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# Land use pattern at Alacam mountainous range land (Submediterranean-Turkey) due to edaphic and physiographical factors

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**Abstract**

Soil degradation is perceived as a major threat in the Mediterranean region due to land use pattern and projected climate change. As the high altitudinal mountainous lands are sensitive lands, the land use patterns at Alaçam mountains were investigated in this study. The assessment of land use distribution is arranged with the altitude, exposure, slope and bedrock parameters. The spatial database of project was created using GRASS GIS open source software (GRASS Development Team, 2008). The scanned land use and main rock map of the project area rectified, digitized, and attributes of land use and bedrocks were entered into the database tables. Also raster SRTM3 data were imported into these databases for making physiographical factor (elevation, slope, aspect) maps. Our findings illustrated that the whole area of Alaçam mountains is 282 480 ha where most of the area of the mass is located between 700-1300 m asl with 200 585 ha corresponding to 71% of the whole area. We detected two kinds of mis-land use; (1) agricultural activities applied at the slopes above 17% (representing 35 220 ha) and agricultural activities applied on metamorphic rocks (representing 872 ha). Total misuse of lands reached 36 092 ha comprised 12.77% of the whole area.

**Key words**

Land use, Sub mediterranean, Physiographic, Altitude

## Introduction

At Mediterranean geographical terrestrial climate is in fact unique for its warm and dry summer season and for its mild and relatively rainy winter (Chiesi *et al.*, 2007) with sensitivity to fire and soil erosion and even desertification (Zavala and Burkey, 1997). As a result of such warm and dry climate, the soil element of the ecosystem should be taken into consideration with its remarkable effect on net primary production and vegetative growth. So, that can be concluded that the land use pattern formed as a result of anthropogenic activities should be in equilibrium with the climate, water and nutrient limitations so as to conservation of the natural sources for the future of human life but the distribution of vegetation has often been modified by anthropogenic influences (Gates and Lieb, 2001). In Turkey while agricultural lands converted to urban places, forest and pasture lands are converted to both urban and agricultural lands. Also, lower altitudinal areas are mostly engaged with urban places.

Alterations in land use make humans to increase resource appropriation, but also of potentially undermine the capacity of ecosystems to provide services (Padilla *et al.*, 2010). For instance the colleagues' studies at southern Italy recorded that cultivation lowered the humification capacity of the soil organic matter at upper 10 cm of the soil at S.Quirico and at 40 cm at Soveria Simeri, suggesting a decrease of chemical and biological stability of soil organic matter at these sites (Papini *et al*., 2010). Çelik (2005) suggested that deforestation, and soil fertility depletion have led cumulatively to an alteration in the global biogeochemical cycles as a result of human land-use and management practices executed at any particular place; while Fonderflick *et al.* (2010) affirmed that deforestation, agriculture intensification and urbanisation are well identified as potential threats, but land abandonment can also lead to diminish biodiversity. Similarly, Schoorl and Veldkamp (2001) stated that land use change can affect soil properties in the landscape context, either in a positive or negative way. Since natural habitats have the potential to restore themselves to some extent, the conversion of forest to grasslands and permanent crops such as plantations usually leads to less degradation after several years.

In the view of the fact that Mediterranean ecosystems are susceptible ecosystems, the conversion of forest and pasture lands to agricultural lands or rural lands causes severe degradation, the adoption of conservation management systems should be encouraged in these Mediterranean environments (Papini *et al*., 2010). Also, Papini *et al.* (2010) called to requirement of sustainable management of pasture lands which are in the Mediterranean environments often suffer significant soil organic carbon loss and soil degradation when improperly managed. Likely, within this study we would like to offer sustainable management for both forest and pasture lands. From the point of view that carbon sequestration raised to twice in the 20$^{th}$ century linked to agricultural abandonment and forest restoration woodland conservation is essential to maintain the ecosystem services that underlie carbon sequestration (Padilla *et al.*, 2010).

Within the intention of evaluation and reconsideration of land use sustainability, comprehensive land-use planning by providing an all-embracing frame work for solving land-use conflicts and controlling potentially damaging developments in environmentally sensitive areas (Recatalá *et al*., 2000), land use patterns under the effects of edaphic and physiographical factors, such as altitude, slope, exposure and bedrock, were investigated but in time extension. We assumed a proper land use pattern because of not receiving immigration region with recalling attention on conservation of those sensitive ecosystems where only limited precipitation is expected.

**Site properties and methods:** Study area was established on Alaçam mountains constituted with Akdag, Ulus mountain, Egrigöz mountain and itself which laid between 29° 15' 30" – 28° 15' 00" latitudes and 39° 38' 00"-39° 07' 30" longitudes (Sevim, 1954). Average annual precipitation ranges between 492.7 and 860.3 mm, the average extreme temperature values change from 1.4 to 24.5°C with minimum and maximum peaks according to the climatic data of Bigadiç, Çagis, Dursunbey, Simav, Sindirgi, Tavsanli and Yagcilar meteorological stations which are located around the study site. Alaçam mountain is a mass where summer drought decreases with increasing altitude (Sevgi *et al.*, 2010). The study site is present in precipitation receiving compartment of Sub-Mediterranean region (Mayer and Aksoy, 1998). The mountainous mass composed from the granite, dasite, tuff, metamorphic bedrocks and alluvial material formations formed at Cenozoik, Quaternary, Tertiary, Pliocene, Miocene eras. The Black pine is the mostly distributed tree species with its unique and productive stands and its optimum area (Saatçioglu, 1976) while oak sp., alder, poplar and willow species also present in various groups and individual mixtures (Sevim, 1954; Sevgi *et al.*, 2010).

The evaluation of land use distribution is arranged with the altitude, exposure, slope and bedrock parameters. While various altitude intersects were incorporated at the previous studies (Kantarci, 1979) 100 m sections were preferred which allowed an inclusive description of land use. 0 - 9, 9 - 17, 17 - 36, 36 - 58 and > 58% slope intervals was sufficient and proper for the study site whereas different slope scales were used as given in the literature (Bibby and Mackney, 1969; Tunçdilek, 1969). In ecological studies, the exposure was embraced with its only two main representative groups including northern and eastern that were spoken for shady and southern and western ones for shiny exposures (Çepel, 1995). We classified the exposures of the study site based on Çepel (1995) categorization.

The spatial database of project was created using GRASS GIS open source software (GRASS Development Team, 2008). Then scanned land use and main rock map of the project area (Dursunbey, 1977; Gökçedag, 1977; Kütahya, J22a; J22d; J21d; J21c; J22a; J21b 1977) rectified, digitized, and attributes of land use and bedrocks were entered into the database tables. Also spatial and attribute data of these maps were cleaned and corrected. In addition to this, raster SRTM3 data were imported into these databases for making physiographical factor (elevation, slope, aspect) maps. The required elevation, slope, aspect maps were generated and converted to the vector data for using SRTM3 data. All these generated maps were overlaid for making necessary queries easily.

## Results and Discussion

**Spatial distribution and categorization of the lands in Alaçam mountains in relation to altitude, exposure and slope:** The whole area of Alaçam mountains is 282 480 ha and 32 ha of the whole area lays below 300 m asl and 198 ha area lays above 2000 m asl while the most of the area of the mass is located between 800-900 m asl with 44 030 ha. If we enlarge the altitudinal belt to between 700-1300 m then the area laid between those altitudes reaches to 200 585 ha which corresponds to 71% of the whole area (Table 1). The downhill part of the Alaçam mountains subsides to 300 m elevation along western and north-western slopes. Conversely southern, south-eastern and eastern slopes of the mountain begin upper than 800 m asl. Thus, the land magnitude increases up to 800 m and then decreases. The total amounts of the lands categorized into slope and exposure groups, present quite similarity among each other.

**Land use pattern according to altitude:** The land use trend illustrates distinct enhancement up to 800-900 m asl. The uppermost

**Table - 1:** Areal matrix of the altitude, exposure and slope (ha)

| Exposure | 1 | | | | | 2 | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Slope** | **1** | **2** | **3** | **4** | **5** | **1** | **2** | **3** | **4** | **5** | |
| 300 | | | | | | 1 | 25 | 6 | | | 32 |
| 400 | 343 | 123 | 34 | 2 | | 66 | 185 | 168 | 4 | | 925 |
| 500 | 46 | 678 | 931 | 53 | | 58 | 839 | 1079 | 83 | | 3767 |
| 600 | 185 | 1206 | 3499 | 336 | | 343 | 1634 | 3289 | 295 | | 10787 |
| 700 | 236 | 3196 | 6578 | 682 | 7 | 269 | 2953 | 6003 | 538 | | 20461 |
| 800 | 2420 | 5010 | 9307 | 997 | 18 | 2867 | 4102 | 9055 | 680 | | 34456 |
| 900 | 3053 | 8112 | 10430 | 1306 | 24 | 2031 | 7127 | 11117 | 829 | 2 | 44030 |
| 1000 | 1310 | 5482 | 10561 | 1497 | 30 | 616 | 3911 | 11003 | 1157 | 15 | 35582 |
| 1100 | 224 | 3658 | 11223 | 1392 | 34 | 472 | 2779 | 10716 | 1472 | 23 | 31993 |
| 1200 | 120 | 2386 | 11073 | 1326 | 14 | 168 | 2687 | 10032 | 1476 | 30 | 29311 |
| 1300 | 20 | 1777 | 9523 | 1330 | 14 | 30 | 2123 | 9172 | 1207 | 17 | 25213 |
| 1400 | 11 | 1264 | 7296 | 1124 | 14 | 24 | 1903 | 6957 | 1056 | 1 | 19649 |
| 1500 | 2 | 777 | 4733 | 753 | 1 | 10 | 1499 | 5019 | 579 | | 13373 |
| 1600 | 8 | 486 | 2380 | 422 | | 19 | 712 | 2533 | 290 | | 6851 |
| 1700 | 12 | 353 | 1023 | 216 | | | 203 | 1147 | 160 | | 3114 |
| 1800 | | 73 | 484 | 150 | | 5 | 95 | 569 | 75 | | 1451 |
| 1900 | | 17 | 239 | 123 | | | 41 | 344 | 62 | | 825 |
| 2000 | | 13 | 118 | 71 | | 1 | 19 | 216 | 24 | | 463 |
| 2100 | 4 | 35 | 48 | 11 | | 15 | 26 | 58 | 2 | | 198 |
| Slope | 7993 | 34647 | 89479 | 11790 | 155 | 6994 | 32863 | 88484 | 9988 | 87 | 282480 |
| Exposure | 144064 | | | | | 138416 | | | | | |

**Table - 2:** Land use distribution according to exposure

| Exposure | Land use (ha %)* | | | | |
|---|---|---|---|---|---|
| | **Others** | **Rural sett.** | **Forest** | **Pasture land** | **Agricultural land** |
| 1 | 336 (76) | 681 (38) | 105711 (52) | 4133 (46) | 33203 (49) |
| 2 | 106 (24) | 1119 (62) | 97949 (48) | 4840 (54) | 34401 (51) |
| Total | 442 (100) | 1800 (100) | 203660 (100) | 8973 (100) | 67604 (100) |

*The percentages are given in the parenthesis

**Table - 3:** Land use distribution according to slope classes

| Land use | Slope classes (ha %)* | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| Others | 52 (0.4) | 205 (0.3) | 171 (0.1) | 14 (0.1) | 0 (0) |
| Rural settlement | 289 (1.9) | 789 (1.2) | 689 (0.4) | 32 (2) | 0 (0) |
| Forest | 5425 (36.2) | 40047 (59.3) | 138469 (77.8) | 19497 (89.5) | 223 (92.2) |
| Pastureland | 688 (4.6) | 2616 (3.9) | 4956 (2.8) | 703 (3.2) | 10 (4.1) |
| Agricultural land | 8532 (56.9) | 23853 (35.3) | 33679 (18.9) | 1532 (7.3) | 9 (3.7) |
| Total | 14986 (100) | 67510 (100) | 177964 (100) | 21778 (100) | 242 (100) |

* The percentages are given in the parenthesis

striking effect of the altitude is its impacts on climate change. Besides lessening of vegetation period, the upper limits of the land use possibilities restricted, such as rural settlement altitude could not raise over 1400 m (Fig. 1a). Related to altitudinal constraint founded on climatic harsh conditions and decreased vegetation period agricultural land use practices could reach to the uppermost 1500-1600 m asl within only 10 ha, whereas settlements were at highest 1400 m asl. Forest land use increased up to 800-900 m then decreased up to 1600-1700 m and again increased. The vegetation formation, resistant to coldest climatic conditions, pasture lands raised at upper elevations of forest belt that is called alpine zone. After interpretation of demographic changes in population Taillefumier and Piegay (2003) found that the populations of the communities (Bourdeaux and Mornans (France) remained fairly stable until the end of the 19$^{th}$ century and then gradually declined which are small towns that has been less affected by surrounding rural changes. Likely Çamurcu (2002) had emphasized that Dursunbey released population towards central city Balikesir related to unemployment in rural areas.

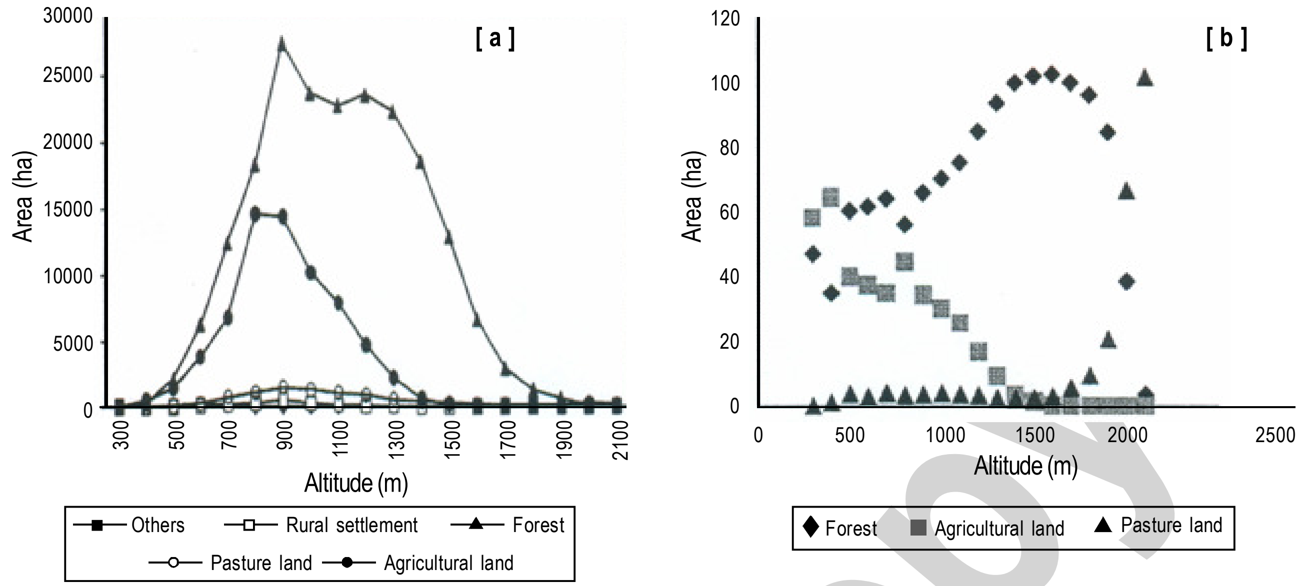


**Fig. 1:** (a) Land use states according to altitude (b) the rates of various land uses according to altitude

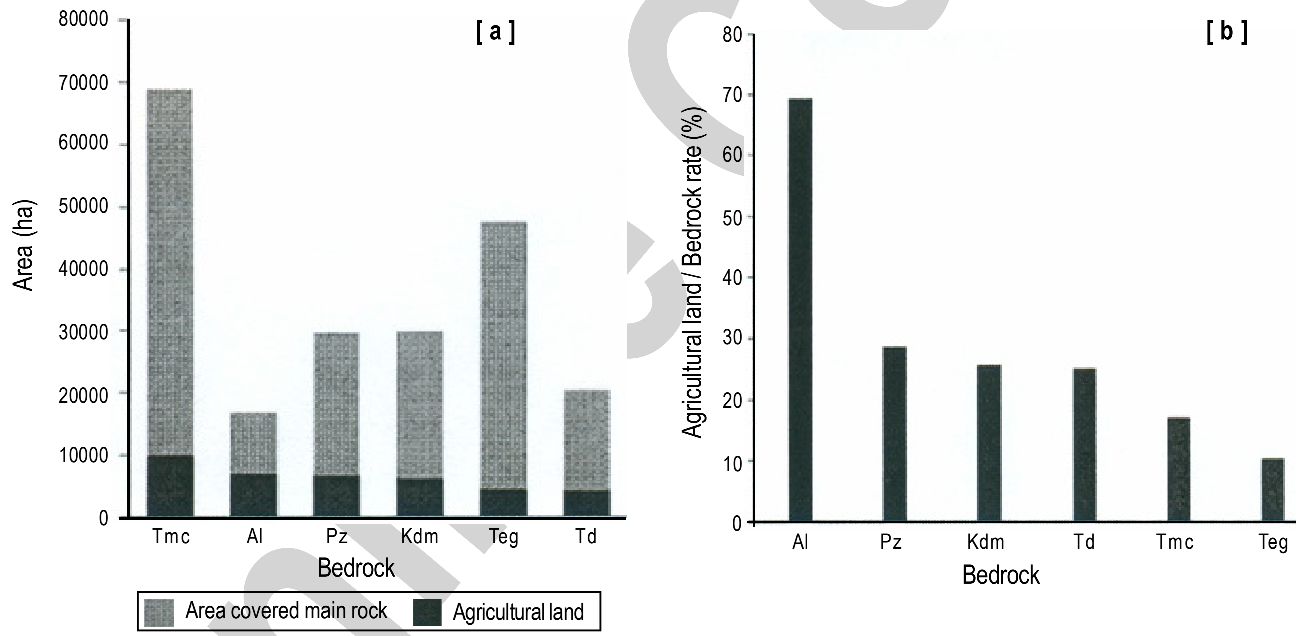


**Fig. 2:** Agricultural land distribution on areas covered by various bedrocks (a) agricultural land (b) bed rock rates for each bedrock type

The effects of altitude become more clear when the rate of land use type : whole land is incorporated such as below 1500 m asl the agricultural land use raised while pasturelands raise at above 1800 m asl (Fig. 1b). On the eastern part of the mass at 800-900 m asl forest land use type decrease because of increased agricultural lands, however, forest land use type is not less than 60% of all the land area between 600-1900 m asl.

**Land use pattern according to exposure:** Except rural settlement areas various land use states did not reflect any remarkable difference according to exposure. The conventional practices oriented people to prefer shiny exposure (Table 2). But Balci (1996) highlighted S-faced slopes more susceptible exposures to the erosion referring to its drier and less vegetation cover potential. Comparable to Balci (1996) in their study Cammeraat and Imeson (1998) found that soil aggregates were more stable and were often coarser on N-facing exposed slopes when compared to S-facing exposed slopes which in turn underline the soil aggregation parameters as a key-indicator for land degradation studies whereas soil degradation is perceived as a major threat in the Mediterranean

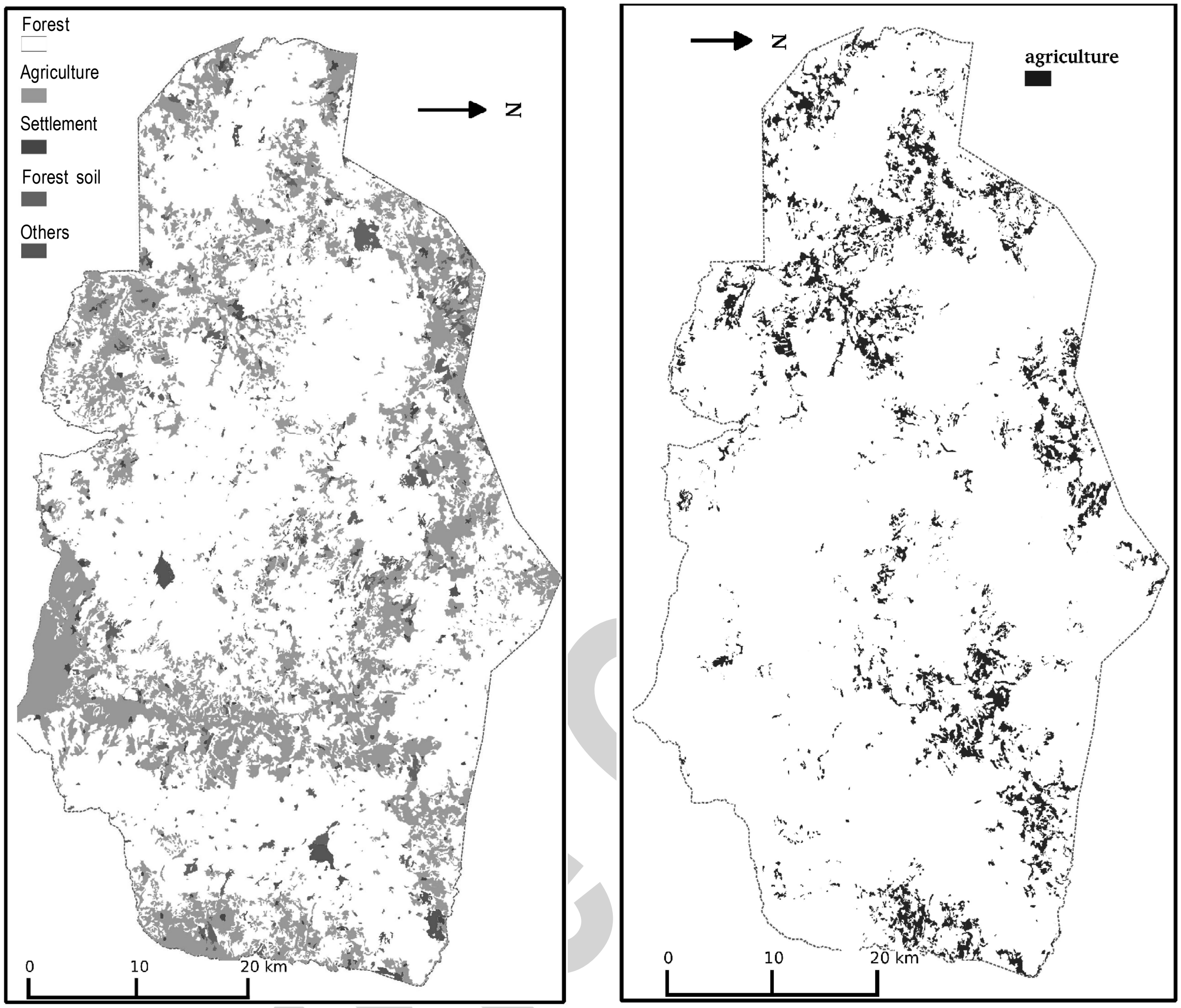


**Fig. 3:** (a) Actual land use, (b) incorrect land use

region due to changes in land-use and projected climate change. Indeed the importance of exposure relies on the realization of climatic factors (*e.g.* light receiving, temperature, precipitation, transpiration *etc.*) at varying quality and quantity and its effect varies according to location (Irmak, 1970).

**Land use pattern according to slope:** The highest magnitude is found in the 3 group referring to 17-36% within 177 964 ha. The uppermost areas of settlement are in second and third slope groups which indicate the slopes between 9 to 36% (Table 3). Slope is one of the most important criterion dictating the most proper land use type. Slope degree is a significant factor in determining of the status concerning protection or production of forests (Irmak, 1970) whereas at steep slopes forest cover regulates the water regime and provides soil protection (Çepel, 1986). Serra *et al.* (2008) declared that in the transitional subregion, agricultural abandonment of permanent crops at steeper slopes has generated more fire and erosion risk and landscape degradation. The study site is referred as the favorite forest land in Turkey because of their high wood quality (Göker, 1977). We detected forest land use at flat slope lands as a result of expectation of good quality forest products. The critical slope threshold at classification and categorization of land use is 15% and when that value is exceeded the land types are improper and harmful for soil capital if devoted to agricultural use (Akalin, 1974). Likewise Arhonditsis *et al.* (2000) found that at sloping terrains nutrient losses as a result of erosion were considerable in the cultivated olive groves, and these losses should be ascribed mainly to anthropogenic disturbances. The study on erosivity at abandoned agricultural lands by Koulouri and Giourga (2007) resulted that if the slope gradient is steep (25%), soil erosion is increasing significantly probably because the dense protective cover of annual plants decrease and shrubs' vegetation cover increases. From the point of view misuse of land the mentioned measure should strictly be taken in consideration. Literally Koulouri and Giourga (2007) declared that important land use change recorded in the Mediterranean basin comprises the abandonment of agricultural lands due mostly to economic and social changes, which is followed by significant impacts on soil erosion.

**Land use pattern according to bedrock:** The total agricultural land use 38 466 ha is distributed to Civana tuff (Tmc), alluvion (Al), metamorphic rocks (Pz), Dagardi melanj (Kdm), granite (Teg) and dasite (Td) with 10 055, 4 512, 6 158, 6 665, 4 125 and 6 962 ha respectively (Fig. 2a). Rationally the highest amount of agricultural land is distributed on alluvion sites where its ratio to all alluvion areas is 69%, while the rates for the rest of bedrocks are as follow 29, 26, 25, 17 and 11% for metamorphic rocks, Dagardi melanj, dasite, Civana tuff and granite respectively (Fig. 2b). The agriculturally occupied lands over third slope group lands on granite, dasite, Civana tuff rocks and alluvion materials are 10 641 ha. Those agricultural lands interpreted under obviously open to soil erosion risk owing to both their slope groups and native soil characteristics. Granite, dasite and Civana tuff generated mainly sandy silt soils (Sevgi *et al.*, 2010) providing evidence to their susceptibility to erosion. Under such conditions agricultural activities ought to be abandoned; both soil and nutrient losses recovery of ecosystems could be impossible. Particularly the slowly aerated metamorphic rocks (Kantarci, 1983) given stony soils provide limited water and, nutrient budget capacity should be avoided from agricultural activities even on the slope group 9-17% that were amounted 872 ha at our study site.

**Mis-use versus true-use characteristics of land:** Since forest vegetation has the land protection potential and the site subjected to this study can be assumed as its high productive site if the lower slope areas are occupied by forests it could be eliminated from mis-land use account. Given that the population immigration is towards outgoing the absence of social pressure in the direction of agricultural land enlargement should be mentioned. Above and beyond some mis-land use samples exist in our study site (Fig. 3a). Two main reasons cause to mis-land use; agricultural activities applied at the slopes above 17% (representing 35,220 ha) and agricultural activities applied on metamorphic rocks (representing 872 ha). Total misuse of land reaches to 36 092 ha comprised 12.77% of the whole area (Fig. 3b).

Misuse of land has several globally threatening effects such as annual emissions of carbon dioxide from land use change Canadell (2002), SOM decrease when the pasture was converted into cultivation (Çelik 2005) and from the point of biodiversity view Fonderflick *et al.* (2010) asserted that biodiversity is threatened by tree and shrub encroachment when the agricultural lands abandoned at Mediterranean upland.

Globally, the estimates of the transformation of natural ecosystems for the cultivation of food, feed and fiber come to the conclusion that 37 million ha, or 34% of the global land surface, is directly occupied by cultivated systems (Abha *et al.*, 2006). Bakker *et al.* (2005) reconsidered and offered that abandonment of arable land due to declining productivity is a land use change that may result from soil erosion. On the basis of their approach the land use elements constituting the land use concept might be ranked in misuse of land – erosion - agricultural land abandonment and again erosion turn. The land use transformation and the consistence of proper use convention expected to become more common than the historical background. In conclusion at susceptible ecosystems such as high altitudinal and under the Mediterranean climate the long term land use planning and the optimization of natural and social needs and supplies is crucially required.

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