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Research Article

Application of Hypothetical Ecological Risk Analysis to Sustainable Usage of Possible Winter Recreation Areas in Seyhan Basin (Türkiye)

Okan Yeler[1], Gazel Burcu Aydın[2], Belgin Çamur-Elipek[2], Süha Berberoğlu[3]

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ABSTRACT

In this study, the long-term suitability of the area proposals for winter recreation activities in the Seyhan Basin (Türkiye), which is located in the Mediterranean and Central Anatolia regions and includes a large part of the Taurus Mountains, were examined ecologically. For this purpose, the predicted global warming scenarios in the basin and the anthropogenic impacts arising from the planned recreation areas were evaluated for the upper basin (recreation areas) and lower basin (water resources, agricultural lands, and settlements) using a hypothetical risk analysis. For this purpose, multispectral images were obtained by using Landsat 8 Oli Multispectral images of the snow areas in the region in January-February-March 2019, and a hypothetical ecological risk analysis was created considering a total of 5 pressure factors originating from global climate change and anthropogenic effects. These possible factors were determined as flood (S1), drought (S2), sedimentation (S3), aquatic nutrients (S4), and tourist density (S5). The effects of these factors on a total of four features (C1: water quality, C2: fauna-flora, C3: agricultural areas, and C4: settlements) in the region were evaluated by hypothetical grading based on the literature. According to the hypothesis results obtained by the formula and statistical calculations, it was determined that the flood factor (S1) that will occur due to possible snow melt due to global climate change in the winter recreation areas in the studied region is the most significant factor limiting the sustainable usage of the Basin. For this reason, it has been emphasized in this study that the possibility of regions being exposed to the effects of climate change in the future should be taken into account, especially when planning for winter recreation areas. At the end of this study, it was concluded that the ecological balance analysis of basins is important, especially in terms of ensuring the long-term sustainable use of winter recreation areas.

Keywords: Climate change, Ecology, Environmental parameters, Hypothetical risk, Sustainability

ORCID IDs of the author:
O.Y. 0000-0002-0405-4829;
G.B.A. 0000-0002-9131-240X;
B.Ç.E. 0000-0002-0954-8967;
S.B. 0000-0002-1547-6680

[1]Van Yüzüncü Yıl University, Architecture and Design Faculty, Landscape Architecture Department, Van, Turkiye

[2]Trakya University, Faculty of Science, Department of Biology, Edirne, Turkiye

[3]Çukurova University, Faculty of Architecture, Adana, Turkiye

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Correspondence:
Gazel Burcu AYDIN
E-mail:
gburcuaydin@trakya.edu.tr

INTRODUCTION

Considering the basic needs and the balance of protection/use of recreational areas due to the increase in the population living in the cities and the acceleration of urbanization activities, the decrease in the quality of life due to the lack of recreational activities emerges as the most important problem (Değerliyurt & Çubuk, 2015). Although Turkiye has recreational areas that can be created in many different regions, from ecosystems at sea level to ecosystems in high mountain areas, it is important that the usability in these areas is sustainable. For this reason, deficiencies in the analysis of the relationship between natural/cultural features and systems in planning and design processes leads to the deterioration of the natural balance and the inability to meet the needs.

One of the recreational activities that people prefer is undoubtedly winter sports activities. The suitability of the areas where these activities will be planned is related to meteorological

events and it can be said that it will be one of the areas most affected by global climate change. However, in order to determine the recreational areas suitable for winter sports, many factors, especially the potential snow amounts in the region and the effects of global warming, should be evaluated together. In addition, it should not be forgotten that the ecological changes that these effects will create in the upper basin will also affect the lower basin.

Turkiye hosts many areas which are potentially suitable for all kinds of recreational activities. There are many suitable areas in Turkiye for winter sports, which is one of the recreational activities that people prefer, especially in winter. However, it is reported that even in the first priority centers for winter sports in Türkiye, there are tourism investments that are not compatible with the environment based on incorrect land use (Akın & Erdoğan, 2017). For this reason, the adaptation of the activity to the ecosystems is as important as the suitability of the site for the activity in the selection of recreational areas.

Snow, which is an important component of mountainous ecosystems, in particular, will undoubtedly exhibit a very sensitive structure against temperature increases due to global warming, which has become more important in recent years. This situation will not only affect the areas planned for winter recreation but also cause changes in the ecosystem balance. Because it is inevitable that the snowmelt in the upper basin will put pressure on other ecosystems, especially the freshwater resources in the -basin (Dönmez, Berberoğlu & Çilek, 2016). In addition, anthropogenic effects (such as aquatic nutrient salt and pollution) in the upper basin will be carried to the lower basin by the melting of snow. For this reason, it is also important to determine the ecological risks by taking into account the global warming scenarios as well as the amount of snow in winter recreation areas when planning.

Physical and chemical components of the ecosystem, climate changes, and anthropogenic effects are among the main factors that cause pressure on ecosystems. Determining the probability of adverse effects due to these physical, chemical, and biological pressures is called "ecological risk analysis" (USEPA, 1998; Salihoğlu & Karaer, 2004; Erdoğan, 2012). When performing an ecological risk analysis, it is important to identify "ecological risk factors" (ERF), which represent possible and potential pressures on the preservation and long-term sustainability of the ecosystem structure. Thus, the sustainability of the ecosystem can be ensured by predicting the long-term effects of the factors causing ecosystem degradation and determining the measures that can be taken.

There are a lot of analyses on Ecological Risk Assessment (ERA), which can be used for different ecosystems: Harris et al. (1994) developed a methodology based on anthropogenic stressors affecting an ecosystem and a set of impaired use criteria; Håkanson (1980) used an ecological risk index for aquatic pollution control based on a sedimentological approach; Elias et al. (2014) and Ilie et al. (2017) evaluated heavy metal contamination by ecological risk index for freshwater ecosystems.

ERA analysis is one of the important environmental management tools applicable to various ecosystems and is characterized as an essential process for developing environmental management decisions, and compiling and presenting scientific information (Lemly, 1997; Serveiss, 2002). In addition, studies on the application of ERA by using Geographic Information Systems (GIS) and ecology are becoming increasingly common (Lemly, 1997; Preston, 2002; Solomon & Sibley, 2002).

In Türkiye, the Seyhan Basin is reported to be one of the areas that will be significantly affected by global climate change (Özfidaner, Şapolyo & Topaloğlu, 2018). Researches indicate that the average monthly temperatures in the Seyhan Basin (especially in the months of January, April, October, November, and December) will increase by 3^0C and the annual precipitation will decrease by 25% in the near future (Özfidaner et al., 2018). It is also reported that these climate changes will adversely affect water resources, snow storage, and groundwater potential by up to 30% in many basins (Kimura, Kitoh, Sumi, Asanuma & Tatagai, 2006; Tezcan et al., 2007).

Although there are studies on the seasonal snow dynamics of some areas in the Seyhan Basin and the proposal for suitable recreation areas in the region, no comprehensive study has been found that considers the basin as a whole and evaluates the ecological risks together. In this study, the suitability of the potential recreation areas for winter sports in the mountainous regions of the Seyhan Basin was examined by considering the future global climate change scenarios and the possible ecological effects of the settlements to be located in these regions on ecosystems. For this purpose, ecological risk factors determined based on global climate change scenarios and the literature were evaluated with a hypothetical ecological risk analysis and it was aimed to make some suggestions on the sustainability of winter recreation areas to be planned.

MATERIALS AND METHODS

Study area

The Seyhan Basin, located in Central Anatolia and the Mediterranean Region, is located between the coordinates 36° 33'- 39° 12 'North and 34° 24' - 36° 56 'East. Seyhan, Göksu, and Zamantı Rivers are located in the basin (Figure 1). In addition, most of the northeastern extensions of the Taurus Mountains are located within the basin, and the Seyhan Basin has very favorable conditions for both mountain and water recreation areas.

A large part of the basin is located in the Mediterranean climate zone with an average rainfall of 700 mm in winter, and it is an important food production area for Turkiye and Europe as well as being a common agricultural and pasture potential (Özfidaner et al., 2018). Therefore, water resources and management in the basin are very important for the agricultural production, ecosystem productivity, food safety, and biodiversity future of the basin.

Methods

In this study, image bands of areas suitable for winter recreation, using Landsat 8 Oli Multispectral images, were combined and a Red Green Blue (RGB) color code was set as 5-6-4. Thus, images of snow areas covering the months of January-February-March 2019 were obtained. Then, considering the effects of global warming scenarios and the effects that may develop depending on the tourist density in the region, a total of 5 different ecological Impact Factors (IF) were determined. These hypothetical IFs are grouped

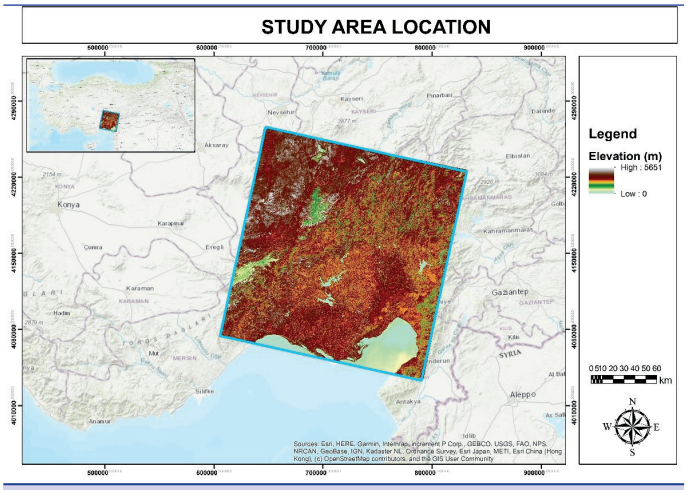

Figure 1. The location of study area

into flood (S1), drought (S2), sedimentation (S3) due to global warming, aquatic nutrient salt increase (S4), and tourist density (S5) due to anthropogenic use (Table 1). Also, for the hypothetical ecological risk assessment, a total of 4 main factors (MF) to be affected by IFs were identified: water quality (C1), fauna-flora (C2), agricultural lands (C3), and settlement areas (C4). A conceptual model developed by Harris et al. (1994) was applied to the identified factors (Figure 2). This conceptual model is used as a multi-criteria decision-making technique derived from fuzzy logic theory and allows the comparison of environmental risks with the risks presented to the ecosystem (Harris et al., 1994). The relevant literature was used to determine the degree of effect in the formula (Salihoğlu & Karaer, 2004). Accordingly, the main of "0 degree" was determined as "ineffective", "1 degree" as "mild effect", "2 degrees" as "effective", "3 degrees" as "severe effect", hypothetically. In the formula, the "k" value was taken as 1, "m" value was taken as 5, and the effect of each IF on each MF was determined as Matrix R.

$$D_k(i,j) = X_{ik} - X_{jk}$$

$$\text{Matrix R} = r_{ij} = \sum_{k}^{n} D_k(i,j);\ j=1,2,\ldots,m$$

Figure 2. The Formula of Hypothetical Ecological Risk Analysis (Harris et al., 1994)

RESULTS AND DISCUSSION

In this study, the future ecological risks of the areas to be proposed for winter recreation in the mountainous regions in the north of the Seyhan Basin were evaluated based on global climate change scenarios in the literature and the effects that will occur due to anthropogenic use. For this purpose, a hypothetical ecological risk analysis based on the literature was conducted. Thus, it is aimed to make suggestions for the long-term sustainable use of the areas to be proposed as a winter recreation area and to be invested in the basin.

Firstly, satellite images of areas with snow dynamics suitable for winter recreation in the mountainous regions of the Seyhan Basin between January-February-March 2019 were obtained and are presented in Figure 3. When the maps were evaluated, it was observed that the snow dynamics, especially in January and February, were suitable for winter recreation, but there were rapid area contractions due to the melting of snow with the onset of the spring season. This observation was evaluated as an indication that the snow melting at the beginning of spring from the areas to be planned for recreation will affect the downstream. Thus, the situations that may occur due to global warming in the Region (flood, drought, sedimentation) and the situations that may occur due to anthropogenic use in recreation areas (increased aquatic nutrient salt and tourist density) were considered as pressure factors (IF). In addition, the impact values of these IFs especially on the sub-basin (water quality, flora and fauna, agricultural lands, and residential areas) were also determined using the literature and formulated hypothetically. Accordingly, obtained results of hypothetical impact situations are presented in Table 2. According to the hypothetical impact matrix results, it was determined that the most influential factor was flood (S1=22), followed by drought (S2=17), sedimentation (S3= -3), nutrients (S4= -8),

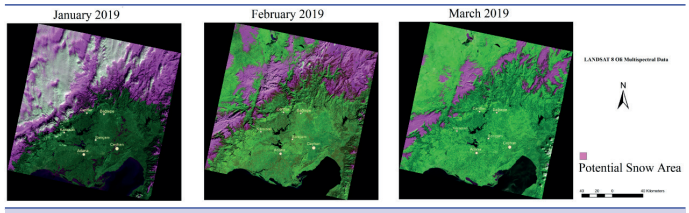

Figure 3. Satellite Images of Snow/Water Dynamics in Seyhan Basin (LANDSAT 8 Oli Multispectral Data)

Table 1. Hypothetical ERA pressure profile for Seyhan Basin Winter Recreation Areas

	Criteria			
Pressure Elements	**Water quality (C1)**	**Fauna-Flora (C2)**	**Agricultural land (C3)**	**Settlement area (C4)**
Flood (S1)	3	3	3	3
Drought (S2)	3	3	3	2
Sedimentation (S3)	2	2	1	2
Nutrients (S4)	2	2	2	0
Tourist population (S5)	1	1	0	0

0: No effect, 1: Slight effect, 2: Considerable effect, 3: Severe effect

Table 2. Hypothetical Impact Matrix Results

Stressors Assessment	S1	S2	S3	S4	S5	Row Sum (Impact Assessment)
S1	0	1	5	6	10	**22**
S2	-1	0	4	5	9	**17**
S3	-5	-4	0	1	5	**-3**
S4	-6	-5	-1	0	4	**-8**
S5	-10	-9	-5	-4	0	**-28**

and tourist density (S5= -28) (Table 2).

Flood and drought are among the leading effects of global warming, and it is estimated that this situation will have negative consequences both in the upper basin recommended for winter recreation and in the lower basin due to the resulting effects. It was predicted that this situation will especially affect water resources, agricultural areas, and settlements in the lower basin, affecting both the upper and lower basin fauna and flora with the creatures they drag. On the other hand, the runoff of melting snow due to global warming can be beneficial by bringing the nutrient salts from the water to downstream agricultural fields. However, erosion material in flood sediment can cause turbidity of the water and degradation of the fauna/flora ecosystem. It should also be noted that the negative effects of melting and drought on water quality will be the most important factors that will affect the lower basin rather than the upper basin. In addition, the human population in winter recreation areas will also affect the upper basin and indirectly will contribute to the negative impacts lower basin.

Although snow dynamics is an important component for winter recreation activities planned in mountainous areas and plays an important role, especially in the establishment of winter tourism, many factors such as land appearance, elevation, slope, soil groups, and hydrological structure are also taken into account. However, evaluating the effects of global warming in these areas is also very important in terms of the sustainability of the areas to be determined and ensuring the balance between ecosystems.

Snow cover plays an important role in mountainous hydrological balance, and flow water stored in the form of snow in the higher parts of a basin is a potential freshwater reservoir that can be used when the snow begins to melt (Dönmez et al., 2016). In addition to providing seasonal freshwater potential in the upper and lower basin interactions, snow can be a potential hazard for rapid melting and cause major flooding problems in lowland areas. With these characteristics, the snow process is considered a critical component of hydrological processes and dynamics of many basins, especially in mountainous regions. Estimates of the temporal and terrestrial distribution of natural snow cover in snow processes are among sustainable planning objectives and issues, particularly in terms of landscape planning for the selection and suitability of potential runway areas. However, in such studies, the analysis of ecological balance and the effect of snow water quality on lower-basin water quality can be neglected. Also, with the melting of the snow, the waters mixed with the surface resources will be effective in the areas fed by snow water. Especially, the snow thickness measured in spring plays an important role in estimating the entry of snow water into regional hydrological systems (Yücel & Güventürk, 2012). Therefore, monitoring seasonal snow thickness is of great importance for climatological, hydrometeorological, and water-based issues (Tekeli, Akyürek, Şorman, Şensoy, & Şorman, 2005). However, it should not be forgotten that the thickness of snow and the presence of snow can be affected by global warming and this can directly or indirectly affect the aquatic ecosystems in the lower basin, and therefore agriculture and settlement areas.

The Seyhan Basin, which is considered within the scope of the study, is located in the Central Anatolia and Mediterranean region, and it is a suitable region for both mountainous and aquatic recreation areas as it includes a part of the Taurus Mountains. In this study, the results of previous studies were also taken into account while evaluating the long-term use of the regions to be designated as winter recreation areas in the basin.

In a study to determine suitable areas for winter sports in Aladağlar, located in the Seyhan Basin, it was emphasized that environmental sensitivity should also be taken into consideration (Akın & Erdoğan, 2017). Dönmez et al. (2016) analyzed the seasonal snow dynamics in the Eğribük sub-basin in the Seyhan Basin and they reported that the main expected effect of temperature increase will be on the change of stream flows. Gönençgil and İçel (2010) examined the precipitation changes in the Eastern Mediterranean coasts and reported that precipitation decreases in this region will have negative effects on human life, and natural geographical elements and processes. Gürkan (2005) evaluated the effects of climate change on precipitation, drought, agricultural yield, and water resources in the Seyhan Basin. Bayer-Altın & Barak (2012) investigated the temperature and precipitation rates of the Seyhan basin between 1970 and 2009, and reported that they observed significant increases in temperature and a significant decrease in precipitation. Similar results were also reported in the studies by Türkeş, Koç & Sarış (2007) and Özfidaner et al. (2018). Similarly, the possible effects of climate change on Catalan dam flows in the Seyhan basin were examined by Malkoç, Arslan, Diren & Sargın (2013), and significant flood events were reported in the basin, especially due to snowmelt in spring. In a study conducted by Kantarcı (2012), flood events and the effects of Çakıt sub-basin in Seyhan Basin were examined and it was reported that floods are more frequent in this region due to drought. By evaluating the flow data of Seyhan Basin by Özfidaner et al. (2018), drought analysis was made and it was emphasized that drought would affect the natural life. Yüce, Ercan, Equal, Ünsal & Yüce (2018) analyzed the precipitation data of Seyhan basin and reported significant decreases in some. It is stated that the temperature changes com-

pared to the 1971-2000 reference period are approximately 10 ^{0}C in the north of the Seyhan Basin, 20 ^{0}C in the south, and an average of 13 ^{0}C in the inner parts of the basin (Tezcan et al., 2007). In Tezcan's study, it is stated that the temperature increase in the region will jump after the 2021-2030 period, and the temperature will be slightly higher in regions far from the sea (Tezcan et al., 2007). In addition, in the study conducted by Bayer-Altın and Barak (2012), they examined the changes in precipitation and air temperature in the Seyhan Basin between 1970 and 2009 and determined that the temperature increase occurred in all seasons and there was a tendency towards arid conditions. In a modeling study conducted by Askar and Başıbüyük (2020), the impact of climate change on the water resources of the basin was evaluated and it was reported that negative effects due to temperature increase are expected in the 2045-2080 period. As it can be understood from all these studies it should be taken into consideration that the Seyhan Basin will be adversely affected by global climate change. So, it is suggested that snow and water-based recreation area planning, scenarios that may develop due to global climate change, and ecosystem balances should also be taken into consideration in order to make more robust recommendations for the determination of suitable recreation areas.

CONCLUSION

In this study, some possible predictions for the long-term sustainable use of winter recreation areas to be proposed in the mountainous parts of the Seyhan Basin are emphasized. Especially, it was recommended to consider the possible ecological effects that may occur in the basin due to global climate change. In addition to the problem of decreasing water resources due to drought, there is the discharge of sediment and waste from settlements in recreation areas to the lower basin due to the early melting of snow waters. This situation may cause changes in water quality that will develop with sedimentation, may affect the fauna and flora depending on water quality, and may cause an increase of nutrient salts in the lower basin.

While determining the suitable area for winter recreation, it is recommended to carry out comprehensive ecological analyses as well as an assessment of the geographical features and snow potential of the area. Thus, long-term use of these areas can be ensured.

Conflict of Interests: The authors declare that they have no financial interests or personal relationships that could affect this work.

Ethics committee approval: This study does not need ethical approval.

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