify the reproduction of all kinds of power elements. Therefore, the relational relations of space can only be understood depending on when, where, and by whom it is constructed. Football spaces, where this relationality is intensely embedded, are constantly reproduced by different actors at different scales and presented to the daily life consumption of individuals and societies in new contexts. In this context, this article aims to analyze the relational contexts of football spaces in the case of the Qatar World Cup. In the study, in which the qualitative research method was used, the data obtained from Twitter users during the 2022 World Cup were analyzed using content and descriptive analysis techniques. As a result of the research, it was understood that football spaces have multi-layered sociopolitical, economic, and cultural contexts constructed by both individual and ideological actors and systems.

Keywords: Critical Human Geography, Culture Industry, Cultural And Political Geography, Football, Hegemony, Relational Space, Sports Geography

ÖZ

Coğrafyanın rutin eylemselliği içerisinde sürekli olarak yeniden şekillenen mekân kavramı, uğradığı süreçlerle bağlamlarını oluşturarak "öteki" üzerinden temel ilişkilerini inşa etmektedir. İyi-kötü, güzel-çirkin, politik-apolitik gibi her türlü dikotomik kurulumu bünyesinde barındıran bu ilişkisellik doğal bir kurguya sahip olabildiği gibi ideoloji yüklü hegemonik bir yapısallığa da dayanabilmektedir. Bireysel ve kolektif kültürün, kimliğin ve belleğin sürekliliğini sağlayabilirken aynı zamanda her türlü güç unsurunun yeniden üretimini metalaştırılabilmektedir. Dolayısıyla mekânın ilişkisel bağıntıları ancak ne zaman, nerede ve kim tarafından kurgulandığına bağlı olarak anlaşılabilmektedir. Bu ilişkiselliğin yoğun bir şekilde içerimlendiği futbol mekânları ise farklı aktörler tarafından farklı ölçeklerde sürekli olarak yeniden üretilmekte ve yeni bağlamlarıyla birey ve toplumların gündelik yaşam tüketimine sunulmaktadır. Bu kapsamda bu makalede, Katar Dünya Kupası örnekleminde futbol mekânlarının ilişkisel bağıntılarının analiz edilmesi amaçlanmaktadır. Nitel araştırma yönteminin kullanıldığı çalışmada 2022 Dünya Kupası sürecinde Twitter kullanıcılarından elde edilen veriler içerik ve betimsel analiz tekniği ile çözümlenmiştir. Araştırma sonucunda futbol mekânlarının hem birey hem de ideolojik aktörler ve sistemler tarafından kurgulanan çok katmanlı sosyopolitik, ekonomik ve kültürel bağlamlara sahip olduğu anlaşılmıştır.

Anahtar kelimeler: Eleştirel Beşerî Coğrafya, Futbol, Hegemonya, İlişkisel Mekân, Kültür Endüstrisi, Kültürel ve Siyasal Coğrafya, Spor Coğrafyası

1. INTRODUCTION

As with all sub-disciplines of the social sciences, geography has been significantly influenced by the post-structuralist theory. These influences have been recognized in all aspects of geographical endeavors, especially in the study of the individual, society, and space, which are the three main research areas of human geography.

Post-structuralism has affected not only what geographers should analyze, but also how they should analyze, that is, their research methodology. Following this influence, geographers have begun to use innovative research methods to analyze a wider range of sociospatial phenomena than was previously possible. Another common feature of post-structuralism and (human) geography is the interest in *"relationality"*. When post-structuralists and geographers began to closely examine spatially located interactions, they began to realize that there are many different types of relations that pass in and around particular spatial locations (Murdoch, 2006, p. 2). The fundamental problem concerns the often poorly defined nature of the *"relations"* that constitute space and/or place. What are these relations? What is related? How is it that some things (places, etc.) are rich in relations, while in other places relations are weak? Who relates the actions? Is there anything that is not related (Cresswell, 2013, p. 220)? These questions are essentially an output of the multidimensional social, political, economic, etc. construction of space. On the one hand, this construction is unconsciously constructed by the subject himself according to the sociological, theological, psychological, and cultural characteristics of the subject, mostly within the basic rituals of his daily life, while on the other hand, the subject, which cannot be outside of power relations (Foucault, 1980), is defined by hegemonic constructions and shaped according to limited contexts. In the secondary situation where the subject is in the receptive position, power can redefine its relational contents in very complex ways (Leitner, Sheppard, & Kristin, 2008, p. 169) by fetishizing all kinds of space phenomena (language, religion, race, body, cultural values, entertainment, leisure, etc.) to produce the commodity it desires by its ideological form and ensure its continuity. Consumption of the emerging spatial relations by the subject without knowing the perpetrator, on the one hand, enables the natural succession of the relationship, on the other hand, the new relational dynamics that emerge in the implementation phase re-categorize the semantic and connotative dimensions of space. This situation has been a basic postulate of the late capitalist period in which the subject is made to exist only in consumption practices and is "thingified" through media tools and other manipulators of the market culture (Şimşek, 2016).

The postmodern period is based on the circulation of *"position"*, that is, the relationship between points and phenomena, rather than the spatial (point) foundations of space. Therefore, individuals maintain their ontology not in a space decorated by different colors separated by certain boundaries, but in heterotopias as a set of relations defined as positions irreducible to each other (Foucault, 2000, p. 294). In this natural context, there is no mention of a certain centrality in space. As there is no formal similarity, any phenomenon in space does not have a primary or secondary status vis-a-vis another, but is in a constant state of relation, becoming, and flow. The problem that is important in these principles regarding space is whether it is the subject itself or the power surrounding it and the ideological apparatuses it possesses that *"postpones, neutralizes or reverses"* (Foucault, 2000, p. 295) the totality of relations regarding the representations produced. The basic answer to this question lies in space and its relational dimension. Because space itself, which has a heterotopic context, has the specificity of difference in a tremendously diverse social geography. Therefore, space is perceived, produced, and consumed by both the subject and power in different thematic patterns and scales. In the spatial appearance that emerges and functions mostly based on the hegemony of power, the subject is mostly involved in the production of spatial relations within the boundaries determined and/or desired by the power.

One of the relational spaces where power is intensively involved in reconstruction and consumption is football pitches. The fact that football extends far beyond its spatial practice with its new contexts also makes it an important component of the geography of sport. Because the geography of sport is also influenced by the structural analyses brought by poststructuralist theory to cultural studies: (a) the relationship of organizations to sociopolitical, cultural, and economic connections (b) the correlates and distribution of spatial development (c) the consequences of hegemonic imposition after colonialism and postcolonialism (d) the historical development of sport, its massification and, especially with digitalization, the labels of information on sociospatial practices; and (e) the emotional and affective correlates that mobilize ethnic, religious, sectarian, and sexual collective influence (Bale, 2002 cited in Gregory et al, 2011, p. 718), analyzing the construction of an archaeological and anthropological geographical view of the sport. Thus, the deterministic approach focusing only on objective facts between sport and geography was overcome, and sociopolitical, cultural, and economic relations were focused on in accordance with the meaning world of critical thinking (Avcı, 2006, p. 107). Based on this theoretical context, football spaces, which Nelson

Rodrigues (as cited in Talimciler, 2005, p. 87) describes as *"If all you see is the ball, it means you see nothing.",* offer a unique area of investigation in terms of sports geography. Influenced by the imperialist global structure, it produces the interests of power and capitalist consciousness as an area of interest for all segments with billions of dollars of capital (Öcal, 2002, p. 128; Talimciler, 2008, p. 93). However, football spaces can also be functional as spaces of resistance against hegemony with their symbolic coding and practices based on participation. Therefore, football, with its multi-layered relations, has left behind its modest approach and has shown considerable variability.

Accordingly, this study analyzes the relational dimensions of football as a form based on spatial practice in the Qatar World Cup sample. In addition, the study examined whether football represents the resistance of individuals against the structure by transcending its physical boundaries and whether it is a place of reproduction of subjects as an apparatus of the culture industry.

2. THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1. Structurality of the Relational Space

There are three fundamental key concepts that define and are identified with the discipline of geography: space, subject, and the consolidating relationship between the two. Although these words essentially shape the ontology of social sciences, the main phenomenon that constitutes their specific weight in geography stems from the discipline's attempt to analyze all kinds of dynamics, such as culture, identity, memory, power installations, etc., related to the subject by addressing human-environment, space, field studies, and geoscience traditions (Pattison, 2003; Arı, 2022) from a holistic perspective. At this point, space, which constitutes the basic conceptual plane of the research and derives from the Latin word *space* with the meanings of distance or distribution (Agnew, 2004, p. 81) It can be stated that the concept has been on the agenda of geographers intensively. Moreover, when the deconstruction of the hermeneutical context between the user and the user is analyzed, it can be stated that it is reduced to quite various contexts. Moreover, not only because of its relationship with the subject, but also because of its apriority context, space is too value-laden to be handled on an essentialist basis with its plural (cultural, political, concrete, abstract, social, relative, absolute, etc.) meanings (Bilgili, 2020, p. 89). This composite structure of the space, which contains a context which is more than the whole of its parts, experienced a significant change, especially in the 1950-1960 period. In the process in

which the modern world system was based on the axiom of positivist epistemology, geography abandoned its analytical approach to the relationality between space and subject and tried to quantify the general laws of space (Bekaroğlu, 2016, p. 130-131). In this Euclidean conception of space, which has a static, immutable, and quantitative context, the subject and thus the related social contexts are ignored (Ar, 2021, p. 10-11). However, especially after 1970, the shift from modernism's mechanistic understanding of society and science to postmodernism's pluralistic, local, and contextual epistemology has changed the positivist paradigm in the social sciences. In fact, in the words of Bekaroğlu (2016), this change, which signifies a return to the tradition of monocultural science, has enabled geography to return from the geometric and passive design of space to an active relational space that is shaped and constructed by different social contexts loaded with ideology, power, and government (Kaygalak, 2011, p. 5). The main element that gains importance in the lens of postmodern geography is clarifying the cultural, identity, and political contexts of the subject by tracing different meanings, organizations, and changes related to space (Kaya, 2013, p. 34). This is because the concrete boundaries of space are pragmatically shaped by material practices and processes that mediate the reproduction of everyday social life. In other words, all forms of social construction involve specific spatial patterns and thus practices (Ar, 2020, p. 168). This is the result of the mutual production of the individual and space based on their dichotomous necessity because it is natural for both space and subject to produce one another, to construct identical contexts, and to transform one another depending on the metaphor of time (Bilgili, 2016). The phenomenon that emerges at this point is *"relationality"* as the tertiary concept of geography. Studies that emerged as the antithesis of the understanding of absolute space and labeled as relational space in geography (Amin, 2004; Massey, 2013; Malpas, 2012) have increased significantly. The common feature of these studies is that they see space as a product of connections rather than a product of a basic self on the basis of relational thinking. This approach is an anti-essentialist way of thinking (Cresswell, 2013). Critical geography, in particular, has shaped the thematic position of space as active, dynamic, and composed of relations (Ar, 2023).

Since any sense of spatial solidity or permanence arises only from the coming together of connections and processes, Massey (2005) insisted that a relational understanding of space is a product of mutual relations, a field of multiplicity, and that it is always in process or in becoming. Since space consists of competing and co-existing relations, it has an unpredictable character that can produce "new spaces, new identities, new

relations, and differences" (Massey, 1999). Relational space becomes "a meeting place", a place where relationships intertwine and intersect (Massey, 2008). The relational construction of space is both a consensual and a contested process. "Consensual" because relations are often made up of agreements or harmonizations between two or more entities; "Contested" because the construction of a set of relations can lead to the exclusion of some entities (and their relations), while others are adopted and consumed through hegemonic processes based on coercion or consent. Massey (1999, p. 8) summarizes this complex process at the core of his approach in three basic propositions: (a) Space, as defined above, is a product of reciprocal relations. These interrelationships pass through different spatial scales, from the local to the global, and all points in between. (b) Space is the sphere of the possibility of multiplicity. Since various relations "pass-through" space - that is, they constitute space - they can all exist spatially. (c) Space is never closed and can never be fixed. In other words, space is always in the process of becoming as relations emerge: "always in time" there are connections yet to be established, juxtaposition yet to become interactions and relations that may or may not be realized. According to Soja (1998), all these "marginal" areas come together in what he calls the "third field. "This term is added to Soja's categories of 'first space' (the formal organization of things in space) and 'second space' (representations and concepts of space) found in the work of Lefebvre (2014). Soja defines the third space as follows: The third space [...] is portrayed as multifaceted and contradictory, oppressive and liberating, passionate and routine, knowable and unknowable. It is a field of radical openness, a field of resistance and struggle, and a field of multiple representations that can be analyzed through their binary oppositions. It is a meeting space, a space of hybridity and mestizaje, and a margin or border beyond established boundaries, where ties can be broken, and new ties can be forged. It can be mapped but never captured in traditional cartographies, it can be imagined creatively but only makes sense when implemented and fully lived.

It is only possible to comprehend and analyze space if both are understood and functional together. As a result, space is not static but dynamically (re)shaped. It is also not absolute, depends on who is looking and can be perceived in different contexts depending on the position of the actors. In short, relational space is a "power-filled" space where certain alignments are constructed through the ideological, cultural, and social forms of the subject, but at the same time passively fetishized and dominated. These relational geographies, which Lefebvre (2014) describes as the epitome of politics, are as far removed as possible from a worldview of neatly enclosed compartmentalized worlds, which are intensely constituted by deeply structural forces and practices (Cresswell, 2013). Especially considering the fact that fluid modernity reorganized the individual and his/her geographical environment with intricate relations on the one hand and reconstructed the subject, which it spontaneously abstracted on this ground, through hyperreality in supermodernity, analyzing the latent/implicit production between the subject and space has become possible with the development of poststructuralism in geography. As Gregory (1994, p. 75-76) summarizes: The closures and certainties of the objectivist tradition in human geography have become increasingly suspect [...] a kind of strategic reversal has now come into force that constantly disturbs attempts to claim a summarized unity for the geographical project. Therefore, it has been argued that "critical human geography must pay attention to how meanings are spun around the topoi of different lifeworlds and woven into social practices and power relations." (Bell & Valentine, 1997).

2.2 Football as a Space of Culture Industry, Ideology, and Hegemony

As a fundamental component of physical and mental development, sports and practice spaces, with their different variants (athletics, gymnastics, volleyball, basketball, football, rafting, etc.) are an important dynamic of individuals' daily life practices. However, sport, which today exceeds the reality and conditions it has with its different dimensions from micro to macro scale, is no longer just a set of movements and events that occur internally but has become a reflection of the process of revealing the sociopolitical and cultural phenomena at the core of a community (Hognestad, 1997, p. 195). At this point, football, which stands out more in the global spectrum compared to other sports applications, has transcended the spaces in which it is mobilized and has multiple contexts with its deep structural relations that it establishes with the subject and is constructed on behalf of the subject.

Football was first played in China and Egypt between 5000 and 2500 BC (Erdoğan, 2008, p. 26). The process of evolving into a modern sport dates back to the English Football Association, founded on October 26, 1863, with the participation of 11 club representatives. After this date, the realization of the English Cup in 1871, the establishment of the English Professional Football League in 1888 (with the participation of 12 clubs), the formation of the International Football Associations Association (FIFA) on May 24, 1904, and the first World Cup in Uruguay in 1930 enabled football to spread in Europe, Latin America and Asia (Stemmler, 2000, p. 103). Industrialization, which forms the basis of today's

political and cultural relations, has had a great impact on the rapid development and worldwide spread of football. The change in social life practices with industrialization, urbanization, and the differentiation of working conditions with the emerging new social classes have necessitated the control of the masses. At this point, football has been used as an ideological device to keep bodies fit for more functional gains and to behave according to the dynamics determined by the hegemonic structure based on the understanding of managing the leisure time of workers who are under heavy conditions and exploited by Fordist practices (Öngören & Karadoğan, 2002, p. 214). The emergence of football as a sporting practice of the proletarians in the face of aristocratic games such as tennis and cricket (Şahin, 2010, p. 223) can be considered a semiological reflection of the inverse proportion between ball size and class position (the smaller the ball, the higher the class position) (Büker, 1992) on the relationship of exploitation. Although it has been subjected to significant transformations over time, the relationship between football and social life has moved to a different dimension due to globalization in the last quarter of the 20th century. While the symbolic values within it have increased its importance, economic developments have deepened the relationship between football and the ideological system. In the process of adopting consumption to the masses with neoliberal policies, football has paved the way for its commodification due to its ability to influence societies (Talimciler, 2008, p. 92). This situation, in which the Frankfurt School defines culture as "the thing" in which capitalist production relations are shaped by continuous production and which it defines as the culture industry, causes the masses who cannot attain the desired life to reach satisfaction without problematizing the structure in this deprivation (Adorno, 2007, p. 74). The return of football culture, with the changes that have taken place since the last decade of the twentieth century, has prepared the way for the industry to move from the realm of cultural pursuit to the multi-billion-dollar entertainment industry. Full integration of the game into the competitive arteries of world capitalism (IFA, 2013) has become one of the biggest expenditures in the sports and entertainment industry. So much so that football, which attracts the intense interest of exploited and elitist sovereigns with its capital worth billions of dollars, was established in the middle of stadium spaces. However, over time, it has become a "football industry" with its intermediary actors expanding hierarchically toward the periphery (Öcal, 2002, p. 128). In the football industry, where the audience is subalternised, many consumption concepts are offered through intermediate actors (club, football player, broadcast, etc.) (Yılmaz, 2002, p. 21). Among them, the betting industry, which has a capital of more than 1 trillion dollars and simultaneously markets the visible pleasure of the female body, is used as an important tool (SABAH, 2023). In the football industry, the most important device that mediates the exploitation of societies by ensuring their control is the mass media. The opportunities provided by digital broadcasting have increased the industrial value of football. The (digital) media, which makes football an element of globalization, can, on the one hand, market the practice as a phenomenon of cyberspace by eliminating borders, and on the other hand, create formal and informal categories of production and consumption (betting, digital money trading, product marketing, etc.) for actors with the tools it has developed (Twitter, Discord, Instagram, Facebook, etc.).

Although the football industry attempts to dominate actions and orientations by influencing the human mind through mass communication (Özdağ, Duman, & Fişekçioğlu, 2011, p. 15). At the same time, it is also a space of oppositional organization against hegemonic structures as a place of resistance, resurrection, and politicization based on mass media. As a state of being intertwined with the politics, this situation produces common grounds for communities and builds geographies of resistance between concrete and cyber spaces. These spaces become centers of the search for freedom as geographies where crowds can express all kinds of sociopolitical reactions (criticism of exploitation, culture and identity politics, sexist installations, etc.) against power structures. At the same time, as spaces where historical constructions are reconstructed, football is reconstructing national consciousness as spaces where the postcolonial struggle is carried out, and on this basis, the cult of exploitation is kept alive in social memory. This context, in which at sense of integration emerges, also has a function in which nationalist discourse is produced and the identity of "us" is constructed through the creation of the "other" (Hobsbawm, 1995, p. 170), and mediates the development of a democratic, resistant, and alternative culture.
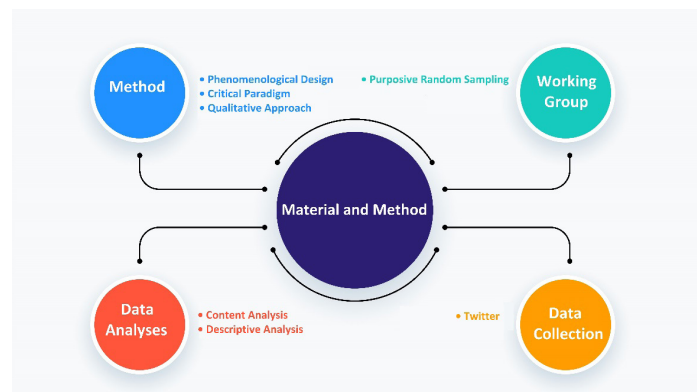
3. MATERIAL AND METHOD

Figure 1: Material and method.

A phenomenological design was used in this research, which aims to analyze the type of relationships individuals develop through football spaces and the dynamics that are effective in revealing such relationships. As one of the five basic types of approaches used in social science studies, the phenomenological design provides significant advantages to researchers in explaining the views, perceptions, and thoughts of the phenomenon/subject about a concept, event, or phenomenon (Rose, Beeby, & Parker, 1995, p. 1124). The underlying factor underlying the choice of the phenomenological perspective is the attempt to illuminate the context between the individual, society, and space by centering the critical paradigm in the study. Because discovering the power and structural construction relations in the datasets obtained from individuals' acquisitions by the researcher and categorizing them through the main themes, performing scientific analyses for change, and analyzing the areas of domination, alienation, and struggle (Morrow & Brown, 1994) necessitates the selection of a research paradigm suitable for the study design based on the study design. In this direction, qualitative research was used to study of the critical nature of the research. Thus, it enabled the researcher to address the subject of the study in a sociopolitical and cultural context and enabled the integrity between approach, paradigm, and method in the research by enabling its unique reflectivity and specificity in its analyses (Creswell, 2015, p. 45).

3.1. Working Group

Twitter User Real Name
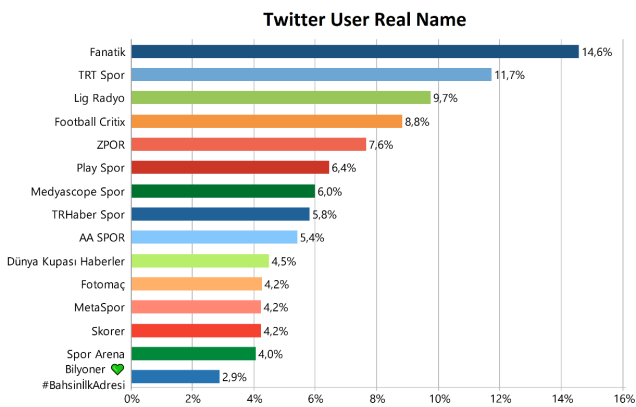
Graphic 1: User information and sharing rates in Twitter activity.

Purposive random sampling was used in the study to obtain richer dataset and to increase the validity/reliability of the study (Flick, 2010). In random sampling, a sample group is first determined from the universe, and then the subgroup that is thought to contribute the most to the research within this study group is determined (Tashakkori & Teddlie, 2010). In this context, the study group consists of users who use the social

media platform Twitter during the 2022 Qatar World Cup. After determining Twitter users as the population group within the scope of purposive random sampling, the participants were limited to the subgroup that shared the hashtag study related to the World Cup for the purpose of the research. The information of the 15 corporate users based on the research and their data weights in the sample group are shown in Graphic 1.

3.2. Data Collection and Analysis

In the analysis of social media data, the data obtained from the selected sample group can be used directly in a user-centered manner or can be analyzed in the context of word-based criteria. In the user-centered criterion, data collected from limited accounts determined within the scope of simple purposive sampling by the purpose of the study can be analyzed, whereas in the word-based criterion, predefined tags (hashtags) or key concepts can be analyzed as a result of the snowball-like increase in messages and responses to them (Einspänner, Dang-Anh, & Thimm, 2014, p. 99). In this direction, the Twitter social media tool was used as the data source of the study, and the data of the study were collected by following three stages: In the first stage, the dataset was obtained through the Twitter hashtags "*Qatar2022, #Morocco, #FIFAWorldCup, #FIFAWorldCup2022, #BoycottQatar2022*" initiated by the purposive random sampling group and retweeted by other participants. First of all, the hashtags ranked on Twitter related to the Qatar World Cup between 20 November-18 December 2022 were followed and necessary notes were taken. The hashtag data were then extracted and recorded from the Twitter system through the MAXQDA program for a period not exceeding one week. The main reason for such an application is that the MAXQDA web collector feature used for data collection allows only the last week of Twitter data to be stored. This process was repeated for each hashtag, and a total of 209,455 tweets were recorded.

In the second phase, it is the stage in which the collected data are sorted by the purpose and basic problem of the study. The dataset obtained in this phase was sorted through a computer-aided program, and 135,088 tweets were classified for direct use in the study. In the third stage, the data obtained were analyzed in depth using content and descriptive analysis techniques. Content analysis, as an analysis technique used significantly in the qualitative research methods, is an in-depth and patterned application of the subject included in the research. Content analysis, as an effort to make a meaningful whole by revealing the relationships and consistency in multidimensional qualitative data (Patton, 2014), is an application carried out for visual

expression as well as concepts. In this regard, all kinds of words and phenomena involved in the information process are considered as texts (Neuman, 2014). The data decided to be analyzed by the researcher are grouped under certain concepts, subthemes, and main themes, each of which is related to the other, and designed to appeal to the meaning world of the reader. Finally, the correlation between descriptive analysis and content analysis is ensured by quoting the memos obtained during the analysis process for each category and the data classified by the weight assignment method. In this context, the data were analyzed using the MAXQDA 2022 computer-aided software program, which has visual and statistical tools for visualization and thematization. Since coding is a cyclical practice and it is not possible for the researcher to produce perfect coding at one time, the two-dimensional cycle technique, which is frequently used in content analysis, was used. After the precoding process is completed, the first coding process of the data is carried out by selecting the ones suitable for the purpose of the study among the seven basic practices (grammatical, basic, affective, literature and language-based, exploratory, procedure-based, and thematizing the data). The second coding cycle is the process of reorganizing the data obtained in the first cycle. At this stage, facts that are perceived as irrelevant are associated with each other in a logical way. Codes, sub-codes, and main categories are harmonized with each other. For this purpose, patterned, focused, axial, theoretical, exploratory, and longitudinal coding techniques can be applied in the second cycle of coding (Saldana, 2019, p. 69). Nevertheless, in both the first and second coding cycles, one sub-coding technique for each dimension can be selected, or the coding function can be performed by operating multiple application techniques together. At this point, in the first coding process of the study, the descriptive, process, and In Vivo coding techniques under the basic application technique were applied together. By using the axial coding technique, the coding process

that will provide code, sub-code, and main category integrity in the second cycle of the coding process was completed.

4. ANALYSIS AND FINDINGS

Within the scope of the study, the data obtained from Twitter users were analyzed through content analysis, and the relational dimensions put forward in the context of the 2022 Qatar World Cup were categorized in a way to form meaningful integrity, and the main differences were examined. At the same time, the relational dimensions representing the conceptual summary of the expressions on football spatiality are specified under 4 main categories and 11 sub-categories. In this framework, the frequency ratios of the data analyzed through the Twitter hashtags "*Qatar2022, #Morocco, #FIFAWorldCup, #WorldCup2022, #BoycottQatar2022*" are shown in Table 1.

When the opinions of the users about the 2022 Qatar World Cup on Twitter were analyzed, it was determined that the *political* main category had a higher percentage than the total rates of all other main categories, with a frequency rate of 55.36% in terms of total rates. It was followed by the *theological* (18.76%) and *cultural* (15.72%) main categories in second and third place, respectively. Among the main categories, the main category with the lowest frequency percentage in terms of total proportions was *sports marketing* with 6.34%. In terms of subcategories, the concepts of *the boycott of exploitation* (31.48%), *postcolonial reaction* (21.90%), and *the spread of Islam (*18.04%) under the *political* main category and *the theological* main category, respectively, were the first three categories with the highest frequency percentages. On the other hand, the conceptual expressions with the lowest frequency percentages were determined as: *Muslim stance* in *the theological* main category (0,72%), *political identification* in the *political*

Table 1: Frequency analysis of the opinions of users in the context of football spatiality.

Main Category	Intermediate category	#BoycottQatar2022	#worldcup2022	#FIFAWorldCup	#Morocco	#Qatar2022	Total
Political (%)	Boycott of exploitation	56.10	11.30	20.30	13.20	56.50	31.48
	Postcolonial reaction	0.19	20.70	17.60	57.20	13.80	21.90
	Iranian resistance	2.00	0.20	0.00	0.70	3.00	1.18
	Political identification	2.00	0.60	0.20	0.90	0.30	0.80
	Subtotal (%)	60.29	32.80	38.10	72.00	73.60	55.36
Theological (%)	Muslim stance	1.20	0.20	0.50	1.10	0.60	0.72
	Spread of Islam	6.90	28.00	33.30	12.70	9.30	18.04
	Subtotal (%)	8.10	28.20	33.80	13.80	9.90	18.76
Cultural (%)	Arab culture	2.50	4.70	5.30	1.80	1.70	3.20
	Europe saw civilization	1.90	4.10	4.40	2.70	1.10	2.84
	Cultural capitalism	4.30	25.80	12.00	4.30	2.00	9.68
	Subtotal (%)	8.70	34.60	21.70	8.80	4.80	15.72
Sports marketing (%)	Women and betting	1.10	1.30	3.40	2.40	4.80	2.60
	Online betting	2.90	3.20	3.00	2.80	6.80	3.74
	Subtotal (%)	4.00	4.50	6.40	5.20	11.60	6.34

main category (0,80%), and *Iranian resistance.* In addition, when the highest and lowest frequency ratios related to sub-concepts in terms of main categories were evaluated, the following results emerged: The subcategories of *the boycott of exploitation* (31.48%) and *political identification* (0.80%) in the *political* main category, *the spread of Islam* (18.04%) and *Muslim stance* (0.72%) in the *theological* main category, *cultural capitalism* (9.68%) and *Europe saw civilization* (2.84%) in the *cultural* main category, and *online betting* (3.74%) and *women and betting* (2.60%) in the *sports marketing* main category were the concepts with the highest and lowest frequency rates, respectively.

When analyzed in the context of Twitter hashtags, the following results were obtained in terms of main categories: In the *political* main category, the subcategory of *postcolonial reaction* (57.20%) under the hashtag #Morocco had the highest frequency rate. In the *theological* main category, the subcategory of the *spread of Islam* (33.30%) under the hashtag #FIFAWorldCup had the highest frequency percentage, while in the *cultural* main category, the subcategory of *cultural capitalism* (25.80%) under the hashtag #worldcup2022 had the highest frequency percentage. Finally, in the *sports marketing* main category, the *online betting* subcategory (6.8%) under the #Qatar2022 hashtag was the concept with the highest frequency percentage.

Figure 2 shows the concept network of the main category *political*. When the relevant figure was analyzed, it was determined that the main category formed by Twitter users' expressions on the relationality between football and politics consisted of 4 subcategories and 31 concepts. In the subcategory *boycott of exploitation*, which has the highest concept frequency among all subcategories in the *political* main category, the concepts of *oil and the power of money* (14528) and *capital exploitation (10149),* and the expressions *exploitation of labor* (9627), *starvation and waste* (1691), and *America* (238) under *exploitation of capital* were the subcodes most frequently mentioned by the users, respectively. On the one hand, these concepts highlight the unequal geographies created by global capitalism, and on the other hand, they reflect the reaction that intensely implies the labor power that the elitist hegemony commodities and exploits on this basis. In particular, the fact that the concept of *FIFA bows to money* ranked third with 2052 frequencies under the subcategory *boycott of exploitation* also refers to the relational categorization of the liberal dynamics of capital exploitation, such as being supposedly transparent, egalitarian, and democratic. These relational dimensions related to the *political* main category were confirmed by user expressions:

"This football system, controlled by the rulers, one of the most important areas of ideological hegemony, intertwined with finance
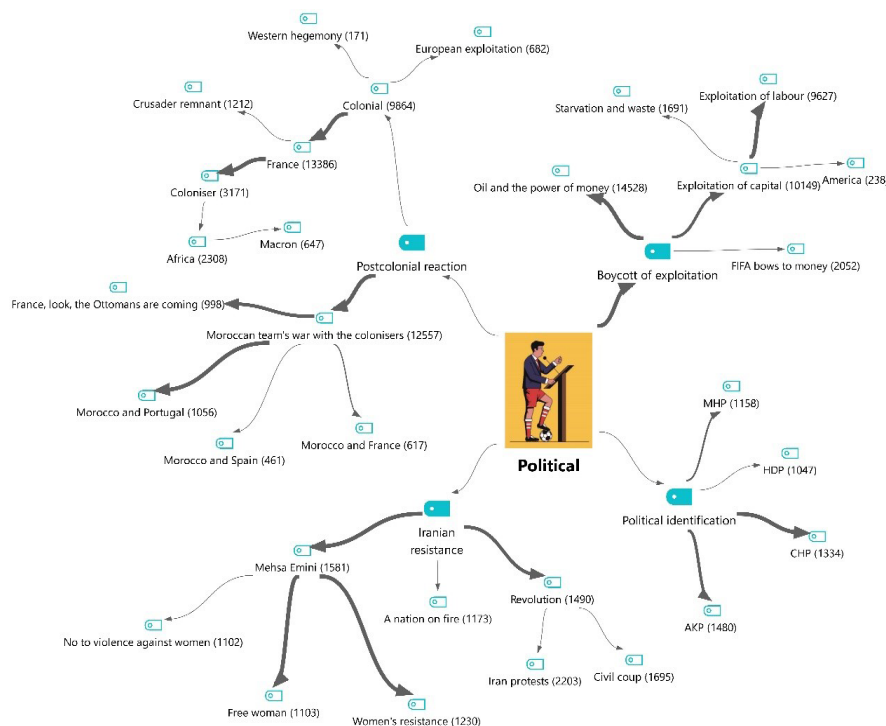

Figure 2: Code-subcode concept network for the political main category.

capital, is an opium." (#BoycottQatar2022)

"2 million Muslim slaves worked in the construction of these stadiums under the harshest conditions, some of them returned to their countries without even receiving their money, and many of them lost their lives." (#BoycottQatar2022)

"They spent so much money on the World Cup that with that money, every hungry and miserable Syrian would have been satisfied." (#worldcup2022)

The subcategory of *postcolonial reaction* (Figure 2) under the *political* main category was the subcategory in which users produced discourse based on historical, cultural, and political affiliations during the World Cup, which Turkey could not participate in. At this point, it was determined that the sub-code of the *Moroccan team's war with the colonizers* (12557) with the sub-expressions of *Morocco and Portugal* (1056), *Morocco and France* (617) and *Morocco and Spain* (461) was the concept with the highest frequency density. It was followed by the sub-concept of *colonial* with a frequency density of 9864. Under this concept, expressions such as *European exploitation* (682) and *Western hegemony* (171) are generally associated with the contextual dynamics of Western geographical colonialism. In a specific sense, the expression *colonizer* (3171) under the concept of *France* (13386), the subcodes *Africa* (2380), *Macron* (647), and the concept of *crusader remnant* (1212) were the postcolonial output of the historical struggle between the Ottoman Empire and France.

"#France defeated Morocco, the pride of Africa in the World Cup, with players recruited from Africa, again exploitation, again exploitation..." (#Morocco)

"The Franco-Moroccan struggle is a match between the exploited and the slaves of the exploiter. 80% of the French team is African." (#Morocco)

"A big halal to Morocco for sending the Spaniards, who were disturbed by the sound of the call to prayer, back to their country with a prostration of thanksgiving after the victory 👋 Allah" (#Morocco)

In Figure 2, *Iranian resistance is* another sub-code that stands out in the *political* basis category. This subcategory was determined by the reflection of Twitter user expressions on the events that started with the murder of a woman in Iran and the national football team participation in protests by not singing the national anthem at the 2022 Qatar World Cup. Under the subcategory of *the Iranian resistance*, the concept with the

highest frequency number was *Mehsa Emini* (1581). In relation to this expression, the concepts of *women's resistance* (1230), *free women* (1103) and *no to violence against women* (1102) were frequently mentioned. The second sub-code was a *revolution (*1490) with the concepts of *Iran protests* (2203) and *civil coup* (1695), followed by the concept of *a nation on fire* with a frequency of 1173.

"People are being slaughtered in the streets of Iran for demanding basic human rights." (#worldcup2022)

"Violent behavior against women in Iran violates their civil rights. Women do not have the right to freedom to watch or play football and other sports matches." (#Qatar2022)

"Iran national team footballers support #MahsaAmini protests: The footballers refused to sing the national anthem, while the fans supported the protests by holding banners reading "Women, Life, Freedom." (#worldcup2022)

Another relational dimension that emerged especially in the context of users, was the reproduction of political identity. At this point, when Figure 2 is analyzed, it is determined that the last subcategory that emerged under the main category of *political* is *political identification*. In the sub-code systematic where users frequently emphasized the concepts of *AKP* (1480), *CHP* (1334), *MHP* (1158), and *HDP* (1047)[1] respectively, the relationality of the ideological construction between football and national dimension through political identity emerged.

"HDP members should go and defend America in Iran vs America match, after all, they are brothers in fate." (#worldcup2022)

"The match between Morocco and Spain is a struggle between poles as different as AKP and CHP. The struggle between the exploiting CHP and the nationalist AKP and MHP 💪💪💪 who revolt against exploitation... "(#FIFAWorldCup2022)

The *theological* main category, which indicates the concepts that users put forward in the context of the relationship between religion and football in the context of the 2022 Qatar World Cup, consists of 2 subcategories and 9 concepts (Figure 3). The fact that the World Cup, which is the locomotive component of the football industry, was held for the first time in a country whose official religion was declared as Islam (Qatar) was intensely reflected in the conceptual emphasis of Twitter users. At this point, when Figure 3, which shows the *theological* main category, is analyzed, it is determined that the sub-code of the *spread of Islam* has a higher frequency number. Under the related concept,

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1   The AKP, CHP, MHP, and HDP are political parties representing different ideologies in Turkey.
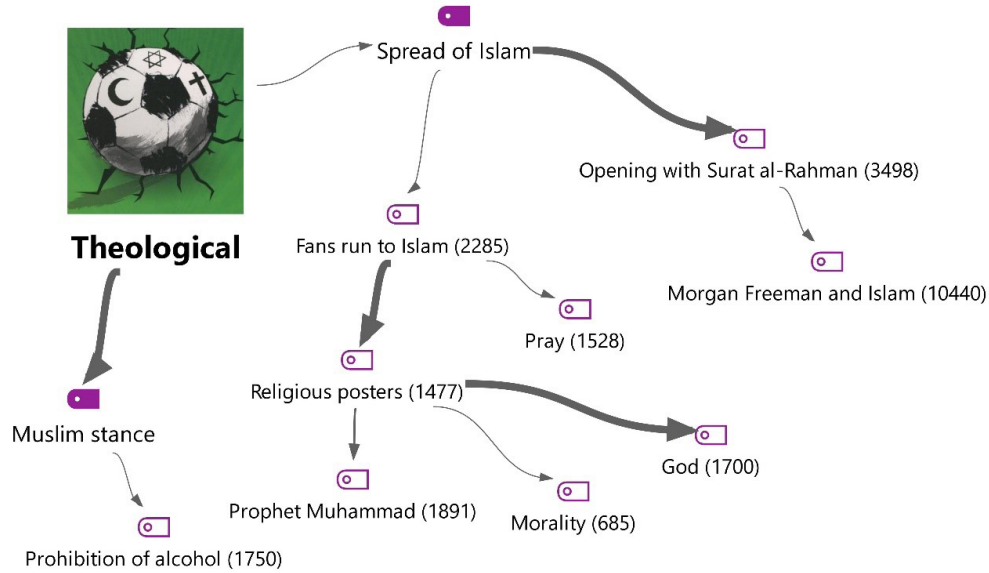
Figure 3: Code-subcode concept network related to theological main category.

opening with Surat al-Rahman (3498) and the expression *Morgan Freeman and Islam* (10440) expressed in relation to this concept came to the forefront, while in the second place, the *Muslim stance* sub-code and the concept *prohibition of alcohol* (1750) emphasized in relation to this concept were frequently mentioned.

"I could swear that even atheists are chanting Allah Allah in those stadiums in Qatar, but I can't prove it 😊😊😊😊😊😊😊" (#Qatar2022)

"In the World Cup, where the West constantly criticized the drinking ban and regulations because it is a Muslim country, Qatar became the host of one of the most exciting cups in the world with a successful organization from opening to closing, from stadiums to matches, with a surprise like Morocco." (#Qatar2022)

"At the 2022 World Cup in Qatar, a Mexican fan who was attracted to Islam became a Muslim by bringing the Kelime-i Shahada. They saw the truth. Moreover, there are so many Muslims that it was worth Qatar spending so much money hahaha..." (#worldcup2022)

Another main category shaped by the expressions put forward by the users through football relationality, which is also seen as a fundamental element of cultural geographical transmission, is the *cultural* basis category (Figure 4). It was determined that the
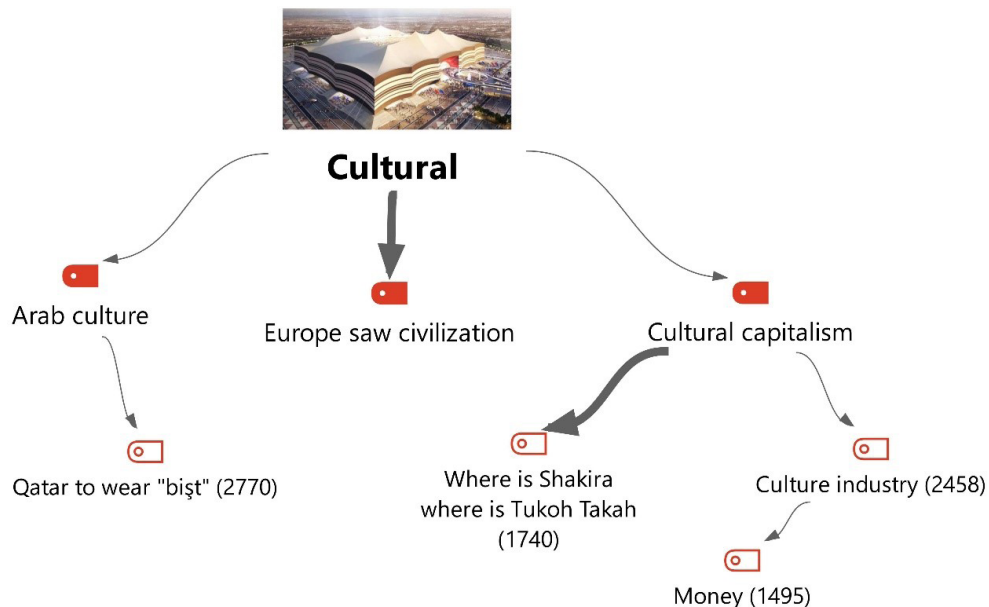

Figure 4: Code-subcode concept network for the cultural main category.

cultural main category, which signifies the area where popular culture is fetishized, consists of 3 subcategories and 4 concepts. The subcategory with the highest frequency was *cultural capitalism*, which consists of the concepts of *cultural industry* (2458) and *money* (1459) in relation to this concept and *where is Shakira where is Tukoh Takah* (1740), respectively. The *Arab culture* subcategory, under which the concept of *Qatar to wear "bist"* (2770) is also included, was the category with the second highest frequency density, followed by the subcategory of *European saw civilization.*"We must realize once again that civilization and culture can be bought with money." (#Qatar2022)

"When did it go from Shakira's Waka Waka to Myriam Fares' Tukoh Taka 😬😂" (#Qatar2022)

"Westerners love the toilet with a tap in Qatar. Maybe you can learn some civilization, uneducated Bedouins 😬😬😬😬" (#worldcup2022)

of 2 subcategories and 34 concepts. With its frequency and concept density, the online betting subcategory was determined to be the subcategory where expressions related to both legal games of chance such as, football-based betting (671), and prohibited games of chance such as casino (306) and trial bonus (362), came to the fore. In addition, the female body can be transformed into a means of pleasure through the practice of football. At this point, another subcategory that shows that the female body is made the object of games of chance is *women and betting*.

"💸Winning with BetitBet tastes completely different! ⚽" (#worldcup2022)

"💵Ratio 3.70 👆💵Subscribe and start winning with the number 1🍀" (#Qatar2022)

"Friend, am I going to look at the girls on this betting site or am I going to bet 😊😊😊😊😊😊😊" (#worldcup2022)
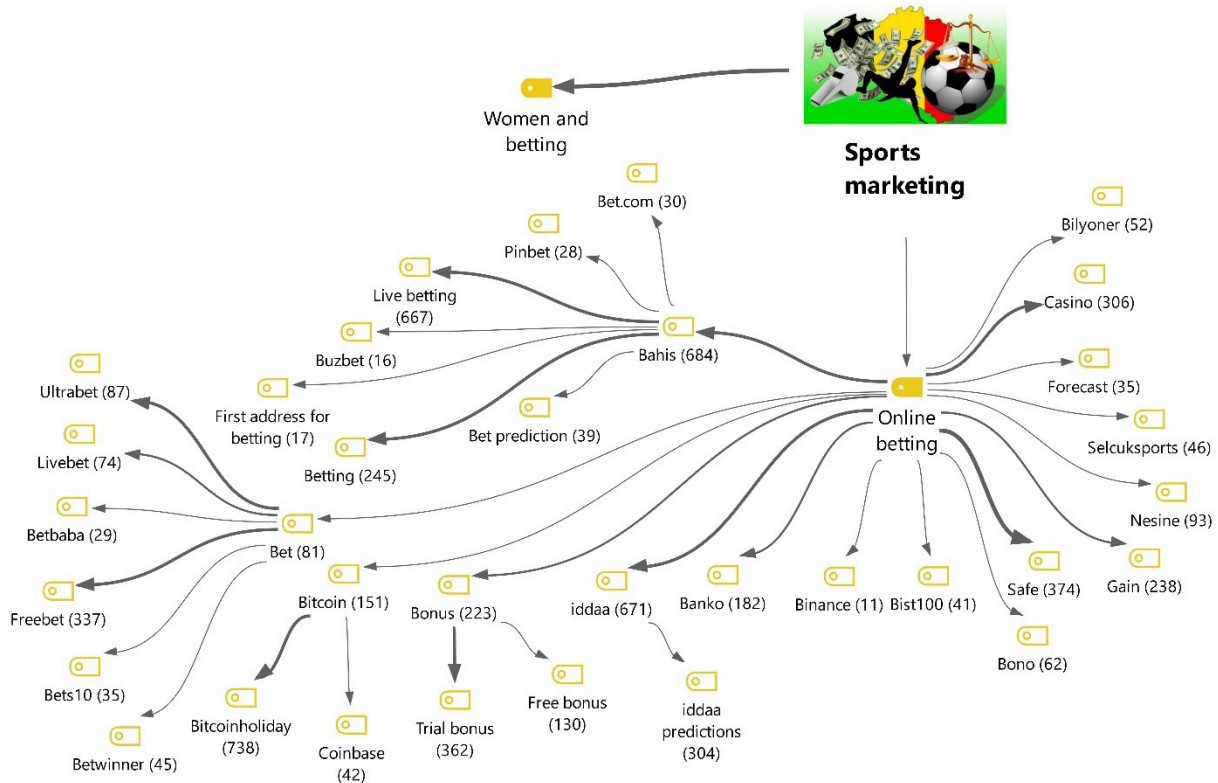
Figure 5: Code-subcode concept network for the main category of sports marketing.

Another main category that emerged as a result of the analysis of Twitter user expressions was the main category of *sports marketing* (Figure 5). The main category of *sports marketing* is reflected in user expressions in football relationality, which has become a very large industry with its dependent informal consumption systematic in addition to formal marketing areas (advertising, product sales, broadcasting respaces, etc.), consists

Among the Twitter hashtags "*Qatar2022, #Morocco, #FIFAWorldCup, #FIFAWorldCup, #WorldCup2022, #BoycottQatar2022*", which constitute the basic dataset of the research, the 19 most frequently used common concepts related to *Qatar2022 and #WorldCup2022*, where the highest code frequency was obtained, are shown in Figure 6. When the hashtags #Qatar2022 and #worldcup2022, which came to the

Figure 6: Qatar2022 and #worldcup2022 the most frequently used common concept network on twitter.

fore in the Twitter activity in which users were involved at different times, were analyzed on the basis of main categories, it was determined that the *political* main category ranked first with 10 common concepts. The *theological* (5), *cultural* (3), and *sports marketing* (1) main categories follow it, respectively. The top fiv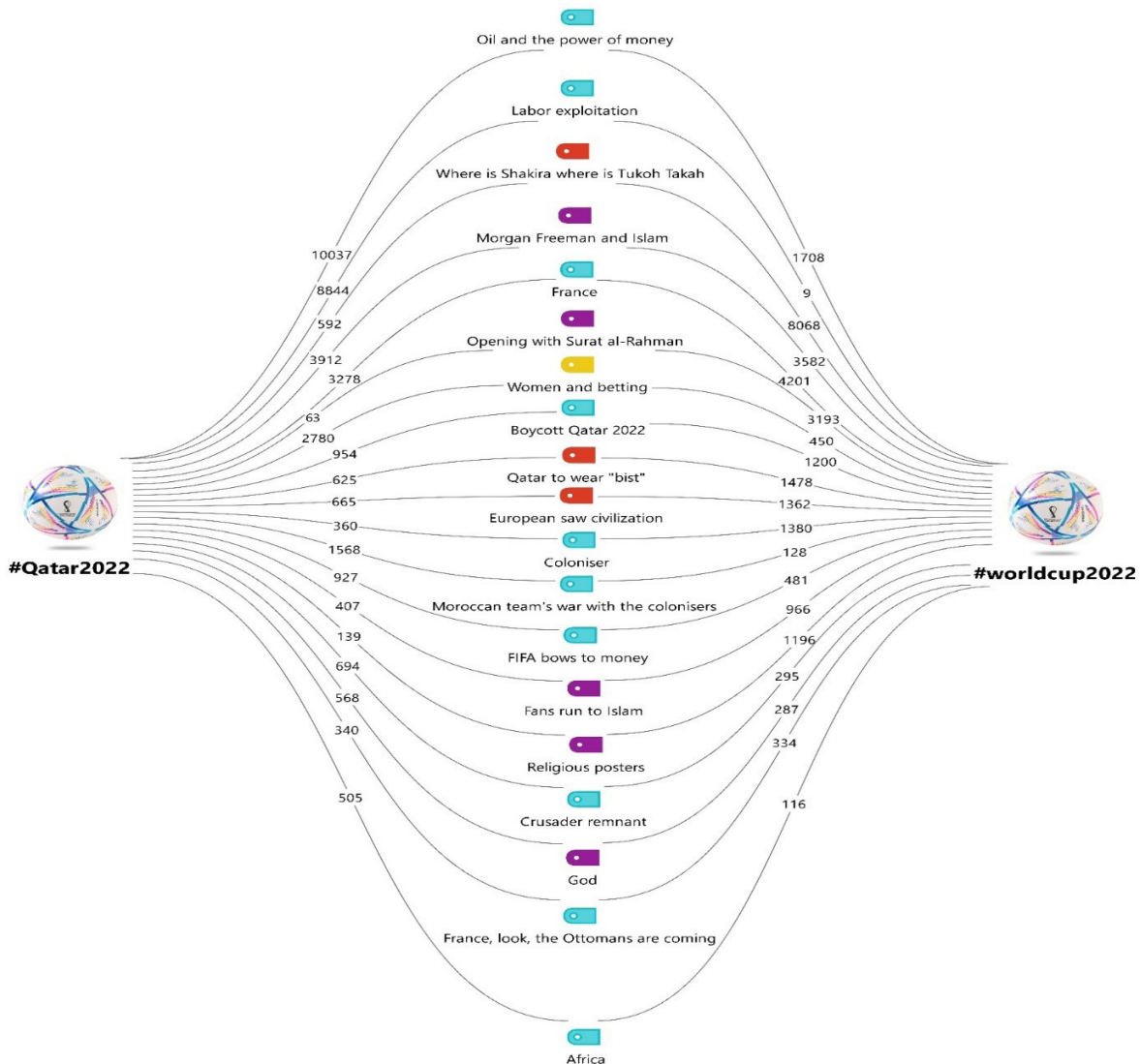e concepts with the highest number of expressions with common concept usage in both datasets are: *oil and the power of money* (11745) and *labor exploitation* (8853), which are under the *political* main category; *where is Shakira and where is Tukoh Takah* (8660), which are under the *cultural* main category; *Morgan Freeman and Islam* (7494), which are under the *theological* main category; and *France*, which is also under the political main category. On the other hand, the common conceptual expressions with the lowest number of frequencies were: *Africa* (621) and *France, look, the Ottomans are coming* (674) in the *political* main category; *Allah* (855) in *the theological*

main category; *crusader remnant* (989) in the *political* main category and *religious posters* (1335) in *the theological* main category. The most balanced common concept emphasis in both Qatar2022 and #worldcup2022 Twitter hashtags was the phrase *France, look, the Ottomans are coming* under the *political* main category, which had frequency densities of 340 and 334 in Qatar2022 and #worldcup2022 hashtags respectively. However, the expression with the most irregular frequency distribution in the common concepts between the two datasets was the concept of *labor* of *exploitation*, which is also connected to the *political* basis category. The concept of *labor exploitation*, which has a frequency number of 8844 in the hashtag *#Qatar2022 (8844), has a* frequency number of 9 in the hashtag *#worldcup2022*.

When Figure 7, which shows the conceptual relations and the intensity of these relations that users put forward through football
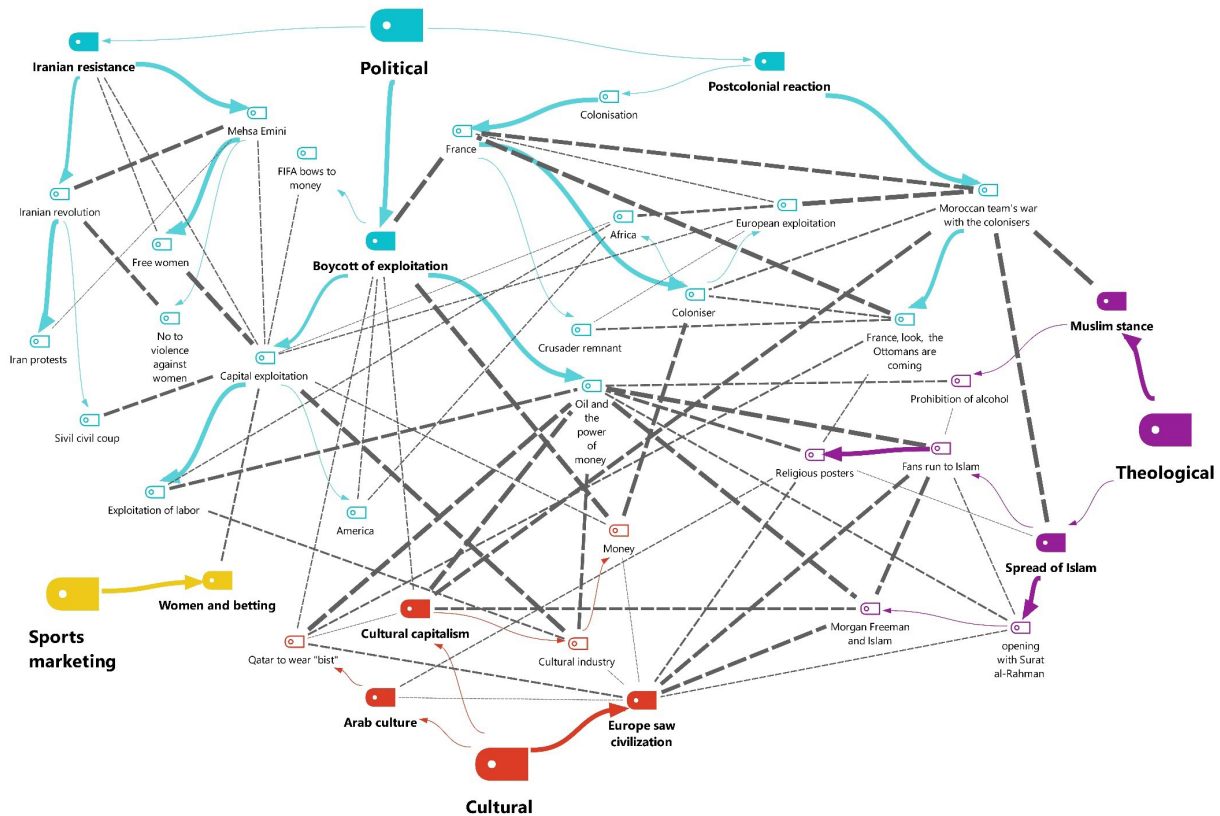
Figure 7: Twitter users' conceptual association network related to the 2022 World Cup context.

spatiality in the context of the 2022 World Cup, is examined, it is determined that the subcategory of *women and betting* under the main category of *sports marketing is* frequently mentioned together with the concept of *capitalist exploitation* in the *political* basic category. The subcategory of *Iranian resistance* under the main category of *politics* is frequently mentioned with the concept of *capital exploitation* under the subcategory of boycott exploitation. This concept is also heavily associated with the notion of *free women* under the concept of *Mehsa Emini*. Both the concepts of *Mehsa Amini* and *free woman* are densely intertwined with the concept of *capital exploitation*, which is in the subcategory boycotting of exploitation. In addition, the concept of *Mehsa Amini* in the *Iranian resistance* subcategory was frequently associated with the *Iranian revolution* and the *Iran protests* related to this concept. The concept of the *Iranian revolution* was frequently emphasized together with the concept of *no to violence against women* under the expression *Mehsa Amini* and with the concept of *capital exploitation* in the *boycott of exploitation* subcategory of the *civil coup* expression under the *Iranian revolution.*

The concept of *boycotting* of *exploitation* in the *political* main category is associated with the concepts of *Qatar to wear*

"bişt", cultural capitalism, and *money* under the *cultural* main category, while at the same time, it is frequently emphasized with the expression *France* in the *postcolonial reaction* subcategory. Again, the concept of *FIFA bows to money* under the subcategory *boycotting* of *exploitation was* frequently mentioned together with the expression *capital exploitation* in the same subcategory, while the concept *of capitalist exploitation* was frequently mentioned together *with the* expressions *European exploitation* and *Africa* in the *postcolonial reaction* subcategory and with the concepts of *money* and *culture industry* under the main category of *culture*. The expression *America, which is* related to the concept of *capital exploitation under the* subcategory *boycott of exploitation,* is frequently mentioned with the concept of *Africa* in the *postcolonial reaction* subcategory, while the concept of *labor of exploitation*, which is also under *capitalist exploitation, is* intensively coded with both the concept of *Africa* and the *cultural industry* in the main category of *culture* and the concepts of *oil* and *the power of money in* the subcategory *boycott of exploitation*. Again, the concept of *oil and the power of money under the* subcategory of a *boycott of exploitation* was frequently associated with the *cultural* main category of *cultural industry, cultural capitalism, Qatar to wear "bist"* and the *theological* main category of

opening *with Surat al-Rahman*, *fans run to Islam, prohibition of alcohol, religious posters* and *Morgan Freeman and Islam*. The concept of the *Moroccan team's war with the colonizers* under the subcategory of *postcolonial reaction* under the main category of *politics* is intensely emphasized with the concepts of the *colonizer*, *France*, and *European exploitation* in the same subcategory. The concept of *Muslim stance* under the *theological* main category is frequently mentioned in terms of the *spread of Islam*, as well as the concept of *cultural capitalism* under the *cultural* main category. In addition, the concept of *France, look, the Ottomans are coming* under the expression of *the Moroccan team's war with the colonizers is* intensely associated with the concepts of *France* and the *crusader remnant and colonizer* concepts under the *postcolonial reaction* subcategory.

The cultural main category was the second category with the highest relationship density after the *political* main category. The *Europa saw civilization* subcategory under this main category, *Qatar to wear "bist"* under the *Arab culture* subcategory, and the *fans run to Islam*, *Morgan Freeman and Islam* under the *theological* main category, were frequently mentioned together with the concepts of *religious posters* and *opening with Surat al-Rahman*. The subcategory of *cultural capitalism* was frequently emphasized with the concepts of *Qatar to wear "bist"* under the *Arab culture* subcategory and *Morgan Freeman and Islam* under the *theological* main category. Again, the expression of *Qatar to wear "bist"* under the *Arab culture* subcategory was frequently emphasized together with the concept of *France, look, the Ottomans are coming* in the *political* main category. Finally, the theological main category is the one in which the relational contexts of Islam and its basic dynamics are presented. Under this main category, the concept of *fans run to Islam* was frequently emphasized with the *opening with Surat al-Rahman, prohibition of alcohol, Morgan Freeman and Islam* in the same main category, while the concept of *religious posters* under this concept was frequently emphasized with the concept of *Arab culture* in the *cultural* main category.

5. DISCUSSION AND CONCLUSION

Relationality, as the fundamental dynamic of the discipline of geography in general and [critical] human geography in particular, creates a dichotomous context by shaping the semiology of dialogical networking between subject and space. These spaces, which can develop in multidimensional forms in the world of meaning of individual and collective memory, are the spaces where social, political, and cultural construction is constantly reconstructed at different scales. The findings

obtained in the context of football spaces within the scope of the research clearly support the dimensions of this relationality.

When the themes that emerged in the context of the main categories in the study were analyzed, it was determined that the *political* main category came to the fore with the subcategories of the *boycott of exploitation, postcolonial reaction, Iranian resistance,* and *political identification* (Table 1). This situation is actually parallel to the chronological adventure of the first emergence of football. Because it is unthinkable that football, which emerged as a tool of the bourgeoisie to numb and intimidate the proletariat, should be isolated from power relations as an alternative field of resistance against hegemonic installations in the process of evolution, as a place of oppositional feelings and emancipation (Arık, 2004, p. 180). In this context, football as a space of revolt against sociopolitical inequality (Rowe, 1996, p. 23) Football continues to be a series of politically charged articulations. Considering the Janus-faced relationship between football and politics, since the subject(s) are actors in this context, they can mobilize by building common ground in different areas of daily life. Therefore, the concept of *Iranian resistance* (Figure 2) categorically emerged in Twitter user expressions depending on the actual situation in the 2022 Qatar World Cup. In this categorization, where the construction between ideology and politics gives rise to social reaction through the female body, football spaces have become oppositional spaces where social strata are organized and the discourse that is expressed/not expressed on the streets is resonated. This is reflected in user expressions through the subcategories of the *boycott of exploitation* and *postcolonial reaction* (Figure 2), which have the highest frequency in the main *political* category. Football spaces, where the image of us and the other is revealed/exposed with sharp boundaries, show that historical realities, conflicts, polarizations, and xenophobic stances are reconstructed at the representation level. As it is understood from the user findings, this relational dimension can inwardly construct the context of *"I"* with *"us"* (as in the subcategory of *political identification*), while determining the distance and legitimacy of *us with the other, thus* ensuring identity formation and continuity. At this point, the concepts of *European exploitation, colonizer, France, Moroccan team's war with the colonizers, France, look, the Ottomans are coming,* and the relations established between them (Figure 7), which are reflected in user expressions through the dialectic of East and West, refer to historical consciousness on the one hand, and on the other hand, they enable the reconstruction of political, social, cultural, etc. identity by constructing the *"self/us"* categorization. Of course, this situation, which takes place in a systemic dimension, is reflected in the frequency density in the subcategory of the *boycott of exploitation* with the concepts of *oil and the power of*
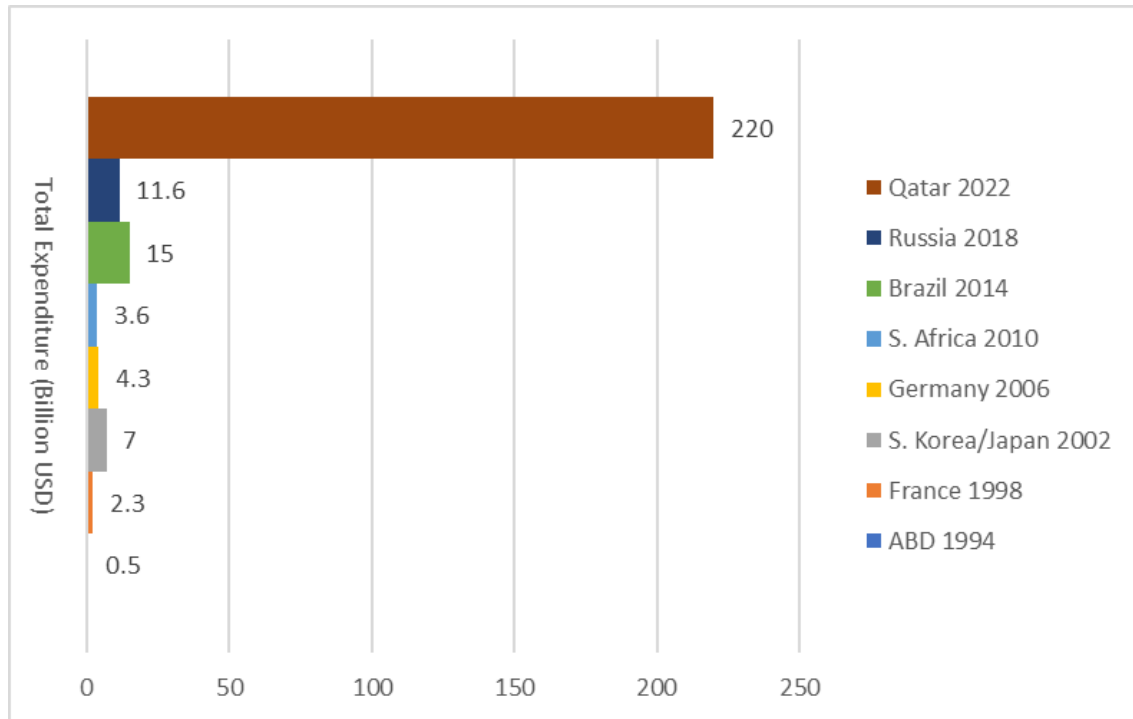
Graphic 2: World Cup expenses by year (Bizimungu, 2022).

money, capital exploitation, America, starvation and waste, exploitation of *labor* in the *political* main category, and the concepts of *online betting, women and betting* (Figure 2) in the main category of *sports marketing* (Figure 5). In this regard, the commodification of football by abstracting it from being an alternative field based on the resistance of the subject to democratic foundations is reflected in the concept network through two basic contexts: First, it reveals the relationship between football and capital. In particular, the financial expenditure that arises as a result of the mass dissemination of the consumption industry to produce the economic objectives of capitalist exploitation is emphasized through the context of unequal geographies (such as the concept of *starvation and waste*).

For example, the fact that many urgent humanitarian emergencies in the African continent could be eliminated with the 220 billion dollars spent by Qatar during the 2022 World Cup (Graphic 2) is one of the important indicators of this inequality. The second, related to the first issue, is the fetishization of individuals and their bodies in the context of football and the diversification of consumption concepts for them in order for capital to gain more profit. In this regard, the main category of *sports marketing* (Figure 5), which came to the fore with the concepts of *online betting, betting, and women* in user statements, was a basic reflection of this relationship. So much so that while the online betting market creates a new exploitation area with its huge capital (1 trillion dollars), it also creates masses who want to get a share of economic rent through systematic constructions

based on consent. The female body is the most important phenomenon instrumental in integrating these masses into the betting market offered through football relationality. As it is understood from the user findings (Figure 5 and Figure 8), the female body is put forward as an element of *"pleasure"* in the consumption of the product (Figure 8). This situation, which objectifies individuals, reveals perceptual relations through the sense of emotional/physical curiosity, and creates the desire for consumption through contextual setups between the environment and the subject, is a scopophilic hegemonic structuring situation in which looking is dematerialized as a source of pleasure (Mulvey, 1997). In fact, the transformation of the female body into a marketing tool is not a new phenomenon but constitutes the basic impulse of capital functioning. However, this increasingly intensive use of football, which is based on a masculine construction with its practical forms, is a result of the categorical relational consumption of capital through the entertainment sector. Thus, both physical and digital spatial appearances are coded through scopophilic relations, and the individual can legitimize the system of exploitation of which he is the object.

Another important result obtained from the research findings is the relationship between sport, religion, cultural value transmission, and preservation. In this framework, it is observed that *the theological* basis category (Figure 3) with its subcategories of *Muslim stance (prohibition of drinking)* and *spreading Islam (fans run to Islam and opening with Surat al-Rahman)* comes

second in terms of frequency density (Table 1). Given the fact that the World Cup was organized in a Muslim country for the first time, the link between Islam and sports has been on the agenda more intensely than ever before. In addition, the fact that it is based on an ideological antagonism between Eastern and Western civilizations has led to the establishment of the relationship between religion and sport on this ground. For example, in terms of concept density, the fact that the phrase "*Moroccan team's war with the colonizers*" under the *political* main category was frequently mentioned together with the concept of the *spread of Islam* under the *theological* main category (Figure 7) was a result of this relationality constructed through symbolic practices. However, another important phenomenon is efforts to maintain conservative attitudes through the correlation between religious
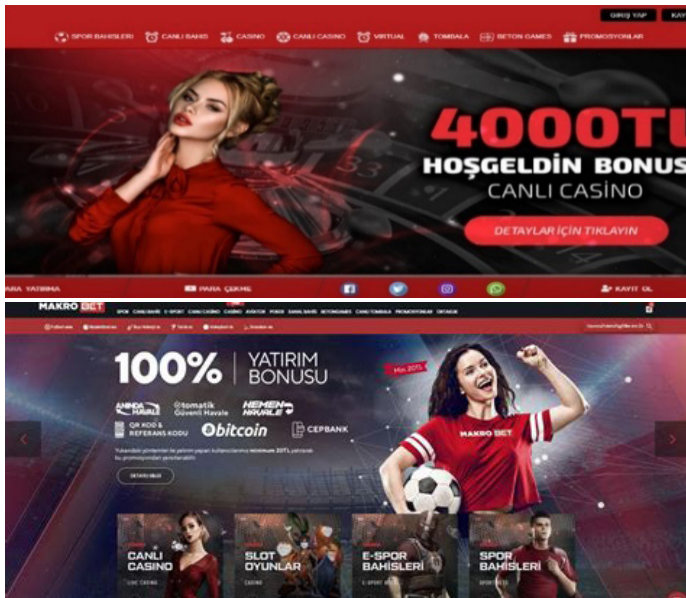

Figure 8: An example of an advertisement showing the marketing of betting games through the female body
Source: https://www.casinomaxi708.com/tr/hesap-ac?from=GmxISJ1o
TyDMnYCv0X82xmNd7ZgqdRLk-AO0853447337&poduct
=common Accessed 04.01.2022.

Figure 9: Lionel Messi's scene wearing the Qatar Bist in the 2022 World Cup Final (Kilani, 2022).

change and adaptation to global trends. In particular, the alcohol debates that emerged during the 2022 World Cup and the alcohol regulation of the Qatari administration have been aimed at ensuring this harmony and conservative attitude. However, aggressive marketing and visibility of alcoholic beverages in sports through sponsorships and TV advertisements during football competitions is an important component. (Bodet & Amara, 2015). Qatar has tried to reconcile these two diametrically opposed spectrums by allowing the sale of alcohol in licensed spaces in the country but not in stadiums. Thus, it tried to balance the steps toward modernization with the preservation of tradition. In addition, sports competitions play an important role in cultural transmission between individuals and societies with different social values in different geographies, as in the relationality between religion and football (especially accelerated by digital information tools). This transfer, which usually occurs as a result of rational practices, is made functional in parallel with the means of capital exploitation. Moreover, as an outcome of the hegemonic nature of the context between capitalist capital and liberal democracy, it can be stated that it is the semiotic manifestation of power-oriented legitimacy (Figure 9). At this point, the fact that the concepts of *Arab culture (Qatar to wear "bist"), Europeans saw civilization* and *cultural capitalism (where is Shakira where is Tukoh Takah, culture industry)* (Figure 4) under the main category of *culture (*Figure 7), which were among the findings of the study, were intensively emphasized by the users together with the expressions of *boycott of exploitation* and *spread of Islam (Figure 4)* was a reflection of this relationality.

As a result, it was determined in the research that football spaces have multidimensional relations that are constructed by different actors rather than a static and apolitical structure. It is understood that football pitches, where spatial boundaries are significantly exceeded as application areas, can construct relational contexts with many forms of daily life such as identification, acculturation, politicization, and resistance against the structure of individuals and societies. It can also be stated that they can be instrumentalized in the functioning of the exploitation system as places that ensure the continuity of capital, which commodities all kinds of social phenomena. Therefore, it is concluded that football spaces, which are not directly seen as a hegemonic apparatus due to both explicit and implicit dynamics, play a role as an important component in their increasing sociopolitical, economic, and cultural relations.

NOTES

1 Figure 7, which shows the relationships between main categories, subcategories, and concepts shaped by the expressions of Twitter users, was created according to the following dynamics: (a) Each main category is constructed as a separate network of relationships. (b) The

main category is located at the center of the network and subcategories and concepts are designed to radiate from this center to the periphery. (c) The main category, subcategory, and related concepts are shaped in different colors to facilitate distinction. (d) The main category, subcategory, and concept links are shown with colored, continuous lines and the arrow directions indicate the subordinate-superior hierarchy of the code system. Relationships between subcategories and concepts are shown with discolored and dashed lines. (e) The thicknesses of both the colored, continuous lines showing the main category, subcategory, and code connection between the concepts and the colorless, dashed lines showing the relationship between them were created in a way that their thicknesses are directly proportional to the frequency rates.

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YAZARLARA BİLGİ

DERGİNİN TANIMI

Coğrafya Dergisi - Journal of Geography açık erişimli, hakemli, yılda iki kere Haziran ve Aralık aylarında yayınlanan, 1985 yılından beri yayın hayatını sürdüren bilimsel bir dergidir. Dergiye yayınlanması için gönderilen bilimsel makaleler Türkçe ya da İngilizce olmalıdır.

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Coğrafya Dergisi zamana ve mekana bağlı fiziki ve beşeri problemler için çözüm üreten coğrafi yaklaşımlara ait (fiziki, beşeri, doğal çevre ve coğrafi bilgi sistemleri) bilimsel araştırmaların yayınlanmasına, bu yönüyle bilimsel bilginin paylaşılmasına imkan sağlayan bir dergidir. 1985 yılından beri yayın hayatını sürdüren dergi bu yönüyle Türkiye'deki en eski coğrafya bilimi dergilerinden birisidir.

Derginin ana motivasyonu çağın gerektirdiği sosyal, fiziki ve doğa-insan ilişkilerinin ve bunun sistematiğinin anlaşılması için bilimsel çözümler üreten eserlere bir platform oluşturmaktır. Bu bakımdan dergi, coğrafya bilimini uygulayarak beşeri ve fiziki coğrafya problemlerine çözüm üreten her özgün makaleye açıktır.

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Dergi yayın etiğinde en yüksek standartlara bağlıdır ve Committee on Publication Ethics (COPE), Directory of Open Access Journals (DOAJ), Open Access Scholarly Publishers Association (OASPA) ve World Association of Medical Editors (WAME) tarafından yayınlanan etik yayıncılık ilkelerini benimser; Principles of Transparency and Best Practice in Scholarly Publishing başlığı altında ifade edilen ilkeler için: https://publicationethics.org/resources/guidelines-new/principles-transparency-and-best-practice-scholarly-publishing

Gönderilen makaleler derginin amaç ve kapsamına uygun olmalıdır. Orijinal, yayınlanmamış ve başka bir dergide değerlendirme sürecinde olmayan, her bir yazar tarafından içeriği ve gönderimi onaylanmış yazılar değerlendirmeye kabul edilir.

Makale yayınlanmak üzere Dergiye gönderildikten sonra yazarlardan hiçbirinin ismi, tüm yazarların yazılı izni olmadan yazar listesinden silinemez ve yeni bir isim yazar olarak eklenemez ve yazar sırası değiştirilemez.

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ETİK

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YAZARLARA BİLGİ

Principles of Transparency and Best Practice in Scholarly Publishing başlığı altında ifade edilen ilkeler için adres: https://publicationethics. org/resources/guidelines-new/principles-transparency-and-best-practice-scholarly-publishing

Gönderilen tüm makaleler orijinal, yayınlanmamış ve başka bir dergide değerlendirme sürecinde olmamalıdır. Her bir makale editörlerden biri ve en az iki hakem tarafından çift kör değerlendirmeden geçirilir. İntihal, duplikasyon, sahte yazarlık/inkar edilen yazarlık, araştrma/veri fabrikasyonu, makale dilimleme, dilimleyerek yayın, telif hakları ihlali ve çıkar çatışmasının gizlenmesi, etik dışı davranışlar olarak kabul edilir.

Kabul edilen etik standartlara uygun olmayan tüm makaleler yayından çıkarılır. Buna yayından sonra tespit edilen olası kuraldışı, uygunsuzluklar içeren makaleler de dahildir.

Araştırma Etiği

Coğrafya Dergisi – Journal of Geography araştırma etiğinde en yüksek standartları gözetir ve aşağıda tanımlanan uluslararası araştırma etiği ilkelerini benimser. Makalelerin etik kurallara uygunluğu yazarların sorumluluğundadır.

- Araştırmanın tasarlanması, tasarımın gözden geçirilmesi ve araştırmanın yürütülmesinde, bütünlük, kalite ve şeffaflık ilkeleri sağlanmalıdır.
- Araştırma ekibi ve katılımcılar, araştırmanın amacı, yöntemleri ve öngörülen olası kullanımları; araştırmaya katılımın gerektirdikleri ve varsa riskleri hakkında tam olarak bilgilendirilmelidir.
- Araştırma katılımcılarının sağladığı bilgilerin gizliliği ve yanıt verenlerin gizliliği sağlanmalıdır.
- Araştırma katılımcıların özerkliğini ve saygınlığını koruyacak şekilde tasarlanmalıdır.
- Araştırma katılımcıları gönüllü olarak araştırmada yer almalı, herhangi bir zorlama altında olmamalıdırlar.
- Katılımcıların zarar görmesinden kaçınılmalıdır. Araştırma, katılımcıları riske sokmayacak şekilde planlanmalıdır.
- Araştırma bağımsızlığıyla ilgili açık ve net olunmalı; çıkar çatışması varsa belirtilmelidir.
- İnsan denekler ile yapılan deneysel çalışmalarda, araştırmaya katılmaya karar veren katılımcıların yazılı bilgilendirilmiş onayı alınmalıdır. Çocukların ve vesayet altındakilerin veya tasdiklenmiş akıl hastalığı bulunanların yasal vasisinin onayı alınmalıdır.
- Çalışma herhangi bir kurum ya da kuruluşta gerçekleştirilecekse bu kurum ya da kuruluştan çalışma yapılacağına dair onay alınmalıdır.
- İnsan öğesi bulunan çalışmalarda, "yöntem" bölümünde katılımcılardan "bilgilendirilmiş onam"

alındığının ve çalışmanın yapıldığı kurumdan etik kurul onayı alındığının belirtilmesi gerekir.

Yazarların Sorumluluğu

Makalelerin bilimsel ve etik kurallara uygunluğu yazarların sorumluluğundadır. Yazar makalenin orijinal olduğu, daha önce başka bir yerde yayınlanmadığı ve başka bir yerde, başka bir dilde yayınlanmak üzere değerlendirmede olmadığı konusunda teminat sağlamalıdır. Uygulamadaki telif kanunları ve anlaşmaları gözetilmelidir. Telife bağlı materyaller (örneğin tablolar, şekiller veya büyük alıntılar) gerekli izin ve teşekkürle kullanılmalıdır. Başka yazarların, katkıda bulunanların çalışmaları ya da yararlanılan kaynaklar uygun biçimde kullanılmalı ve referanslarda belirtilmelidir.

Gönderilen makalede tüm yazarların akademik ve bilimsel olarak doğrudan katkısı olmalıdır, bu bağlamda "yazar" yayınlanan bir araştırmanın kavramsallaştırılmasına ve dizaynına, verilerin elde edilmesine, analizine ya da yorumlanmasına belirgin katkı yapan, yazının yazılması ya da bunun içerik açısından eleştirel biçimde gözden geçirilmesinde görev yapan birisi olarak görülür. Yazar olabilmenin diğer koşulları ise, makaledeki çalışmayı planlamak veya icra etmek ve / veya revize etmektir. Fon sağlanması, veri toplanması ya da araştırma grubunun genel süpervizyonu tek başına yazarlık hakkı kazandırmaz. Yazar olarak gösterilen tüm bireyler sayılan tüm ölçütleri karşılamalıdır ve yukarıdaki ölçütleri karşılayan her birey yazar olarak gösterilebilir. Yazarların isim sıralaması ortak verilen bir karar olmalıdır. Tüm yazarlar yazar sıralamasını Telif Hakkı Anlaşması Formunda imzalı olarak belirtmek zorundadırlar.

Yazarlık için yeterli ölçütleri karşılamayan ancak çalışmaya katkısı olan tüm bireyler "teşekkür / bilgiler" kısmında sıralanmalıdır. Bunlara örnek olarak ise sadece teknik destek sağlayan, yazıma yardımcı olan ya da sadece genel bir destek sağlayan, finansal ve materyal desteği sunan kişiler verilebilir.

Bütün yazarlar, araştırmanın sonuçlarını ya da bilimsel değerlendirmeyi etkileyebilme potansiyeli olan finansal ilişkiler, çıkar çatışması ve çıkar rekabetini beyan etmelidirler. Bir yazar kendi yayınlanmış yazısında belirgin bir hata ya da yanlışlık tespit ederse, bu yanlışlıklara ilişkin düzeltme ya da geri çekme için editör ile hemen temasa geçme ve işbirliği yapma sorumluluğunu taşır.

Editör ve Hakem Sorumlulukları

Editörler, makaleleri, yazarların etnik kökeninden, cinsiyetinden, cinsel yöneliminden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirirler. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlarlar. Gönderilen makalelere ilişkin tüm bilginin, makale yayınlanana kadar gizli kalacağını garanti ederler. Editörler içerik ve yayının toplam kalitesinden sorumludurlar. Gereğinde hata sayfası yayınlamalı ya da düzeltme yapmalıdır.

Editör; yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkiye sahiptir ve Dergide yayınlanacak makalelerle ilgili nihai kararı vermekle yükümlüdür.

Hakemler makaleleri, yazarların etnik kökeninden, cinsiyetinden, cinsel yöneliminden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirirler. Araştırmayla ilgili, yazarlarla ve/veya

araştırmanın finansal destekçileriyle çıkar çatışmaları olmamalıdır. Değerlendirmelerinin sonucunda tarafsız bir yargıya varmalıdırlar. Hakemler yazarların atıfta bulunmadığı konuyla ilgili yayınlanmış çalışmaları tespit etmelidirler. Gönderilmiş yazılara ilişkin tüm bilginin gizli tutulmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar. Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kendileri için makalelerin kopyalarını çıkarmalarına izin verilmez ve editörün izni olmadan makaleleri başkasına veremezler. Yazarın ve editörün izni olmadan hakemlerin gözden geçirmeleri basılamaz ve açıklanamaz. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir. Bazı durumlarda editörün kararıyla, ilgili hakemlerin makaleye ait yorumları aynı makaleyi yorumlayan diğer hakemlere gönderilerek hakemlerin bu süreçte aydınlatılması sağlanabilir.

HAKEMLİK HAKKINDA

Hakem Değerlendirme Politikaları

Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir. Gönderilen ve ön kontrolü geçen makaleler iThenticate yazılımı kullanılarak intihal için taranır. İntihal kontrolünden sonra, uygun olan makaleler baş editör tarafından orijinallik, metodoloji, işlenen konunun önemi ve dergi kapsamı ile uyumluluğu açısından değerlendirilir.

Seçilen makaleler en az iki ulusal/uluslararası hakeme çift taraflı kör hakemlik ile değerlendirmeye gönderilir; yayın kararı, hakemlerin talepleri doğrultusunda yazarların gerçekleştirdiği düzenlemelerin ve hakem sürecinin sonrasında baş editör tarafından verilir.

Hakem Süreci

Daha önce yayınlanmamış ya da yayınlanmak üzere başka bir dergide halen değerlendirmede olmayan ve her bir yazar tarafından onaylanan makaleler değerlendirilmek üzere kabul edilir. Gönderilen ve ön kontrolü geçen makaleler iThenticate yazılımı kullanılarak intihal için taranır. İntihal kontrolünden sonra, uygun olan makaleler baş editör tarafından orijinallik, metodoloji, işlenen konunun önemi ve dergi kapsamı ile uyumluluğu açısından değerlendirilir.

Baş Editör, makaleleri, yazarların etnik kökeninden, cinsiyetinden, uyruğundan, dini inancından ve siyasi felsefesinden bağımsız olarak değerlendirir. Yayına gönderilen makalelerin adil bir şekilde çift taraflı kör hakem değerlendirmesinden geçmelerini sağlar.

Seçilen makaleler en az iki ulusal/uluslararası hakeme değerlendirmeye gönderilir; yayın kararı, hakemlerin talepleri doğrultusunda yazarların gerçekleştirdiği düzenlemelerin ve hakem sürecinin sonrasında baş editör tarafından verilir.

Baş editör; yazarlar, editörler ve hakemler arasında çıkar çatışmasına izin vermez. Hakem atama konusunda tam yetkiye sahiptir ve dergide yayınlanacak makalelerle ilgili nihai kararı vermekle yükümlüdür.

Hakemlerin değerlendirmeleri objektif olmalıdır. Hakem süreci sırasında hakemlerin aşağıdaki hususları dikkate alarak değerlendirmelerini yapmaları beklenir.

- Makale yeni ve önemli bir bilgi içeriyor mu?
- Öz, makalenin içeriğini net ve düzgün bir şekilde tanımlıyor mu?
- Yöntem bütünlüklü ve anlaşılır şekilde tanımlanmış mı?
- Yapılan yorum ve varılan sonuçlar bulgularla kanıtlanıyor mu?
- Alandaki diğer çalışmalara yeterli referans verilmiş mi?
- Dil kalitesi yeterli mi?

Hakemler, gönderilen makalelere ilişkin tüm bilginin, makale yayınlana kadar gizli kalmasını sağlamalı ve yazar tarafında herhangi bir telif hakkı ihlali ve intihal fark ederlerse editöre raporlamalıdırlar.

Hakem, makale konusu hakkında kendini vasıflı hissetmiyor ya da zamanında geri dönüş sağlaması mümkün görünmüyorsa, editöre bu durumu bildirmeli ve hakem sürecine kendisini dahil etmemesini istemelidir.

Değerlendirme sürecinde editör hakemlere gözden geçirme için gönderilen makalelerin, yazarların özel mülkü olduğunu ve bunun imtiyazlı bir iletişim olduğunu açıkça belirtir. Hakemler ve yayın kurulu üyeleri başka kişilerle makaleleri tartışamazlar. Hakemlerin kimliğinin gizli kalmasına özen gösterilmelidir.

DİL

Derginin yayın dili Türkçe ve İngilizce'dir.

YAZILARIN HAZIRLANMASI

Aksi belirtilmedikçe gönderilen yazılarla ilgili tüm yazışmalar ilk yazarla yapılacaktır. Makale gönderimi online olarak ve http://jgeography.istanbul.edu.tr üzerinden yapılmalıdır. Yazılar, yazının Dergide yayınlanmak üzere gönderildiğini ve Derginin hangi bölümü (örn: orijinal araştırma, derleme, vb) için başvurulduğunu belirten bir mektup ve tüm yazarların imzaladığı 'Telif Hakkı Anlaşması Formu' eklenerek gönderilmelidir.

1. Çalışmalar, üst, alt, sağ ve sol taraftan 2,5 cm. boşluk bırakılarak, 12 punto Times New Roman harf karakterleriyle ve 1,5 satır aralık ölçüsü ile hazırlanmalıdır.
2. Çalışmalar en fazla 25 sayfa olmalı, sayfa numaraları sayfanın sağ üst köşesinde yer almalıdır.

YAZARLARA BİLGİ

3. Yazar/yazarların adları çalışmanın başlığının hemen altında sağa bitişik şekilde verilmelidir. Ayrıca yıldız dipnot şeklinde (*) yazarın unvanı, kurumu ve e-posta adresi ve telefonu sayfanın en altında dipnotta belirtilmelidir.

4. Giriş bölümünden önce 180-200 sözcük arasında çalışmanın kapsamını, amacını, ulaşılan sonuçları ve kullanılan yöntemi kaydeden Türkçe ve İngilizce öz ile 600-800 kelimelik İngilizce genişletilmiş özet yer almalıdır. Çalışmanın İngilizce başlığı İngilizce özün üzerinde yer almalıdır. İngilizce ve Türkçe özlerin altında çalışmanın içeriğini temsil eden 3 İngilizce, 3 Türkçe anahtar kelime yer almalıdır.

5. Çalışmaların başlıca şu unsurları içermesi gerekmektedir: Başlık, Türkçe öz ve anahtar kelimeler; yabancı dilde başlık, İngilizce öz ve anahtar kelimeler; İngilizce genişletilmiş özet, ana metin bölümleri, son notlar ve kaynaklar.

6. Çalışmanın giriş bölümü "1. GİRİŞ" şeklinde belirtilmelidir. Alt bölümler her bölüm içinde bölüm numarası kullanılarak, "1.1", "1.2" şeklinde numaralandırılmalıdır. Araştırma yazılarında sorunsalın betimlendiği ve çalışmanın öneminin belirtildiği GİRİŞ bölümünü "AMAÇ VE YÖNTEM", "BULGULAR", "TARTIŞMA VE SONUÇ", "SON NOTLAR" "KAYNAKLAR" ve "TABLOLAR VE ŞEKİLLER" gibi bölümler takip etmelidir. Derleme ve yorum yazıları için ise, çalışmanın öneminin belirtildiği, sorunsal ve amacın somutlaştırıldığı "GİRİŞ" bölümünün ardından diğer bölümler gelmeli ve çalışma "TARTIŞMA VE SONUÇ", "SON NOTLAR", "KAYNAKLAR" ve "TABLOLAR VE ŞEKİLLER" şeklinde bitirilmelidir.

7. Çalışmalarda tablo, grafik ve şekil gibi göstergeler numaralandırılarak, tanımlayıcı bir başlık ile birlikte verilmelidir.

8. Yayınlanmak üzere gönderilen makale ile birlikte yazar bilgilerini içeren kapak sayfası gönderilmelidir. Kapak sayfasında, makalenin başlığı, yazar veya yazarların bağlı bulundukları kurum ve unvanları, kendilerine ulaşılabilecek adresler, cep, iş ve faks numaraları ve e-posta adresleri yer almalıdır (bkz. Son Kontrol Listesi).

9. Kurallar dâhilinde dergimize yayınlanmak üzere gönderilen çalışmaların her türlü sorumluluğu yazar/yazarlarına aittir.

10. Yayın kurulu ve hakem raporları doğrultusunda yazarlardan, metin üzerinde bazı düzeltmeler yapmaları istenebilir.

11. Dergiye gönderilen çalışmalar yayınlansın veya yayınlanmasın geri gönderilmez.

12. Yayın kurulu tarafından yayınlanması uygun bulunan makaleler başka bir yerde yayınlanamaz. Yazarlara telif ücreti ödenmez.

Kaynaklar

Derleme yazıları okuyucular için bir konudaki kaynaklara ulaşmayı kolaylaştıran bir araç olsa da, her zaman orijinal çalışmayı doğru olarak yansıtmaz. Bu yüzden mümkün olduğunca yazarlar orijinal çalışmaları kaynak göstermelidir. Öte yandan, bir konuda çok fazla sayıda orijinal çalışmanın kaynak gösterilmesi yer israfına neden olabilir. Birkaç anahtar orijinal çalışmanın kaynak gösterilmesi genelde uzun listelerle aynı işi görür. Ayrıca günümüzde kaynaklar elektronik versiyonlara eklenebilmekte ve okuyucular elektronik literatür taramalarıyla yayınlara kolaylıkla ulaşabilmektedir.

Kabul edilmiş ancak henüz sayıya dahil edilmemiş makaleler Early View olarak yayınlanır ve bu makalelere atıflar "advance online publication" şeklinde verilmelidir. Genel bir kaynaktan elde edilemeyecek temel bir konu olmadıkça "kişisel iletişimlere" atıfta bulunulmamalıdır. Eğer atıfta bulunulursa parantez içinde iletişim kurulan kişinin adı ve iletişimin tarihi belirtilmelidir. Bilimsel makaleler için yazarlar bu kaynaktan yazılı izin ve iletişimin doğruluğunu gösterir belge almalıdır. Kaynakların doğruluğundan yazar(lar) sorumludur. Tüm kaynaklar metinde belirtilmelidir. Kaynaklar alfabetik olarak sıralanmalıdır.

Referans Stili ve Formatı

Dergiye gönderilen makalelerde American Psychological Association (APA) kaynak sitilinin kullanılması esastır. Yazarlar, makale metninde ve kaynakçada yer alan atıfları, APA stiline uygun olarak belirtmelidir.

Kaynakların doğruluğundan yazar(lar) sorumludur. Tüm kaynaklar metinde belirtilmelidir. Kaynaklar aşağıdaki örneklerdeki gibi gösterilmelidir.

Metin İçinde Kaynak Gösterme

Kaynaklar metinde parantez içinde yazarların soyadı ve yayın tarihi yazılarak belirtilmelidir. Birden fazla kaynak gösterilecekse kaynaklar arasında (;) işareti kullanılmalıdır. Kaynaklar alfabetik olarak sıralanmalıdır.

Örnekler:

Birden fazla kaynak;
(Esin vd., 2002; Karasar, 1995)
Tek yazarlı kaynak;
(Akyolcu, 2007)
İki yazarlı kaynak;
(Sayıner ve Demirci, 2007, s. 72)
Üç, dört ve beş yazarlı kaynak;
Metin içinde ilk kullanımda: (Ailen, Ciambrune ve Welch, 2000, s. 12–13) Metin içinde tekrarlayan kullanımlarda: (Ailen vd., 2000)
Altı ve daha çok yazarlı kaynak;
(Çavdar vd., 2003)
Kaynaklar Bölümünde Kaynak Gösterme

Kullanılan tüm kaynaklar metnin sonunda ayrı bir bölüm halinde yazar soyadlarına göre alfabetik olarak numaralandırılmadan verilmelidir.

Kaynak yazımı ile ilgili örnekler aşağıda verilmiştir.

Kitap

a) Türkçe Kitap
Karasar, N. (1995). *Araştırmalarda rapor hazırlama* (8.bs). Ankara: 3A Eğitim Danışmanlık Ltd.
b) Türkçeye Çevrilmiş Kitap
Mucchielli, A. (1991). *Zihniyetler* (A. Kotil, Çev.). İstanbul: İletişim Yayınları.

YAZARLARA BİLGİ

c) Editörlü Kitap

Ören, T., Üney, T. ve Çölkesen, R. (Ed.). (2006). *Türkiye bilişim ansiklopedisi.* İstanbul: Papatya Yayıncılık.

d) Çok Yazarlı Türkçe Kitap

Tonta, Y., Bitirim, Y. ve Sever, H. (2002). *Türkçe arama motorlarında performans değerlendirme.* Ankara: Total Bilişim.

e) İngilizce Kitap

Kamien R., & Kamien A. (2014). *Music: An appreciation.* New York, NY: McGraw-Hill Education.

f) İngilizce Kitap İçerisinde Bölüm

Bassett, C. (2006). Cultural studies and new media. In G. Hall & C. Birchall (Eds.), *New cultural studies: Adventures in theory* (pp. 220–237). Edinburgh, UK: Edinburgh University Press.

g) Türkçe Kitap İçerisinde Bölüm

Erkmen, T. (2012). Örgüt kültürü: Fonksiyonları, öğeleri, işletme yönetimi ve liderlikteki önemi. M. Zencirkıran (Ed.), *Örgüt sosyolojisi kitabı* içinde (s. 233–263). Bursa: Dora Basım Yayın.

h) Yayımcının ve Yazarın Kurum Olduğu Yayın

Türk Standartları Enstitüsü. (1974). *Adlandırma ilkeleri.* Ankara: Yazar.

Makale

a) Türkçe Makale

Mutlu, B. ve Savaşer, S. (2007). Çocuğu ameliyat sonrası yoğun bakımda olan ebeveynlerde stres nedenleri ve azaltma girişimleri. *İstanbul Üniversitesi Florence Nightingale Hemşirelik Dergisi, 15*(60), 179–182.

b) İngilizce Makale

de Cillia, R., Reisigl, M., & Wodak, R. (1999). The discursive construction of national identity. *Discourse and Society, 10*(2), 149–173. http://dx.doi.org/10.1177/0957926599010002002

c) Yediden Fazla Yazarlı Makale

Lal, H., Cunningham, A. L., Godeaux, O., Chlibek, R., Diez-Domingo, J., Hwang, S.-J. ... Heineman, T. C. (2015). Efficacy of an adjuvanted herpes zoster subunit vaccine in older adults. *New England Journal of Medicine, 372,* 2087–2096. http://dx.doi.org/10.1056/NEJMoa1501184

d) DOI'si Olmayan Online Edinilmiş Makale

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g) Müzik Kaydı

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Tonta, Y., Bitirim, Y., & Sever, H. (2002). T*ürkçe arama motorlarında performans değerlendirme* [Performance evaluation in Turkish search engines]. Ankara, Turkey: Total Bilişim.
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Erkmen, T. (2012). Örgüt kültürü: Fonksiyonları, öğeleri, işletme yönetimi ve liderlikteki önemi [Organization culture: Its functions, elements and importance in leadership and business management]. In M. Zencirkıran (Ed.), *Örgüt sosyolojisi* [Organization sociology] (pp. 233–263). Bursa, Turkey: Dora Basım Yayın.

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American Psychological Association. (2009). *Publication manual of the American psychological association* (6th ed.). Washington, DC: Author.

Article

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b) English Article
de Cillia, R., Reisigl, M., & Wodak, R. (1999). The discursive construction of national identity. *Discourse and Society, 10*(2), 149–173. doi:10.1177/0957926599010002002
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f) Advance Online Publication
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g) Article in a Magazine
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