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Full Length Research Paper

Ecological Impact Assessment and Analysis of Camili (Macahel) Biosphere Reserve Area (Artvin, NE, Turkey)

Emre Özşahin[1] and Çağlar Kıvanç Kaymaz[2]

[1]University of Namık Kemal, Kampus of Değirmenaltı Faculty of Art and Science, Department of Geography, 59030 Tekirdağ – Turkey
[2]University of Atatürk, Faculty of Art, Department of Geography, Erzurum-TURKEY

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Current study assessed and analyzed the elements that could cause ecological impact in Camili (Macahel), the first and only biosphere reserve area in Turkey and their possible effects. The ecological character of the biosphere reserve area was identified and assessment was provided for appropriate planning to preserve and maintain sustainability of resources. In this process, Geographical Information Systems and Remote Sensing method and techniques were used. The result of analysis was used to generate the ecological map of the biosphere reserve area. According to assessment; natural disasters, construction of a hydroelectric plant, road construction, tourism activities and tourist pressure were found to be the main ecological impact factors in Camili (Macahel) biosphere reserve area. Results of analysis show that the reserve area mostly contains nonimpact areas (15172 ha - 60%). The areas with the highest risk correspond to the settlements in the center of the biosphere reserve area.

Keywords: Ecological Impact, Geographical Information Systems (CIS), Ecological Impact Analysis, Ecological Impact Assessment, Biosphere Reserve Area, Camili (Macahel).

INTRODUCTION

Impact of the mankind on ecosystems is increasing severely along with rapid population increase, advancing technologies and industrial activities (Gürpınar, 1994; Muslu, 2000; Tozar, 2006; Tağıl, 2006). This situation causes pressure on natural resources and accelerates the degradation of ecological balance (Sütgibi, 2008). Detailed ecological studies which protect ecological balance and takes natural resources into consideration are needed to deflect this process into positive outcomes (Çelikyay, 2006; Tağıl, 2006).

These types of studies which will create the foundation for managing natural resources in a correct and rational manner can be planned in the framework of ecological analyses. In this context, analyses based on ecological modeling provide the foundation for ecological planning (Kocataş, 2010; Çelikyay, 2006). Hence, comprehending ecological conditions in detail is crucial in the organization of the relationships between mankind and the environment (Atalay, 2011a).

In recent years, ecology based studies can be easily undertaken through the use of Geographical Information Systems (GIS) and Remote Sensing (RS) data (Tağıl, 2006). Advances in Geographical Information Systems (GIS) and Remote Sensing (RS) techniques provide different opportunities for undertaking ecological analyses. (Vogelmann, 1995; Tağıl, 2006; Kocataş, 2010). Hence more objective ad healthier results can be obtained by using different and wide range of parameters.

*Corresponding Author's E-mail address: ozsahine@hotmail.com; uzmanemreozsahin@gmail.com.tr; Tel: +90 326 245 58 67 – 1110; Fax: +90 326 245 58 66

Table 1. Biosphere Reserves of World (World Database on Protected Areas-WDPA) (The World Database on Protected Areas (WDPA), 2012)

Biosphere Reserves					
CONTINENTS	**Africa (80)**	**Americas(233)**	**Asia (128)**	**Europe (218)**	**Oceania (17)**
COUNTRIES	Algeria (6) Benin (2) Burkina Faso (2) Cameroon (3) Central African Republic (2) Congo (2) Congo, The Democratic Republic Of The (4) Côte D'Ivoire (2) Egypt (2) Ethiopia (1) Gabon (1) Ghana (2) Guinea (4) Guinea-Bissau (2) Kenya (6) Madagascar (3) Malawi (2) Mali (1) Mauritania (1) Mauritius (1) Morocco (3) Niger (2) Nigeria (1) Rwanda (1) Senegal (5) South Africa (6) Sudan (2) Tanzania, United Republic of (3) Togo (1) Tunisia (4) Uganda (2) Zimbabwe (1)	Argentina (16) Bolivia, Plurinational State Of (5) BrLessil (6) Canada (16) Chile (10) Colombia (5) Costa Rica (3) Cuba (6) Dominican Republic (1) Ecuador (4) El Salvador (2) Greenland (1) Guadeloupe (1) Guatemala (6) Honduras (2) Mexico (82) Nicaragua (5) Panama (2) Paraguay (2) Peru (4) Puerto Rico (2) Saint Kitts And Nevis (1) United States (45) Uruguay (1) Venezuela, Bolivarian Republic of (4) Virgin Islands, U.S. (1)	Cambodia (1) China (29) India (10) Indonesia (7) Iran, Islamic Republic Of (10) Israel (2) Japan (4) Jordan (2) Korea, Democratic People's Republic Of (3) Korea, Republic of (4) Kyrgyzstan (2) Lebanon (3) Malaysia (1) Maldives (1) Mongolia (6) Pakistan (1) Philippines (2) Qatar (1) Sri Lanka (4) Syrian Arab Republic (1) Thailand (4) Turkey (1) Turkmenistan (1) United Arab Emirates (1) Uzbekistan (1) Viet Nam (24) Yemen (2)	Austria (6) Belarus (3) Bulgaria (16) Croatia (1) Czech Republic (6) Estonia (1) Finland (2) France (8) Germany (16) Greece (2) Hungary (5) Ireland (2) Italy (8) Latvia (2) Lithuania (2) Montenegro (1) Netherlands (1) Poland (10) Portugal (7) Romania (4) Russian Federation (44) Serbia (1) Slovakia (4) Slovenia (3) Spain (40) Sweden (5) Switzerland (3) Ukraine (8) United Kingdom (8)	Australia (13) French Polynesia (1) Micronesia, Federated States Of (2) Palau (1)
TOTAL	**32**	**26**	**27**	**29**	**4**
	676				

The most important areas that need ecological studies are the biosphere reserve areas (Price et al., 2010) where practices regarding conservation of biological diversity, economic development and cultural values are implemented, selected, presented and developed (Ulaş, 2010; UNESCO-MAB, 2012). A total of 676 biosphere reserve areas exist in the world in various continents: 80 in Africa, 233 in America, 128 in Asia, 218 in Europe and 17 in Oceania (The World Database on Protected Areas (WDPA), 2012; Table 1; Figure 1).

Putting planning activities into practice for the conservation and use of internationally acclaimed biosphere reserve areas called “living laboratories” or “learning sites” (Batisse, 1982; Schultz and Lundholm, 2010; Reed and

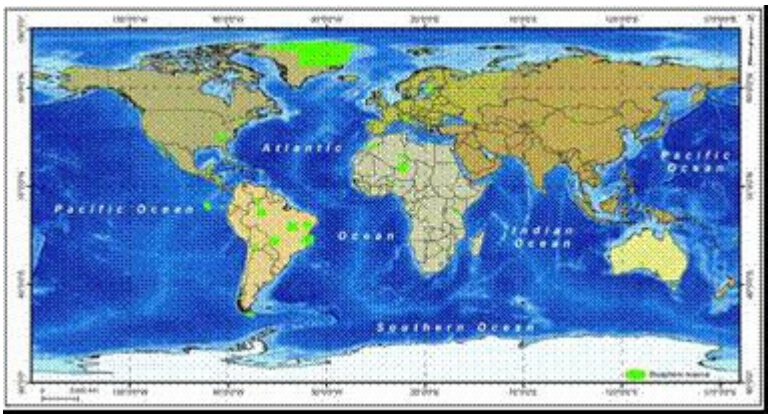

Figure 1. Location of Biosphere Reserves of World (The World Database on Protected Areas (WDPA), 2012)

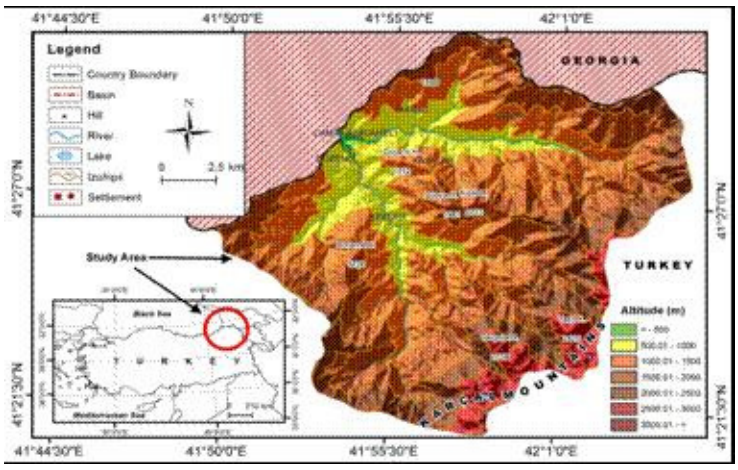

Figure 2. Location map

Egunyu, 2013) is regarded to be crucial for the conservation and their sustainability of natural resources (Hockings et al., 2006a; 2006b; Lu et al., 2012).

One of the biosphere reserve areas in the world is Camili (Macahel), the first and only biosphere reserve area in Turkey. This biosphere reserve area was taken into the framework of biological diversity and sustainable resource management (GEF) project in 2000 and it is highly rich in terms of biological diversity. Although it is also one of the 676 biosphere reserve areas in the world, it is also one of the most important 25 continental ecological regions under risk (Ulaş, 2010). The current study is important due to these reasons. Additionally, lack of sources in the literature in association with perspective based reviews about biosphere reserve areas makes this study important as well.

Current study undertook ecological impact assessment and analysis of Camili (Macahel) biosphere reserve area. The ecological characteristics of the biosphere reserve area were identified to plan natural resources in a more suitable manner. Answers to questions below were sought in the framework of the study: What are the factors that affect the ecological impact in Camili (Macahel) biosphere reserve area? How is the impact of these factors actualized? What are the possible results of this impact? What are the susceptibility factors that cause ecological impact? Which of these susceptibility factors has the most dominant impact? What is the distribution of areas with or without ecological risk in the biosphere reserve area? How should the ecological planning be done and how should it be implemented?

Description of the Study Area

Camili (Macahel) biosphere reserve area, is located in the Georgian border of Turkey (Figure 1). It is situated in Borçka District of Artvin province administratively. It is between 41° 31' 45" - 41° 21' 15" N latitude and 42° 05' 30" - 41° 43' 00" E longitude according to geographical coordinate system (Figure 2).

The biosphere reserve area with a surface area of 25.222 ha is bordered with Georgia in the north and northwest and

Karçal Mountains in the south, southeast and southwest (Figure 1).

The main soil in the biosphere reserve area composed of various age and type lithological units from Mezosoic to the present consists of Alpine orogenesis which started in Mesozoic and lasted until the end of Neocene period and volcanism products created in the same period. The oldest unit is the product of Upper Cretaceous old acid and alkaline underwater volcanism. These units generated thick volcano-sedimentary deposits based on the continuation of volcanism and sedimentation in the same environment from Paleocene to the end of Eocene (Sever and Kopar, 2009).

The area subjected to vertical and horizontal directional tectonic movements in the Upper Pliocene, epirogenic ascents were effective during Quaternary (Gattinger, 1962; Yılmaz et.al., 1998). Again in the same period, reverse faults and imbricated structures that had small angled overthrusts were created in the land where Karçal Mountains exist (Sever and Kopar, 2009).

The biosphere reserve area with an average elevation of 1609 m shows that characteristics of a rugged and high relief fragmented by rivers. Therefore geomorphologic units are mostly represented by mountains, hills or ridges (Koday and Kaymaz, 2013).

The area between Black Sea and the high mountains beyond it show mild and humid climate features with subtropical oceanic character (İnandık, 1969). Annual average temperature value is 11.9 ºC and annual average precipitation is 1315 mm (Kaymaz, 2012).

Biosphere reserve area where precipitation is observed in each season according to climate characteristics is rich in terms of hydrographic elements. The water in the area is drained by Efeler, Uğur and Düzenli rivers (Koday and Kaymaz, 2013).

Entisol, Inceptisol and Mollisol type soils are common in biosphere reserve area. Entisols were generated in the recent past (Atalay, 2011) on the alluvial materials in the river valleys (Efe, 2010). Found mostly on clayed main materials, they are in the initial period of their development (Atalay, 2011) and they can be observed in the whole biosphere reserve area. Mollisols are mostly found in the meadows situated in the high segments of the biosphere reserve area with their rich humus and clay content (Efe, 2010). These areas are mostly used in summer months as pastures (Zaman, 2007; Atalay and Mortan, 2011).

The biosphere reserve area located in the border of Karçal Mountains (Özhatay et.al., 2003) which is identified to be one of the 122 important flora areas is also rich in terms of flora the area with approximately 1021 different types of flora represents about 10% of flora in Turkey. It is located in Kolşik Flora world (Kaymaz, 2012) composed of lush plant assemblies (Atalay, 1994; 2008) made up of broad-leafed trees according to Turkey plant geography and flora regions (Atalay, 1994; 2002, 2011).

There are 6 settlements that bear village status in Camili (Macahel) biosphere reserve area. According to 2011 census, 1136 individuals live in the biosphere reserve area with an average population density of 4.5 individuals per km² (Koday and Kaymaz, 2013).

With the support of several public and private organizations (TEMA, TAR-GEL, UNESCO etc.), various types of economic activities such as beekeeping and organic agriculture have developed in the biosphere reserve area where agriculture and animal husbandry were once fundamental economic activities (Kaymaz, 2012). Also, Karagöl (Kopar and Sever, 2008) and Maral waterfall (Sever ve Kopar, 2009) are important tourism attractions and added value for tourism activities in the area due to the fauna and natural landscape of the attractions respectively (Kaymaz, 2012).

Based on all these reasons, Camili (Macahel) was declared by UNESCO to be the first “Biosphere Reserve Area” in Turkey in June 29, 2005. World Wide Fund for Nature (WWF) registered this area as one of the 20 Ecologic Regions. There are also two nature reserve areas (Camili-Efeler ve Camili-Gorgit) in the biosphere reserve area. The area was also declared “Pure Caucasian HoneyBee Genetic Region” by T.R. Ministry of Food, Agriculture and Livestock (Kaymaz, 2012).

MATERIALS AND METHOD

The study undertaken in the framework of ecological planning approach was completed in two phases. The first phase evaluated the elements that could result in ecological impact and their possible effects in the framework of Ecological Risk Assessment (ERA) method identified by “United States Environmental Protection Agency” (USEPA). In the second phase, factors that were identified during the first phase were analyzed. This analysis was undertaken by adapting the identified ecological factors with the help of weighted overlay technique based on “Ecological Risk Assessment” (ERA) and transferring the data to Geographical Information Systems (GIS) (Ndubisi, 2002; Tozar, 2006) database.

During the adaptation process, 60 factor maps with 10x10 m resolution were generated in grid format by considering the impact values identified during the stages (Çelik, 2000; Salihoğlu and Karael, 2005; Bozhüyük Ardahanlıoğlu et.al., 2012) of assigning impact values to identified problems, problem identification, analysis and risk identification. These factor maps were overlaid to obtain the densities of the ecological impact classes and their spatial distributions. In this phase, ArcInfo/ArcMap 10.0 package program based Geographical Information Systems (GIS) method and techniques which were generally utilized in environmental (Tecim, 2008) and ecological (Hogsett et.al., 1997; Lemly, 1997; Kooistra et.al., 2001; Preston, 2002; Solomon and Sibley, 2002; Salihoğlu and Karael, 2005) practices were used. Maps of various scales and Remote Sensing (RS) supported Land sat Satellite Image of 11.07. 2009 were

Table 2. Assessment of ecological risks factors

Ecological Risks Faktors	Impact area of risks	Cause the problems of ecological risks
Natural disasters	1) Residential area 2) Agricultural area 3) Human activities 4) Areas of natural fauna and flora	1) Landslide 2) Avalanche
Hydroelectric plant	1) River ecosystems 2) Areas of natural fauna and flora 3) Residential area 4) Agricultural area	1) Destruction of natural flora 2) Decrease in the numbers of flora and fauna 3) Destruction of biological environment 4) Deterioration of the natural landscape 5) Pollution of surface waters and degradation of their flow systems 6) Changes in the socio-cultural and economic structures of the local public
Road construction	1) Hidrographical area 2) Areas of natural fauna and flora 3) Residential area 4) Agricultural area	1) Landslide 2) Erosion 3) Destruction of natural flora 4) Decrease in the numbers of flora and fauna 5) Fragmentation of biological environment 6) Migration of wild life 7) Deterioration in the behavior of wild life 8) Icreases in the number of visitors 9) Increases in the number of motor vehicles 10) Noise pollution 11) Air pollution
Tourism activities	1) Hidrographical area 2) Areas of natural fauna and flora 3) Residential area 4) Agricultural area	1) Destruction of natural flora 2) Decrease in the numbers of flora and fauna 3) Narrowing the life space of the wildlife 4) Disregard to regional/local architecture in the news structures built for accommodation 5) Negative effects on socio-cultural life 6) Environmental pollution 7) Widespread mass tourism 8) Increase in the number of marginal people 9) Locals' new status as workers
Tourist pressure	1) Hidrographical area 2) Areas of natural fauna and flora 3) Residential area 4) Agricultural area	1) Environmental pollution 2) Destruction of natural flora 3) Taking endemic species abroad 4) Decreases in the number of flora and fauna 5) Deterioration in the behavior of wild life and migration 6) Negative impacts on socio-cultural life 7) Increases in the places for accommodation 8) Formation of excessive production and consumption activities 9) Widespread mass tourism 10) Exceeding the touristic capacity 11) Increase in the number of marginal people

utilized in generating Factor 1 maps. Findings obtained at the end of study were checked both with the use of literature and in situ field studies. Suggestions were developed following these checks.

RESULTS AND DISCUSSION

The natural environment is composed of two main elements: living and non living beings. There is a balanced and close relationship between these two elements. Deterioration in this relationship due to various factors damages the ecological environment (Atalay, 2008). Therefore identification of factors that affect the ecological environment is crucial (Van Lynden, 2000).

In this section, the factors that threaten the ecological environment in the first and single biosphere reserve area, Camili (Macahel) were identified, assessed and analyzed in the framework of ecological planning criteria.

Assessment of Ecological Effect

Ecological Impact Assessment both acts as a strong support for comparing, ranking and prioritizing the potential risks (Schierow, 1994) and allows the realization of a planning process that foresees the possible risks on the natural resources which will help estimate the negative environmental impact that can be experienced in the future (Bozhüyük Ardahanlıoğlu et.al., 2012).

In the light of both the literature (Ulaş, 2010; Kaymaz, 2012) and the field trips, natural disasters, construction of a hydroelectric plant, road construction, tourism activities and tourist pressure were found to be the main ecological impact factors in Camili (Macahel) biosphere reserve area (Table 2). Although these factors are shaped according to the conditions and the time, they cause the problems identified in Table 2.

The first problem in terms of ecological impact in Camili (Macahel) biosphere reserve area is natural disasters (Table 2). The area is under risk for landslides and avalanche (Koday and Kaymaz, 2013; Özşahin and Kaymaz, 2013). Some settlements were founded ın flatland (Kaymaz, 2012; Koday and Kaymaz, 2013) that are termed as surfaces with landslides (Sever and Kopar, 2009). In the winter, avalanche may be experienced after severe snowfall caused by the snow cover of about 10 m (Kaymaz, 2012). There has been no loss of life or property until now due to natural disasters in the area. However, wild life and forest areas are negatively impacted because of these natural disasters (Kaymaz, 2012).

The second element that threatens the ecological environment in Camili (Macahel) biosphere reserve area is the construction of the hydroelectric plant (Table 2). There are 9 initiatives in project stage in this framework (Board of Trustees Meeting, 2009). It has been stressed that putting these projects into practice will harm the river ecosystems, natural fauna and flora areas and settlements and agricultural land in the ecological sense (Ulaş, 2010). As a result of these damages, destruction of natural flora, decrease in the numbers of flora and fauna, destruction of biological environment, deterioration of the natural landscape, pollution of surface waters and degradation of their flow systems and changes in the socio-cultural and economic structures of the local public may be experienced (Table 2).

Another problem that threatens the ecological environment in Camili (Macahel) biosphere reserve area is road construction (Table 2). The area consists of a total of 99.5 km road, 13.5 km of which are forest road; 30 km is village road, 35 km is plateau road and 21 km is highway. Road density in the area is 3.9 m/ha (Albayrak, 2010). In case road construction in the biosphere reserve area continues in a manner devoid of ecological understanding, degradation of the naturalness of the area will be inevitable (Kurdoğlu, 2001). Especially the hydrographic areas, natural flora and fauna areas, settlements and agricultural areas may be affected more in this case. As a result of negative ecological factors present in the area, primarily natural disasters such as landslides and erosion may occur in addition to destruction of the natural flora, decreases in the number of flora and fauna, fragmentation of the biological environment, deterioration in the behavior of wild life and migration, increases in the number of visitors and motor vehicles, noise and air pollution (Table 2).

The fact that Camili (Macahel) biosphere reserve area is untouched and suitable has facilitated eco tourism activities (Table 2). In this context, many different types of eco tourism activities are undertaken such as plateau and mountain tourism, trekking, bird watching, wildlife (fauna) watching, botanic tourism and adventure tourism. However, each passing day, “eco tourism” is turning into “ego tourism” (Munt, 1994; Arı, 2009) because of insensible human behavior and ecological environment may be damaged (Özgüç, 2007). For instance, it was identified that some tourists damage the flora on the forest floor and pollute the environment around Karagöl which is located in the biosphere reserve area (Kopar and Sever, 2008). Along the same lines, environmental pollution reported around Maral Falls, another tourism value; was linked to tourism activities (Sever and Kopar, 2009).

Hydrographic areas, natural flora and fauna areas, settlements and agricultural areas in the biosphere reserve area can face negative ecological impact as a result of insensible and unplanned tourism activities (Table 2). As a matter of fact, this situation has often been emphasized in the literature (Özgüç, 2007; Kopar and Sever, 2008; Sever and Kopar, 2009; Kaymaz, 2012). Especially the destruction of natural flora, decreases in the number of flora and fauna, narrowing the life space of the wildlife, disregard to regional/local architecture in the news structures built for accommodation, negative effects on socio-cultural life,

Table 3. Evaluation of ecological risks factors

Parameters	Factor of parameters	Category of factor	Level Impact of Ecological Risks					Value of Risk Zoning
			Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	
GEOLOGY	Lithology	Volcanites and sedimentary rocks (Upper Cretaceous)	2	2	2	1	1	2
		Neritic limestone (Upper Cretaceous–Paleocene)	2	1	1	2	2	
		Clastic rocks (Upper Paleocene-Eocene)	3	1	1	0	0	
		Unsorted volcanics (Eocene)	1	3	3	2	2	
		Volcanites and sedimentary rocks (Middle-Upper Eocene)	2	2	2	3	3	
	Distance to fault lines (m)	<-100	3	3	3	3	3	2
		100-1000	2	2	2	2	2	
		1000->	1	1	1	1	1	
GEOMORPHOLOGY	Landforms	Mountain	2	2	1	1	1	3
		Plateau	2	3	1	2	2	
		Plain	1	1	2	2	3	
		Slope	3	3	3	3	2	
	Slope (%)	<-2	1	1	1	3	3	3
		2-8	2	2	2	2	2	
		8-16	2	2	2	2	2	
		16-24	3	3	3	1	1	
		24->	3	3	3	1	1	
	Aspect	Flat	1	0	3	3	3	1
		N-NE-NW	3	3	1	1	1	
		S-SE-SW	1	1	1	2	1	
		E-W	2	0	1	2	2	
	Elevation (m)	<-500	3	3	3	3	3	2
		501-1000	3	3	3	3	3	
		1001-1500	3	2	2	2	2	
		1501-2000	2	2	2	2	2	
		2001-2500	2	1	1	1	1	
		2501-3000	1	0	1	1	1	
		3001->	1	0	1	1	1	

Table 3. Continue

CLIMATE	**Temperature (℃)**	10-11	3	3	3	3	3	**2**
		11-12	2	2	2	2	2	
		12-13	1	1	1	1	1	
	Precipitation (mm)	<-1564.7	1	1	1	3	3	**3**
		1564.8-1834.7	1	1	1	3	3	
		1834.8-2104.7	2	2	2	2	2	
		2104.8-2374.7	2	2	2	2	2	
		2374.8-2644.7	3	3	3	1	1	
		2644.8-2914.7	3	3	3	1	1	
		2914.8->	3	3	3	1	1	
HİDROGRPHY	**Distance to rivers (m)**	<-100	3	3	0	3	3	**2**
		101-250	3	3	0	3	3	
		251-500	2	2	0	2	2	
		501-1000	2	2	0	2	2	
		1001->	1	1	0	1	1	
SOIL	**Soil**	Entisol	1	2	1	2	2	**1**
		İnceptisol	3	3	3	3	3	
		Mollisol	2	1	1	1	1	
LANDUSE	**Landuse**	Residential Area	2	1	3	3	3	**3**
		Forest Area	1	3	2	2	2	
		Bare land	3	0	2	1	1	
	Distance from highway routes (m)	<-100	3	3	3	3	3	**3**
		101-250	3	3	3	3	2	
		251-500	2	2	2	2	2	
		501-1000	2	2	2	2	1	
		1001->	1	1	1	1	1	

environmental pollution, widespread mass tourism, increase in the number of marginal people and locals' new status as workers are the main possible impacts of the risks in these areas (Table 2).

There is a dense tourist pressure as a result of the tourism activities undertaken in Camili (Macahel) biosphere reserve area (Table 2). Accordingly, 240 persons in 2002, 1140 in 2003, 1192 in 2004, 816 in 2005, 1382 in 2006, 1901 in 2007, 2880 in 2008, and 3510 in 2009 visited the area as tourists. It is estimated that the number still increased between 2010 and 2011 and exceeded 4000 persons. Also, the number of tour operators interested in the area in the beginning of 2000s was only one but this number increased to 14 today (Albayrak, 2010). This situation may have an impact on hydrographic areas, natural flora and fauna areas, settlements and agricultural areas in the biosphere reserve area (Table 2).

Environmental pollution, destruction of the natural flora, taking endemic species abroad, decreases in the number of flora and fauna, deterioration in the behavior of wild life and migration, negative impacts on socio-cultural life, increases in the places for accommodation, formation of excessive production and consumption activities, widespread mass tourism, exceeding the touristic capacity and increase in the number of marginal people surfacing in the area may be possible (Table 2).

Analysis of Ecological Impact

Ecological factors identified in the framework of Ecological Risk Assessment (ERA) were analyzed by adapting them to Geographical Information Systems (GIS) base. In the analysis, the impacts of environmental factors rather than human factors that are prominent on ecological factors were assessed in terms of their roles in the formation of the factors. Ranges from 0 to 3 were defined during his assessment (Table 3) where 0 represent no impact, 1 less impact, 2 impact and 3 high impact category Çelik, 2000; Bozhüyük Ardahanlıoğlu et.al., 2012) (Table 3).

According to the analysis, the main factors on the ecological impact in the biosphere reserve area are geology, geomorphology, climate, hydrography, soil and land use (Table 3). These main factors are supported by some

Table 4. Impact degree and surface area of geology factor

Geology factor	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
Volcanites and sedimentary rocks (Upper Cretaceous)	Impact	Impact	Impact	Less Impact	Less Impact	4907	19
Neritic limestone (Upper Cretaceous–Paleocene)	Impact	Less Impact	Less Impact	Impact	Impact	495	2
Clastic rocks (Upper Paleocene-Eocene)	High impact	Less Impact	Less Impact	No effect	No effect	56	1
Unsorted volcanics (Eocene)	Less Impact	High impact	High impact	Impact	Impact	323	1
Volcanites and sedimentary rocks (Middle-Upper Eocene)	Impact	Impact	Impact	High impact	High impact	19442	77
					TOTAL	**25222**	**100**

parameter factors in detail. The parameter factors identified in the biosphere reserve area in the framework of the main factors are investigated below in terms of ecological impact assessment.

The first distinctive main factor regarding ecological impact is geology. In the study, the impact of geology was considered as lithology and distance to fault lines (Table 3).

The visibility of lithological characteristics on ecological impact is crucial since they form the foundation in the environment of development for these factors. Hence, this factor has a distinctive role in the formation of natural disasters in the biosphere reserve area and in the identification of the main soil in construction of hydroelectric plants and roads.

Volcanic and sedimentary rocks that blong to Middle-Upper Eocene that mostly expand in the biosphere reserve area (19442 ha–77 %) were considered in the category of impact outside of tourism activities and tourist pressure which are in the category of high impact. Lithology which comes second in terms of spatial magnitude (4907 ha–19 %) are Upper Cretaceous volcanites and sedimentary rocks. this unit has impact for risks other than tourism activities and tourist pressure regarded in less impact category. Another geological unit in terms of spatial magnitude is Upper Cretaceous–Paleocene neritic limestone (495 ha–2 %). This stack has less impact on road and hydroelectric power plant construction but has impact in the other categories. Eocene era unsorted volcanic that cover an area of 323 ha (1 %) have less impact in terms of natural disasters, have high impact in terms of road and hydroelectric power plant construction and have impact in terms of tourism activities and tourist pressure. The last geological unit Upper Paleocene-Eocene clastic rocks with 56 ha (1 %) are found to have high impact in terms of natural disasters, have less impact in terms of road and hydroelectric power plant construction and have no impact in regards to tourism activities and tourism pressure (Table 4; Figure 3).

Another parameter that can be assessed in terms of geological characteristics is the distance to fault lines. This factor was evaluated in three categories: <-100 (440 ha–2 %), 100-1000 (4152 ha–16 %) and 1000-> (20630 ha–82 %). These classes correspond to high impact, impact and less impact categories respectively (Table 5; Figure 3).

It is a natural factor that plays a role in the ecological impact on geological characteristics. In the study, landforms, slope, exposure and elevation characteristics were evaluated in the biosphere reserve area scale.

The first parameter that will be mentioned is the landforms. Declivities are most found in the biosphere reserve area (15891 ha–63 %). These units are included in

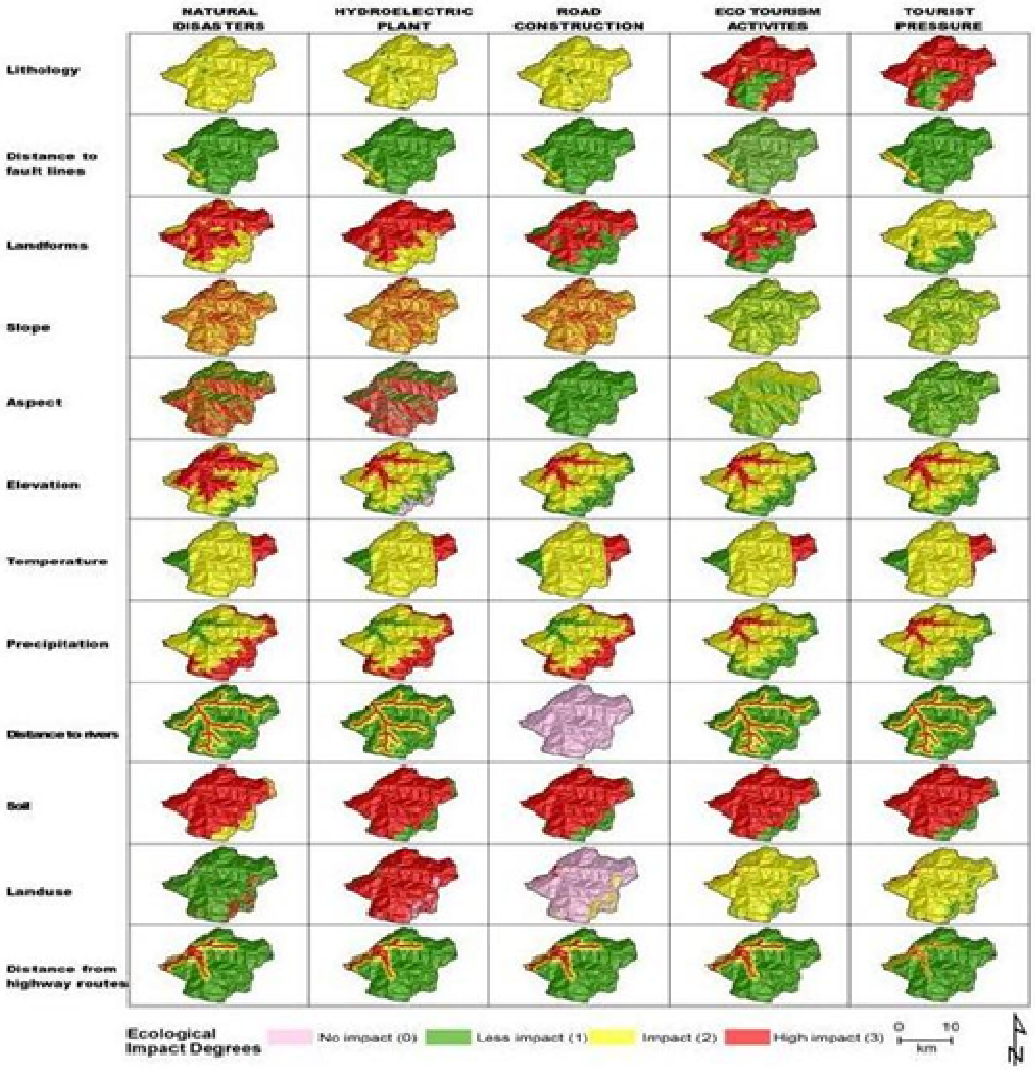

Figure 3. Evaluation of ecological risks factors

Table 5. Impact degree and area of distance to fault lines (m) factor

Distance to fault lines (m)	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-100	High impact	High impact	High impact	High impact	High impact	440	2
100-1000	Impact	Impact	Impact	Impact	Impact	4152	16
1000->	Less Impact	Less Impact	Less Impact	Less Impact	Less Impact	20630	82
					TOTAL	**25222**	**100**

Table 6. Impact degree and surface area of landform factor

Landforms	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
Mountain	Impact	Impact	Less Impact	Less Impact	Less Impact	6919	27
Plateau	Impact	High impact	Less Impact	Impact	Impact	2389	9
Plain	Less Impact	Less Impact	Impact	Impact	High impact	23	1
Slope	High impact	High impact	High impact	High impact	Impact	15891	63
					TOTAL	**25222**	**100**

Table 7. Impact degree and surface area of slope (%) factor

Slope (%)	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-2	Less Impact	Less Impact	Less Impact	High impact	High impact	61	1
2-8	Impact	Impact	Impact	Impact	Impact	5288	21
8-16	Impact	Impact	Impact	Impact	Impact	9173	36
16-24	High impact	High impact	High impact	Less Impact	Less Impact	1175	5
24->	High impact	High impact	High impact	Less Impact	Less Impact	9525	37
					TOTAL	**25222**	**100**

the category of high impact without the tourist pressure included in the category of impact. In terms of special magnitude, this geomorphologic unit is followed by mountains (6919 ha–27 %), plateaus (2389 ha–9 %) and prairies (23 ha–1 %) respectively. Mountains are in the high impact category in natural disasters and road and hydroelectric power plant construction and are in less impact category in other ecological risks. Plateaus are found to have high impact in hydroelectric power plant construction, have less impact in road construction and have impact in the other risk groups. Prairies are found to have less impact in natural disasters and hydroelectric power plant construction, have impact in road construction and tourism activities and have high impact in tourist pressure aspect. (Table 6; Figure 3).

Slope is another geomorphologic parameter which is dominant on ecological impact. Ecological impact degrees, natural disasters and road and hydroelectric power plant construction increase along with increases in slope in biosphere reserve area however tourism activities and tourist pressure decrease. Slope factor values are ranked from large to small spatially 24 %-> (9525 ha–37 %), % 8-16 (9173 ha–36 %), 2-8 % (5288 ha–21 %), 16-24 % (1175 ha–5 %) and <-2 % (61 ha–1 %) (Table 7; Figure 3).

Aspect is another factor which needs to be considered in relation with geomorphologic characteristics. Only hydroelectric power plant construction has no impact in terms of aspect values. N-NE-NW directions in the biosphere reserve area which cover the widest space (12072 ha–48 %) have high impact in terms of natural disasters and the other ecological factors are in less impact category. S-SE-SW directions (8541 ha–34 %) are in the category of less impact in terms of factors other than tourism activities. Flat in the biosphere reserve area (1 ha–1 %) is in the category of high impact excluding natural disasters with less impact. Directions E-W (4608 ha–18 %) is in less impact category in terms of road construction and in impact category in terms of other impact groups (Table 8; Figure 3).

Table 8. Impact degree and surface area of aspect factor

Aspect	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
Flat	Less Impact	No effect	High impact	High impact	High impact	1	1
N-NE-NW	High impact	No effect	Less Impact	Less Impact	Less Impact	12072	48
S-SE-SW	Less Impact	No effect	Less Impact	Impact	Less Impact	8541	34
E-W	Impact	No effect	Less Impact	Impact	Impact	4608	18
					TOTAL	**25222**	**100**

Table 9. Impact degree and surface area of elevation factor

Elevation	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-500	High impact	High impact	High impact	High impact	High impact	126	0.5
500-1000	High impact	High impact	High impact	High impact	High impact	3436	14
1000-1500	High impact	Impact	Impact	Impact	Impact	7590	30
1500-2000	Impact	Impact	Impact	Impact	Impact	7777	31
2000-2500	Impact	Less Impact	Less Impact	Less Impact	Less Impact	4530	18
2500-3000	Less Impact	No effect	Less Impact	Less Impact	Less Impact	1671	7
3000->	Less Impact	No effect	Less Impact	Less Impact	Less Impact	91	0.4
					TOTAL	**25222**	**100**

Elevation affects ecological impact in relation with geomorphologic characteristics. The degree of the impact changes parallel to natural factors and human activities (Sergün, 1993-1996) that change based on elevation. Accordingly, all ecological impact in the biosphere reserve area identified between elevation zones of <-500 m and 501-1000 m are in high impact category. These two zones are dispersed in 126 ha (0.5%) and 3436 ha (14%) area respectively. Elevation zones of 1001-1500 m and 1501-2000 m are in impact category. For 1001-1500 m elevation zone, only natural disasters risk is found in high impact category. These two elevation zones are dispersed in 7590 ha (30 %) and 7777 ha (31 %) area respectively. For elevations higher than 2000 m in the biosphere reserve area, all factors are in less impact category such as hydroelectric power plant construction and only natural disasters is observed with high impact between elevations of 2001-2500 m (Table 9; Figure 3).

Climate characteristics are among the main factors that identify ecological impact. The first parameter to consider is temperature since temperature conditions are important in terms of triggering avalanche risk in the context of natural disasters and it also affects hydroelectric power plant and road construction. Impact values were identified accordingly. Natural disasters and related ecological impact degrees are ranked as high impact, impact and less impact with increases in temperature values. However, temperature is directly proportional to tourism activities and tourist pressure.

Table 10. Impact degree and surface area of temperature factor

Temperature (℃)	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
10-11	High impact	High impact	High impact	Less Impact	Less Impact	3052	12
11-12	Impact	Impact	Impact	Impact	Impact	19987	79
12-13	Less Impact	Less Impact	Less Impact	High impact	High impact	2183	9
					TOTAL	**25222**	**100**

Table 11. Impact degree and surface area of precipitation factor

Precipitation (mm)	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-1564.7	Less Impact	Less Impact	Less Impact	High impact	High impact	14	0.1
1564.7-1834.7	Less Impact	Less Impact	Less Impact	High impact	High impact	2439	10
1834.7-2104.7	Impact	Impact	Impact	Impact	Impact	7073	28
2104.7-2374.7	Impact	Impact	Impact	Impact	Impact	8049	32
2374.7-2644.7	High impact	High impact	High impact	Less Impact	Less Impact	5228	21
2644.7-2914.7	High impact	High impact	High impact	Less Impact	Less Impact	2243	9
2914.7->	High impact	High impact	High impact	Less Impact	Less Impact	176	1
					TOTAL	**25222**	**100**

This situation is caused as a result of the indicative role of temperature conditions generated according to temperature increase on natural disasters. Temperature value are distributed spatially from large to small respectively 11-12 ℃ (19987 ha–79 %), 10-11 ℃ (3052 ha–12 %) and 12-13 ℃ (2183 ha–9 %) (Table 10; Figure 3).

Precipitation is another parameter that can be considered in the context of climate conditions. Increases in the However, less precipitation generates increases in tourism activities and tourist pressure. The dominance of precipitation on ecological impact factors can be ranked from large to small respectively in spatial terms 2104.8-2374.7 mm (8049 ha–32 %), 1834.8-2104.7 mm (7073 ha–28 %), 2374.8-2644.7 mm (5228 ha–21 %), 1564.8-1834.7 mm (2439 ha–10 %), 2644.8-2914.7 mm (2243 ha–9 %), 2914.8-> mm (176 ha–1 %) and <-1564.7 mm (14 ha–0.1 %) (Table 11; Figure 3).

precipitation values in the biosphere reserve area result in increases of the impact degree on natural disasters and hydroelectric power plant and road construction but cause decreases of impact degree in tourism activities and tourist pressure. Increase in the impact degree results in increased risk of mass movement, increased water levels for use in hydroelectric power plant construction and decreases in road endurance/strength with increased precipitation.

Another parameter dominant on ecological impact is hydrography. Distance to rivers is regarded as a hydrography factor that affects ecological impact. In biosphere reserve area, all factors excluding road construction have less impact degrees when the distance from rivers increases. Distance from rivers factor is distributed as areas higher than 1000 m (15074 ha–60 %) and areas under 100 m (1114 ha–4 %) (Table 12; Figure 3).

Table 12. Impact degree and surface area of distance from rivers

Distance from rivers	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-100	High impact	High impact	No effect	High impact	High impact	1114	4
100-250	High impact	High impact	No effect	High impact	High impact	1616	6
250-500	Impact	Impact	No effect	Impact	Impact	2567	10
500-1000	Impact	Impact	No effect	Impact	Impact	4851	19
1000->	Less Impact	Less Impact	No effect	Less Impact	Less Impact	15074	60
					TOTAL	**25222**	**100**

Table 13. Impact degree and surface area of soil factor

Soil	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
Entisol	Less Impact	Impact	Less Impact	Impact	Impact	23	0.1
İnceptisol	High impact	High impact	High impact	High impact	High impact	22271	88
Mollisol	Impact	Less Impact	Less Impact	Less Impact	Less Impact	2927	12
					TOTAL	**25222**	**100**

Soil characteristics, the fundamental environment for the food source of life in all terrestrial eco systems (Akşit, 2010), are important indicators for ecological impact. Therefore Inceptisols with the widest distribution in the biosphere reserve area (22271 ha–88 %) are in high impact category. Mollisols which come second in terms of spatial distribution (2927 ha–12 %) are in less impact category in terms of all ecological factors other than natural disasters which are considered in impact category. Entisols found in narrower distributions (23 ha–0.1 %) have less impact on natural disasters and road construction and have impact on the other factors (Table 13; Figure 3).

Land use characteristics play an effective role on ecological impact factors depending on physical characteristics (Tağıl, 2007). Three land use classes were identified in the biosphere reserve area by using 2000 Landsat Satellite Images. Forests cover the largest area spatially in the biosphere reserve area (23014 ha–91 %). This forest cover class has less impact on natural disasters, have high impact on hydroelectric power plant construction and have impact on the other ecological factors. Bare land that comes second in spatial magnitude (1713 ha–7 %) has high impact in terms of natural disaster, no impact in terms of hydroelectric power plant construction, impact in terms of road construction and less impact in tourism activities. The last land use class, residential areas (496 ha–2 %), has impact on natural disasters, less impact on hydroelectric power plant construction and high impact on road construction, tourism activities and tourist pressure (Table 14; Figure 3).

Distance from highway routes is another factor that needs to be considered in the framework of this study. Identification of this factor is crucial in the identification of ecological impact since it constitutes one of the floor cover elements in the area (Ekinci, 2007). Impact of the transportation factor in the biosphere reserve area is represented as follows: high impact between <-100 m (910 ha–4 %) and 101-250 m (1089 ha–4 %), impact between 251-500 m (1380 ha–5 %)

Table 14. Impact degree and surface area of land use factor

Landuse	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
Residential Area	Impact	Less Impact	High impact	High impact	High impact	496	2
Forest Area	Less Impact	High impact	Impact	Impact	Impact	23014	91
Bare land	High impact	No effect	Impact	Less Impact	Less Impact	1713	7
					TOTAL	**25222**	**100**

Table 15. Impact degree and surface area of distance form highway routes

Distance from highway routes	ECOLOGICAL RISKS					Area	
	Natural Disasters	Construction of Dam	Construction of Road	Tourism Activity	Effects of Tourists	Ha	%
<-100	High impact	High impact	High impact	High impact	High impact	910	4
100-250	High impact	High impact	High impact	High impact	Impact	1089	4
250-500	Impact	Impact	Impact	Impact	Impact	1380	5
500-1000	Impact	Impact	Impact	Impact	Less Impact	2228	9
1000->	Less Impact	Less Impact	Less Impact	Less Impact	Less Impact	19615	78
					TOTAL	**25222**	**100**

and 501-1000 m (2228 ha–9 %) and less impact between 1001-> m (19615 ha–78 %). Tourist pressure factor was found to have impact on distances between 101-250 m whereas tourist pressure factor was found to have less impact on distances between 501-1000 m (Table 15; Figure 3).

CONCLUSIONS

Camili (Macahel) declared as the first and only biosphere reserve area of Turkey is rich in terms of natural resources. However, natural disasters, hydroelectric power plant construction, road construction, tourism activities and tourist pressure are the main factors that threaten the environment. It was identified that areas with no impact (15172 ha–60 %) cover the widest area in Camili (Macahel) biosphere reserve area based on the results of analysis which was undertaken by comparing the impact degrees of the above mentioned factors to other natural factors. Areas with high impact is seen only in a small area (1188 ha–5 %). Other than these, areas with less impact (6590 ha–26 %) and areas with impact (2272 ha–9 %) are found in the biosphere area (Table 16; Figure 4).

Investigation of the distribution of the impact degrees shows that the areas with high impact correspond to the areas in the biosphere reserve area where settlements exist. The section of the biosphere reserve area closer to Karçal

Table 16. Distribution of ecological impact degrees

Ecological impact degrees	AREA Ha	%
No effect	15172	60
Less impact	6590	26
Impact	2272	9
High impact	1188	5
TOTAL	**25222**	**100**

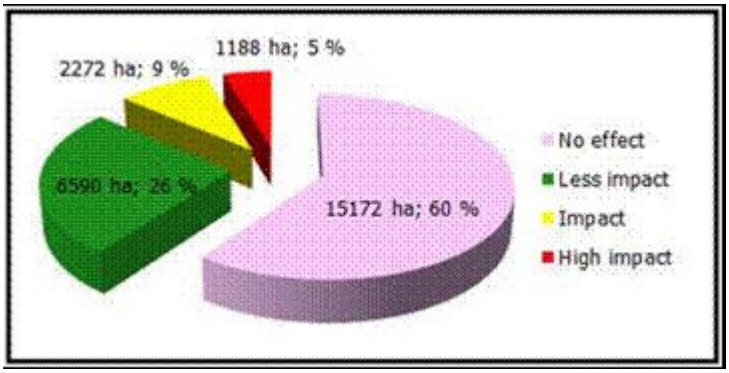

Figure 4. Distribution graphic of ecological impact degrees

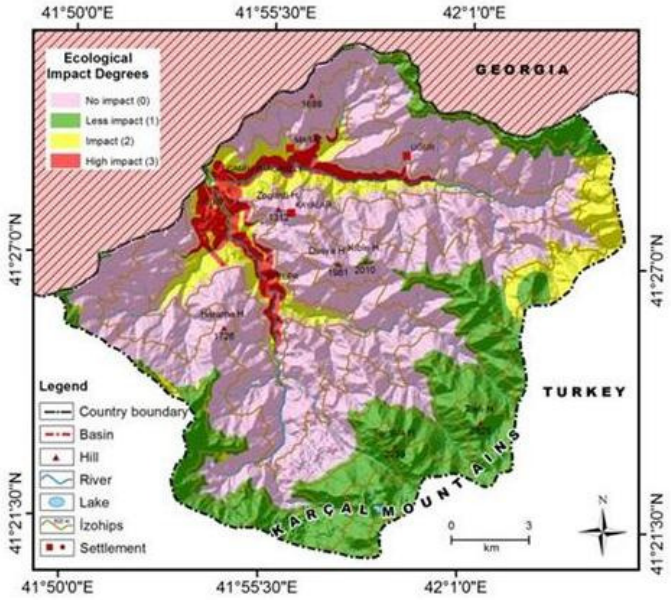

Figure 5. Distribution map of ecological impact degrees

Mountains is observed as an area with less impact (Figure 5).

In the light of the assessment and analyses about the Camili (Macahel) biosphere reserve area, precautions outlined below should be taken:

- Problems identified as priority in impact areas should be focused on with the help of local studies,
- More detailed studies should be provided in which ecological impacts in the biosphere reserve area are separately studied,

- An ecologically appropriate planning system should be developed,
- Care should be given not to damage the cultural texture in the biosphere reserve area
- All types of activities and events should be realized by paying attention to ecological issues which requires prior education and awareness raising
- Local public should be involved in all implementations
- Public and tourists should cooperate in conserving the natural resources which provide added value to this area
- Sustainability approach should be prominent in all implementations

The study has confirmed that some methods developed in ecological framework can be analyzed with the help of Geographical Information Systems (GIS) and Remote Sensing (RS) methods and techniques. Study also shows that the proposed method is suitable for these types of fields.

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