Investigating Impact of physical changes on changes in the area of Hyrcanian forests in the mountains of the southern margin of the Caspian Sea using remote sensing

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A B S T R A C T

Objective: Objective: Knowledge of the extent of forest cover changes is essential for the conservation and management of these natural resources. The present study was conducted with the aim of revealing the extent of changes in the area of Hyrcanian forests in the southern Caspian Sea mountain range.
Methods: This study used Landsat satellite image processing to extract forest, vegetation, and water classes between 2000 and 2022. The method was based on supervised classification with the Support Vector Machine (SVM) algorithm.
Results: The results showed that the forest area in the study area, which includes 11 rural districts, decreased by -232,265 hectares over 22 years,
Conclusion: According to the results obtained from this study, it can be concluded that the increase in man-made land use in the form of second homes in the study area has led to the destruction and change in land use of one of the most important ecosystems in the world in the Middle East, and the continuation of this trend is one of the main factors in the reduction of the area of Hyrcanian forests and its inhabitants.

1. Introduction

Iran is located in a semi-arid and arid region (Modarres& da Silva, 2007). Meanwhile, the northern provinces of Iran are covered with a variety of vegetation, due to being located between the Caspian Sea and the Alborz Mountain range and having the highest amount of rainfall in Iran. As can be seen in Figure 1, this has created a unique landscape of deciduous forests in the Middle East (Najafi & Alizadeh., 2023; Noroozi et al., 2020; Zohary, 1973).
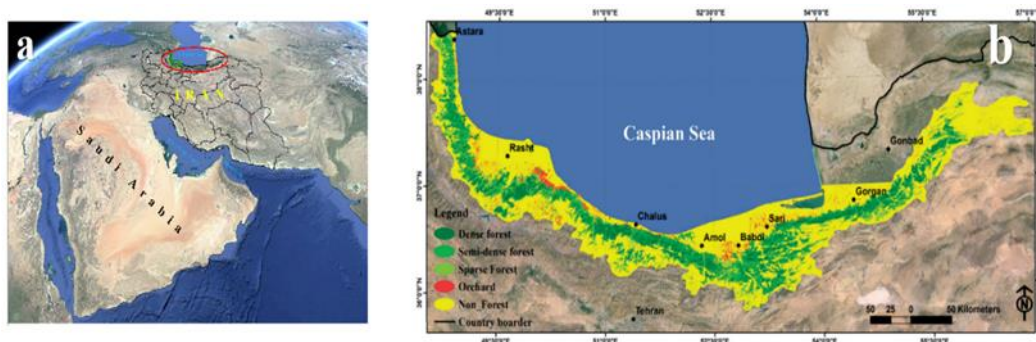
Fig.1- (a) Google Earth; (b) Hyrcanian forest density classes and non-forest map extracted from Landsat 8 Images in 2014(Mirakhorlou & Akhavan, 2017)

This area is the location of the Hyrcanian forests, which remain from the third geological period and are known as the largest living fossils in the world which expanded after retreating during the Quaternary glaciations and as temperatures increased (UNESCO, 2023) And mainly composed of Middle Jurassic to Upper Cretaceous limestone formations (Stöklin, 1974). These forests are one of the richest and oldest forest ecosystems in terms of species diversity, which is richer than the broad-leaved forests of Central Europe. which extend from Talesh mountain range in West Azarbaijan to Northeast Iran and in 2019 it was registered as a world heritage by UNESCO (UNESCO, 2021; Soofi et al., 2018; Browicz, 1982; Satarian et al., 2012; Marvi Mohajer, 2005). These forests, which help retain the moisture of the Caspian Sea, extend from the lowlands to the northern slopes of the Alborz Mountains (Gholizadeh et al., 2020).

Mountain areas are key focus for biodiversity conservation and for providing ecosystem services (Tefera et al., 2024). Knowledge of the process of land changes is essential for the protection of natural resources and the sustainability of rural settlements (Taleshi et al., 2017). The spatial pattern of land cover placement and its changes are very important in providing ecosystem services (Qiu, 2019; Zhu et al., 2021; Yohannes et al., 2021).

The increase in residential areas has led to the reduction of a large area of Hyrcanian forests and pastures (Jafari et al., 2016). Forest functioning is directly related to the diversity of tree species. Human activities have caused significant damage to these important ecosystems in recent decades (Newbold et al., 2015; Giam, 2017).

To maintain the functioning of forest ecosystems, it is important to know the amount and type of tree cover. Unlike traditional mapping methods, which were associated with many problems, remote sensing allows for the preparation of maps of vegetation and tree cover types in a short time and at low cost (Liu et al., 2023; Kerr and Ostrovsky, 2003). In order to identify threats that may affect plant communities, it is essential to collect basic information about them (Esmailzadeheh et al., 2014).

In this study, an attempt was made to answer the following questions by using satellite image processing and support vector machine algorithm: Is there a significant relationship between the increase in second homes and the decrease in forest area? And what level of Hyrcanian forest cover has been affected by the changes that have occurred over a period of two decades?

Therefore, in this article, the attempt has been made to investigate the amount of forest area changes in the study area in the southern mountains of Guilan province. To achieve this goal, a land cover map was extracted in the study area using remote sensing techniques and Landsat satellite images.

2. Material and Methods

2.1. Study Area

The studied area includes the villages of Alborz mountains in the south and east of Guilan province. The latitude and longitude of the study area is, 50°, 13´ 04´´ to 49° 29´ 51´´ E and 37° 03´ 59´´ to 36° 35´ 56´´ N respectively. The area of the region is equal to 2428 km and is spread at an altitude between 0 and 3000 meters (Fig 2).
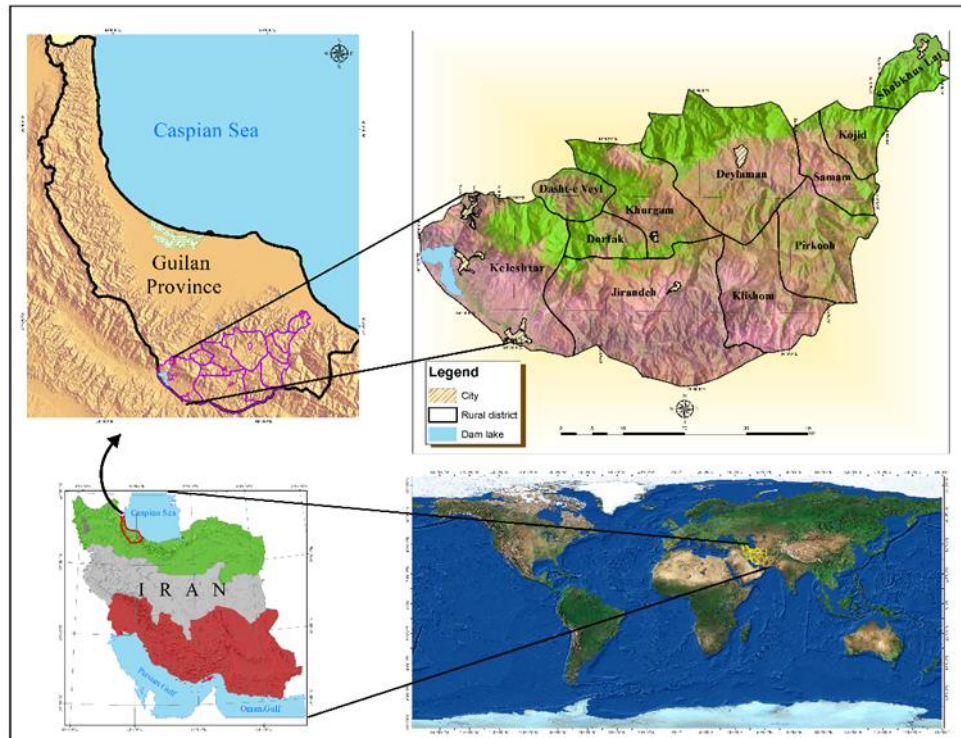

Fig.2- Location of the study area

2.2. Methodology

In order to know the amount of land use changes during the studied period, using remote sensing techniques and satellite image processing, land use maps of the studied area in the years 2000 and 2022 from the images ETM+ and OLI meters were extracted in 3 classes by Forest, Vegetation cover and Waterbody using support vector machine (SVM) algorithm (Fig 3).

First, the images of the study area are captured from the USGS site, then the image pre-processing step is performed. and radiometric corrections are applied to both images. Also, to prepare more detailed maps of the study area, a survey was conducted and number of training pixels were recorded for each class using GPS. Next, the land use map was classified into the desired classes and finally, the post-classification process was performed. Next, the area of each class and the amount of change occurred were determined. Next, to know the amount of forest area change, the forest class was selected from the land use map and the amount of change was calculated.

Support vector machine is a supervised non-parametric statistical learning algorithm proposed by Cortes in 1995 (Singh et al., 2021; Norouzi and Behzadi, 2019; Gigovic et al., 2019; Bhavsar and Panchal, 2012; Mountrakis et al., 2011). The SVM model is a method for linear classifiers and multilayer perceptrons, and it provides higher classification accuracy than traditional methods, especially in remote sensing Successfully (Mantero et al., 2005).
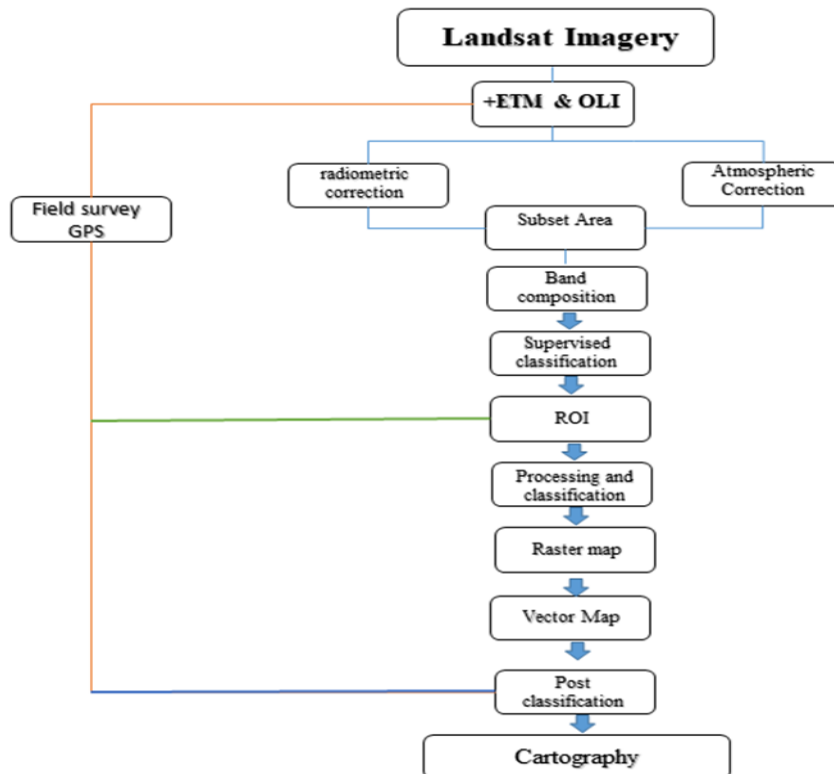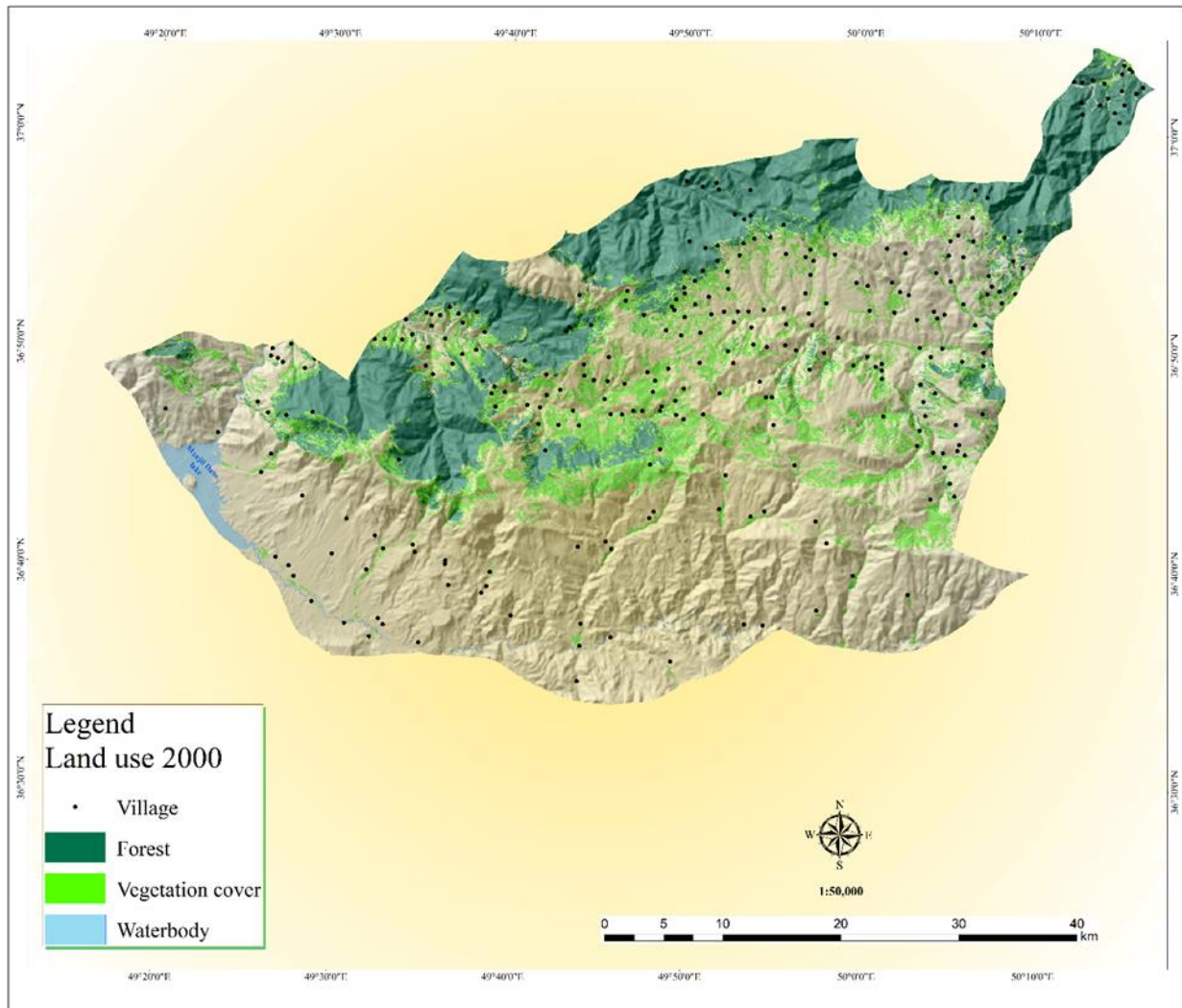

Fig.3- The flowchart of the method

3. Results and Discussion

The map extracted from forest and vegetation classes in 2000 is estimated to be equal to 55148.82 and 36669.06 ha, respectively (Fig 4 and Table 1).
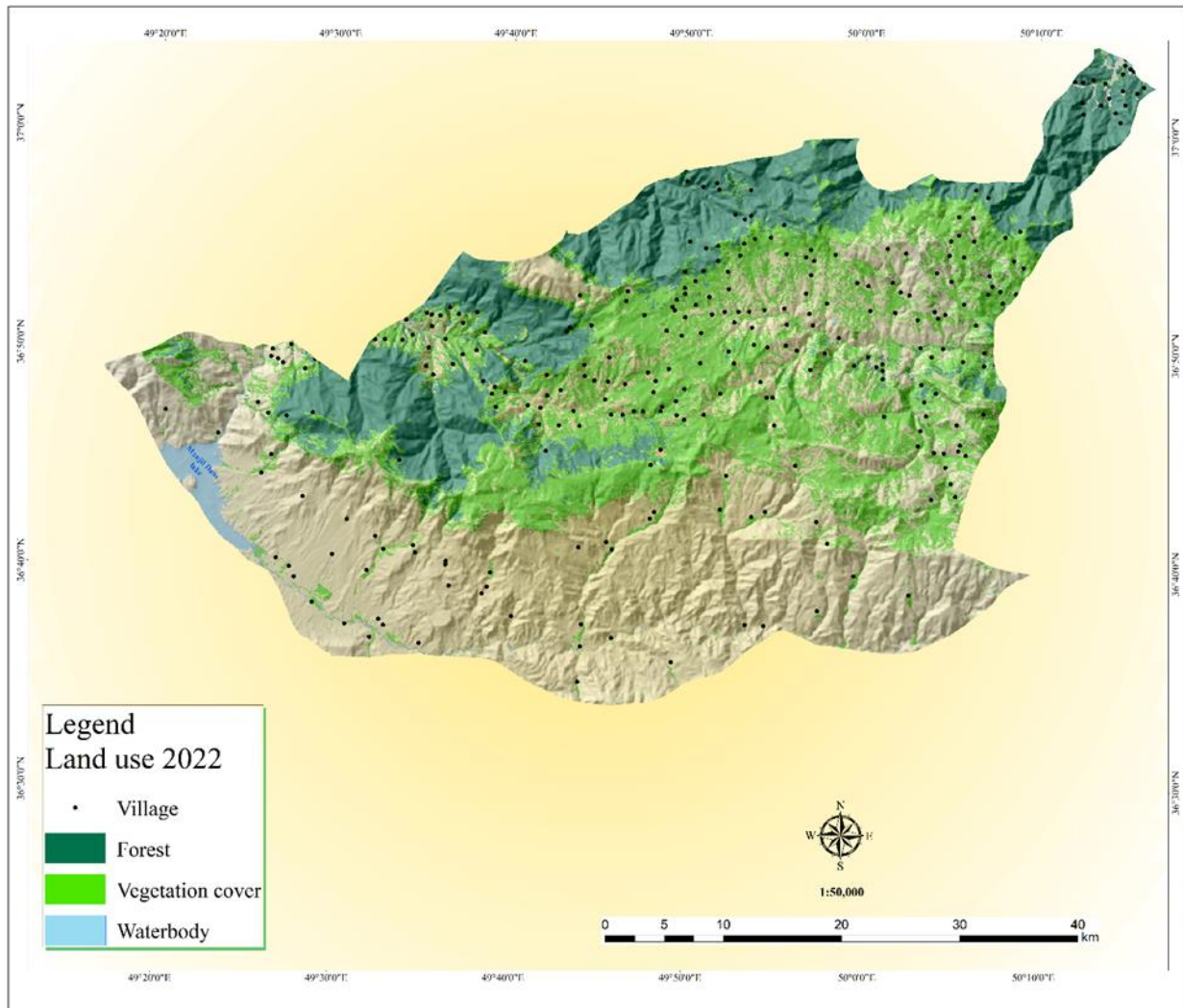
Fig.4- Land use map of the studied area in 2000

Table 1- Area of use in 2000.

Classes	Forest	Vegetation Cover	Water
Area (ha)	55148.82	36669.06	2920.23

The area of the forest in 2022 in the studied area is equal to 5282.617 ha and the area of the vegetation cover class is equal to 71035.3 ha (Fig 5 and Table 2).

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Figure 5- Land use map of the studied area in 2022

Table 2- Area of use in 2022

| Classes	Forest	Vegetation Cover	Water
Area (ha)	52826.17	71035.3	2738.64

Based on land use maps extracted from satellite images, it was determined that the forest class during the studied period from 2000 to 2022 was 232.265 ha had a decrease in area. Meanwhile, vegetation in the area has increased by 34366.24 ha, which can be considered as evidence for the loss of tree cover in the area (Table 3).

Table 3- Change of land use area between 2000-2022

| Classes	Forest	Vegetation Cover	Water
Area in 2000 **(ha)**	55148.82	36669.06	2920.23
Area in 2000 **(ha)**	52826.17	71035.3	2738.64
Area difference **(ha)**	-232.265	34366.24	-18.159

Knowledge of the current situation and the changes that forests have faced over the years is essential for forest conservation and management. Satellite images, as an important source from which a lot of information can be extracted, are efficient tool to achieve these goals.

Hyrcanian forests are considered one of the oldest and most valuable forests in the world due to their special environmental importance, as well as the age of their origin, genetic diversity, tree, shrub, bush, herbaceous and animal species, and ecological and ecotourism applications (Rezaei, 2009). Remote sensing combined with field information can provide an accurate view of the current situation and changes that have occurred (Mirakhorlou & Akhavan, 2017). One of the most important reasons for changing the use of mountain forests is human activities (Resler & Gunya, 2023). This is while natural disasters never change land using and land covering like humans do (Taleshi et al., 2017). The results of processing satellite images over a period of more than 20 years show decrease in the area of one of the world's most valuable forests. Interviews with local communities conducted during field surveys in the region showed that due to economic problems, the sense of belonging among residents of rural settlements in these areas has decreased and they tend to migrate to large cities to earn more money. One consequence of this form of migration and depopulation is a change in population ratios. This means that more people from large cities are able to buy land in uninhabited villages, and gradually, as second homes are built, land use changes occur irreparably. For example, during the holidays, Guilan province faces a large influx of travelers, a significant portion of whom have second homes in various parts of the province (Fig 6).
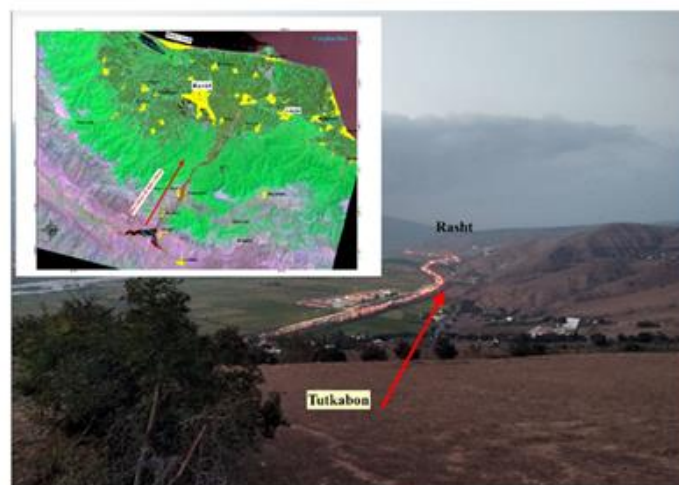
Figure 6- Travel route for vacation travelers to Guilan Province

As can be seen in Figure 7-9, the native texture of the village has changed its nature due to new constructions, and architecture incompatible with the mountain environment has replaced the native architecture of the region (Fig 7-9).

Figure 7- Examples of second homes owned by non-native individuals in the study area
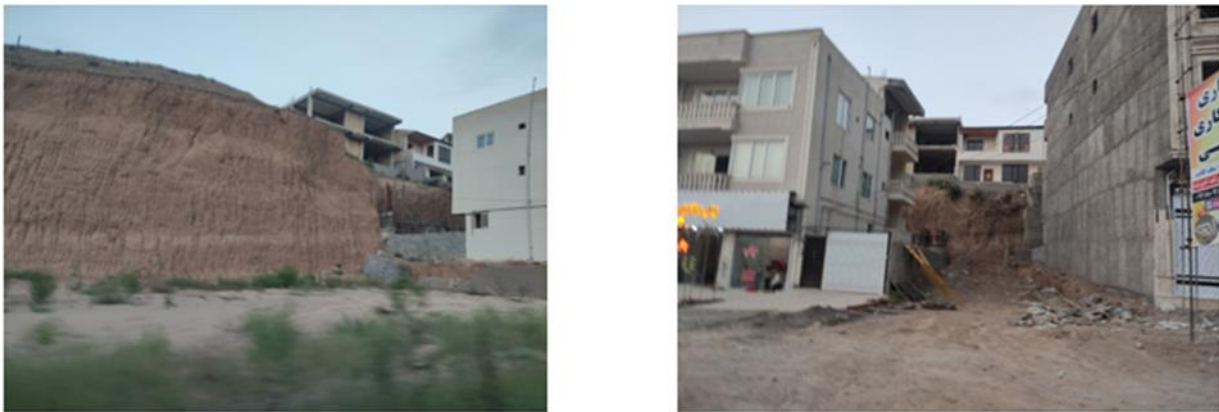
Figure 8- Construction of multi-storey buildings on Collapsible soils (Loess)

Figure 9- Second homes with architecture incompatible with the climate and indigenous methods (Deylaman, Espili)

4. CONCLUSION

In the last few decades, the Hyrcanian forests have faced many challenges, the most important of which are land use change, forest destruction through timber smuggling, livestock grazing, and other issues (Khare et al., 2021).

The reduction in the area of Hyrcanian forests in the southern mountains of Guilan province is also significantly related to human activities. Field studies in the study area showed that due to many reasons such as the lack of proper infrastructure and jobs to meet living expenses, many residents of mountain settlements have migrated from villages to big cities. This is while these areas have a favorable climate that increases the desire of residents of large cities to spend their holidays there and ultimately leads them to buy land and building the second homes, which is the most important reason for land use changes in the studied rural settlements and consequently the impact on the forests of the region.

Jafari et al., 2016, by simulating land use maps in the years 2025 and 2037, showed that the direction of future residential development in Guilan province is towards mountainous and forested plain areas and Hyrcanian agricultural lands, which have the best forest cover and the most fertile lands (Jafari et al., 2016).

Code availability (Not applicable)

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