Technology, 13(4), 251-260, (2010)

TECHNOLOGY

MAPPING AND ANALYSIS OF RIPARIAN FORESTS: CASE STUDY OF BASKONUS RESEARCH AND APPLICATION FOREST IN KAHRAMANMARAS, TURKEY

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Abstract

The riparian forests are the most important zones of forest habitat in terms of maintaining the biodiversity in forest ecosystem. However, it is alarming to realize that riparian ecosystems have been rapidly degraded in many parts of the world. To restore and maintain riparian ecosystems, first, riparian areas should be divided into the buffer zones (i.e. reserve zone and management zone) and then specific strategies for these zones should be properly integrated into the management plans. In this study, GIS techniques were implemented to evaluate the riparian buffer zones in Baskonus Research and Application Forest of Kahramanmaras Sutcu Imam University, located in Mediterranean city of Kahramanmaras in Turkey. The results indicated that the riparian areas in the Research and Application Forest was mostly covered by the management zone of S4 (49.02%) and S6 (36.82%) streams. It was found that large proportion of the riparian zones were located in forested land (82.69%) and followed by lake (8.62%) and agricultural areas (7.46%). The results also indicated that about road sections of 712 m was located within the acceptable minimum distance of riparian areas.

Key words: Forest ecosystem, Riparian zones, GIS techniques, Buffer analysis

1. Introduction

The buffer zones adjacent to surface water network such as streams, lakes or reservoirs, and wetlands are defined as riparian areas (Figure 1). The soil and vegetation in the riparian areas are very effective in removing large amount of nitrogen through discharging groundwater [1]. The riparian vegetation can hold sediment particulates being delivered to the water bodies and regulate stream temperatures by shading [2, 3]. The riparian areas play a critical role in maintaining the downstream water quality and reducing the impact on adjacent aquatic life [4]. Besides, they provide an important habitat area for wildlife and serve as movement corridors between the upland and the downstream [5].

Figure 1. A streamside riparian area in Kahramanmaras, Turkey

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The forests located adjacent to streams, lakes, and wetlands are defined as riparian forests [6]. The riparian forests are vital to the protection of forest ecosystem and the enhancement of the biodiversity. In addition, the riparian forests are complex ecosystems functioning as transitional zones between terrestrial forest habitat and aquatic life. The riparian areas have been degraded in many parts of the world mainly due to human development and agriculture [7]. The forestry operations are also potentially considered to be one of the major causes of the degradation since riparian forests contain high-quality timber and forest roads can be easily located along the streamside [8]. To prevent the long term impacts of degradation, human development, and agriculture should be minimized and ecologically sound forestry operations should be practiced in riparian areas [5, 9].

The previous studies pointed out that it will take long time to restore riparian areas once they have been degraded [10]. Restoring degraded riparian areas is crucial, yet it is very difficult and long term task which requires inputs from variety of disciplines and cooperation between researchers and managers. Besides, the importance of the ecological and hydrological values of riparian ecosystem should be well understood by practitioners and local communities [9].

To restore and maintain degraded riparian areas, first, they should be divided into the buffer zones including reserve zone and management zone [6] (Figure 2). Then, the specific strategies should be determined for these zones and properly integrated into the management plans. The human development, agriculture, and forestry operations are restricted in the reserve zones. Only ecologically sound forestry operations should be applied in the management zones. Forestry practices such as afforestation, regeneration, maintenance etc. should be implemented only to protect reserve zone and to ensure sustainable use of management zones [11]. The road constructions must be restricted in the riparian zones or minimized considering necessary stream crossings points. Besides, the number of stream crossings must be limited and crossing angels should be controlled [12]. To minimize the potential sediment yield from a road section, cut-slope and fill-slope areas must be revegetated after road construction [13].

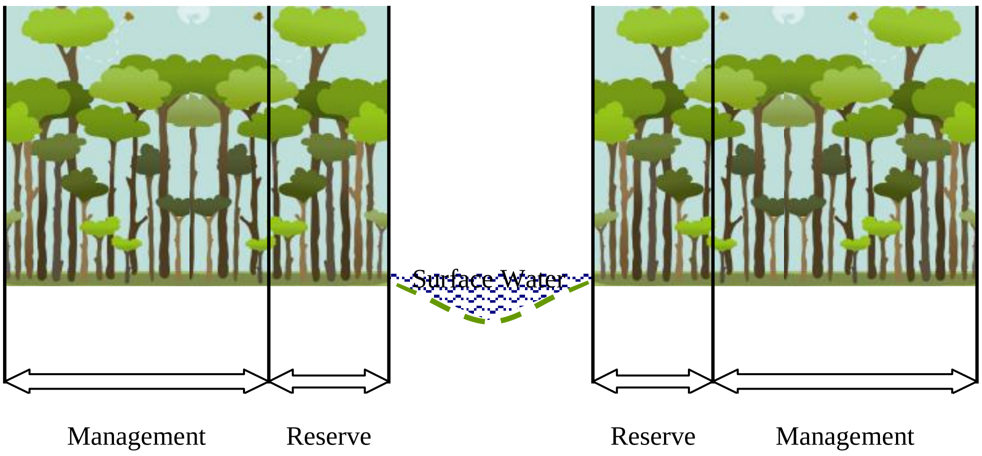

Figure 2. The illustration of a riparian area with management zone and reserve zone

In many parts of Turkey, the riparian forests are mostly degraded as specific management plans have not been implemented for these areas [9]. There have been only few studies concerning management of riparian zones in Turkey [14, 15]. In this study, riparian buffer zones in Baskonus Research and Application Forest in Kahramanmaras Sutcu Imam University, were evaluated by implementing Geographical Information System (GIS) techniques. The land use types along the riparian zones were assessed and the current status of the road network in the Research Forest was analyzed with respect to riparian buffer zones.

2. Material and Methods

2.1. Study Area

Baskonus Research and Application Forest is located in the Mediterranean city of Kahramanmaras in Turkey. The Baskonus Research Forest is managed by the Forest Enterprise Chief of Baskonus under Kahramanmaras Forest Enterprise Directorate. The research forest is about 458 ha in which 374.5 ha is forested land and rest of the land is covered by water bodies, open areas, and agricultural areas. The dominant tree species include Pinus brutia, Pinus nigra, Cedrus libani, and Abies cilicica in the forest. The average side-slope and ground elevation were reported as 73% and 1165 m, respectively [13]. In the research forest, there are over 10 km of road network consisted of asphalt, gravel, and unpaved-forest roads. There are also stream network, a small lake (pond), and a partially wetland area in the forest. The lake has been used mainly for irrigation purposes.

2.2. Data Layers

The GIS database was generated by using ArcGIS 9.2 program. The database included stream layer, road layer, Digital Elevation Model (DEM), slope map, and stand type map. The stream and road layers were generated based on a 1:25000 scale topographic map. The DEM layer was developed based on counter lines with 10 m intervals on the topographic map (Figure 3).

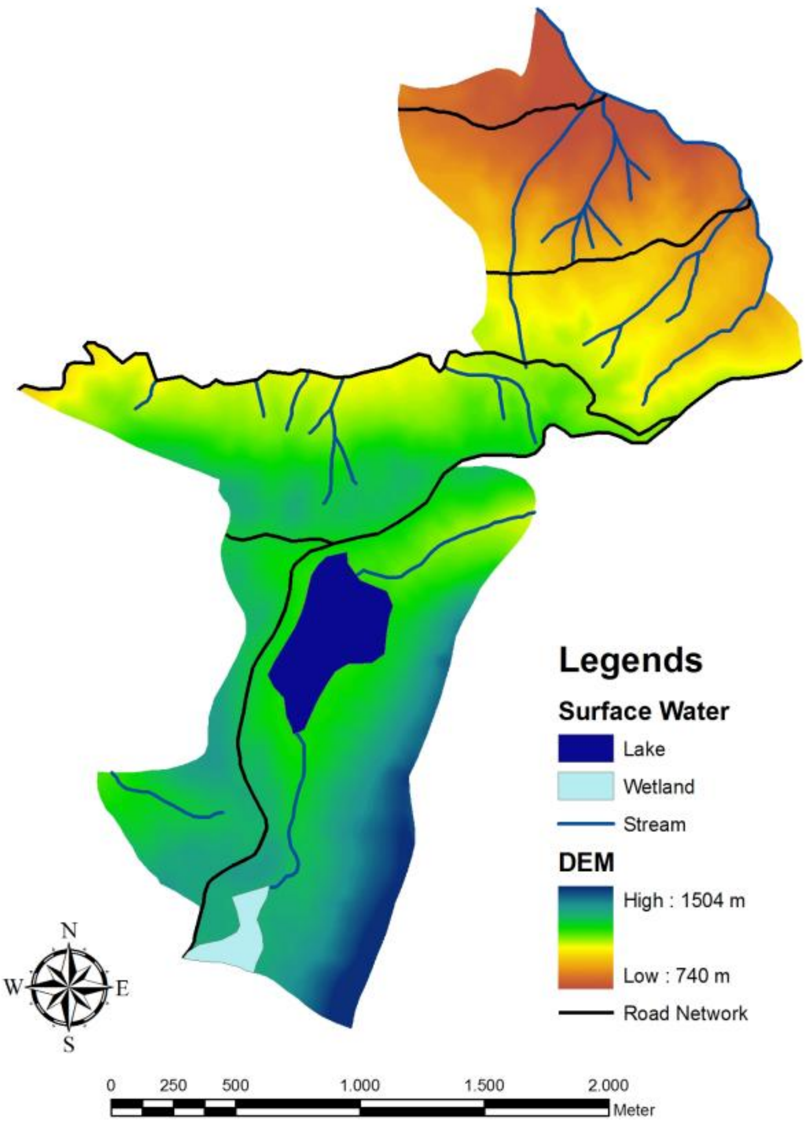

Figure 3. The DEM of the study area indicating road networks and streams

The ground slope layer over the study area was developed depending on DEM layer by using “Slope” feature of “Raster Surface” tool under “3D Analyst Tools” in ArcGIS 9.2. Stand type map was generated based on the Forest Management Plans developed for the Forest Enterprise Chief of Baskonus.

2.3. Mapping Riparian Zones

In order to map the riparian buffer zones, firstly, streams, lake and wetland in the study area were classified according to watershed types, channel widths, and areas. The streams were divided into six classes from S1 to S6 as suggested by [16] (Table 1). The lake and wetland were divided into four (i.e. L1 to L4) and five classes (i.e. W1 to W5), respectively [11] (Table 2). Then, the map of riparian reserve zones and management zones for the stream, lake, and wetland classes were generated by using "Buffer" feature under "Proximity" analysis tool in ArcGIS 9.2. Then, total boundaries of riparian zones were mapped by merging the buffers of three water bodies under the map of reserve zones and the map of management zones separately by using "Union" feature under "Overlay" analysis tool.

Table 1. The widths of riparian buffer zones for six stream classes [16]

Riparian Classes	Stream Channel Width (m)	Reserve Zone Width (m)	Management Zone Width (m)
S1	> 20	50	20
S2	5-20	30	20
S3	1.5-5	20	20
S4	< 1.5	0	30
S5	> 3	0	30
S6	≤ 3	0	20

Table 2. The widths of riparian buffer zones for lake and wetland classes [11]

Riparian Classes	Area of Lake or Wetland (ha)	Reserve Zone Width (m)	Management Zone Width (m)
L1	> 5	10	0
L2	1-5 (dry regions)	10	20
L3	1-5	0	30
L4	0.25-1	0	30
W1	> 5	10	40
W2	1-5 (dry regions)	10	20
W3	1-5	0	30
W4	0.25-1	0	30
W5	> 5 (complex)	10	40

2.4. Assessing Land Use Types and Roads in Riparian Zones

The land use map was generated based on the stand type map by using "Reclassify" feature of "Reclass" tool under "Spatial Analyst Tools" in ArcGIS 9.2. In order to assess the land use types in each riparian zone, the reserve zones and management zones were extracted from the land use map by using "Clip" feature under "Extract" analysis tool. The road network away from the surface water causes minimal impact on riparian ecosystem and produces low percentage of sediment [17]. To ensure the minimum acceptable distance from road embankment to the surface water, the current location of the roads in the Research Forest was analyzed based on stream and slope layers. The range of minimum acceptable distances listed in Table 3 was used in this study [18]. The minimum distances vary from 15 to 45 m as a function of ground slope between roads and surface water.

Table 3. The distance between roads and surface water based on ground slope [18]

Ground Slope (%)	Minimum Distance (m)
0-10	15
10-20	20
20-40	35
40-70	45

To search for the road sections, located within the acceptable minimum distances, firstly, "Reclassify" feature was used to reclassify ground slope layer into five classes including 0-10%, 10-20%, 20-40%, 40-70%, and more than 70%. Secondly, by using "Buffer" feature, the maps of minimum distances for the surface water layers (i.e. stream, lake, and wetland) were generated based on designated minimum acceptable distances of slope classes. Then, the maps of minimum distances were merged by using "Union" feature. Finally, road layer were extracted from this merged layer using "Clip" feature to evaluate the road sections within the minimum distances from the surface water.

3. Results and Discussion

3.1. Riparian Zones

The field observations indicated that the study area was consisting of three types of stream classes including S3, S4, and S6. It was found that the lake and wetland classes in the study area were L1 and W1, respectively. Figure 4 shows the map of riparian buffer zones around the stream, lake, and wetland layers in the study area. The results indicated that the area of the reserve zone and management zone were 3.47 ha and 62.68 ha, respectively. It was also found that large proportion of the riparian areas in the Research Forest was covered by the management zone of S4 (49.02%) and S6 (36.82%) streams (Table 4). The amount of the reserved zones around S3, L1, and W1 was computed as 0.26, 1.96, and 1.25 ha, respectively.

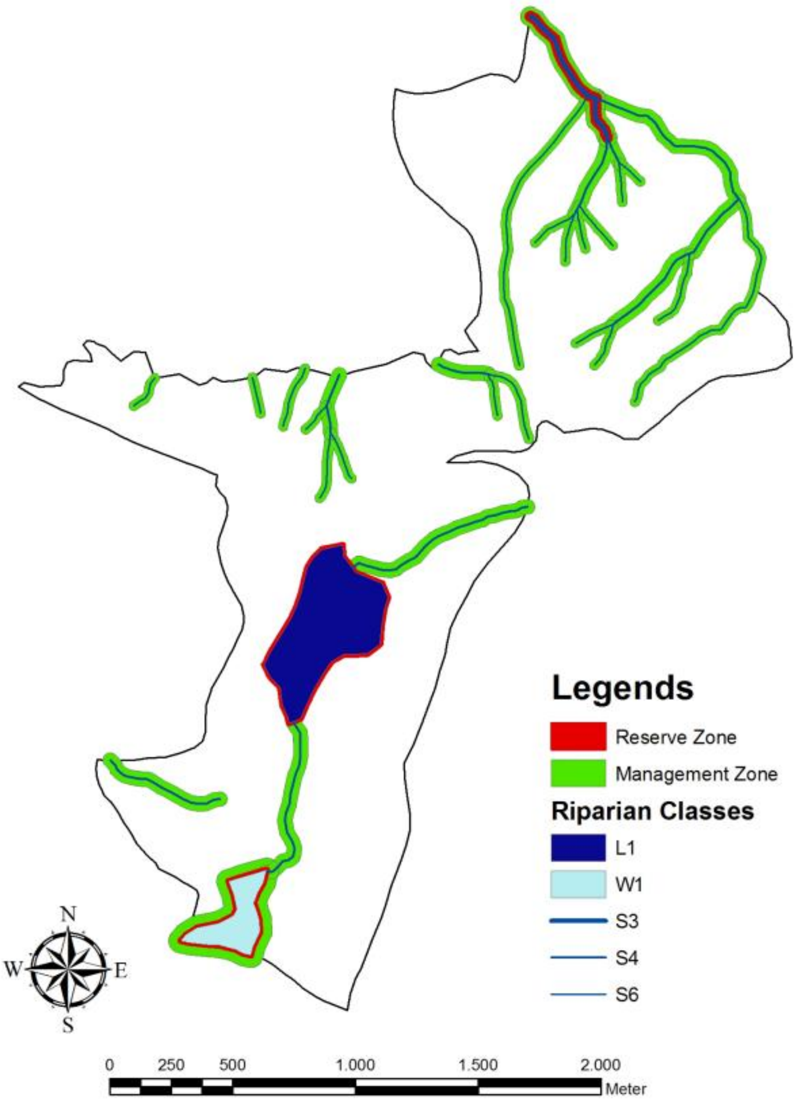

Figure 4. The map of riparian buffer zones around the surface water layers

Table 4. Percent area of total riparian zones around water surfaces

Riparian Classes	Reserve Zone (%)	Management Zone (%)	Total (%)
S3	0.39	0.43	0.82
S4	-	49.02	49.02
S6	-	36.82	36.82
L1	2.96	-	2.96
W1	1.89	8.49	10.38
Total	5.24	94.76	100.00

3.2. Land Use Types and Roads in Riparian Zones

The land use types in research forest were classified into six main classes including forest, agriculture, forest soil, lake, and wetland. The land use map of the study area is illustrated in Figure 5. The results indicated that most of the Research Forest was covered by forested land (81.77%) and agricultural areas (8.20%), and followed by lake (6.24%), forest soil (2.17%), and wetland (1.62%). The percentage of the land use types within the riparian zones were also computed and listed in Table 5. It was found that large proportion of the riparian zones were located in forested land (82.69%) and followed by lake (8.62%) and agricultural areas (7.46%).

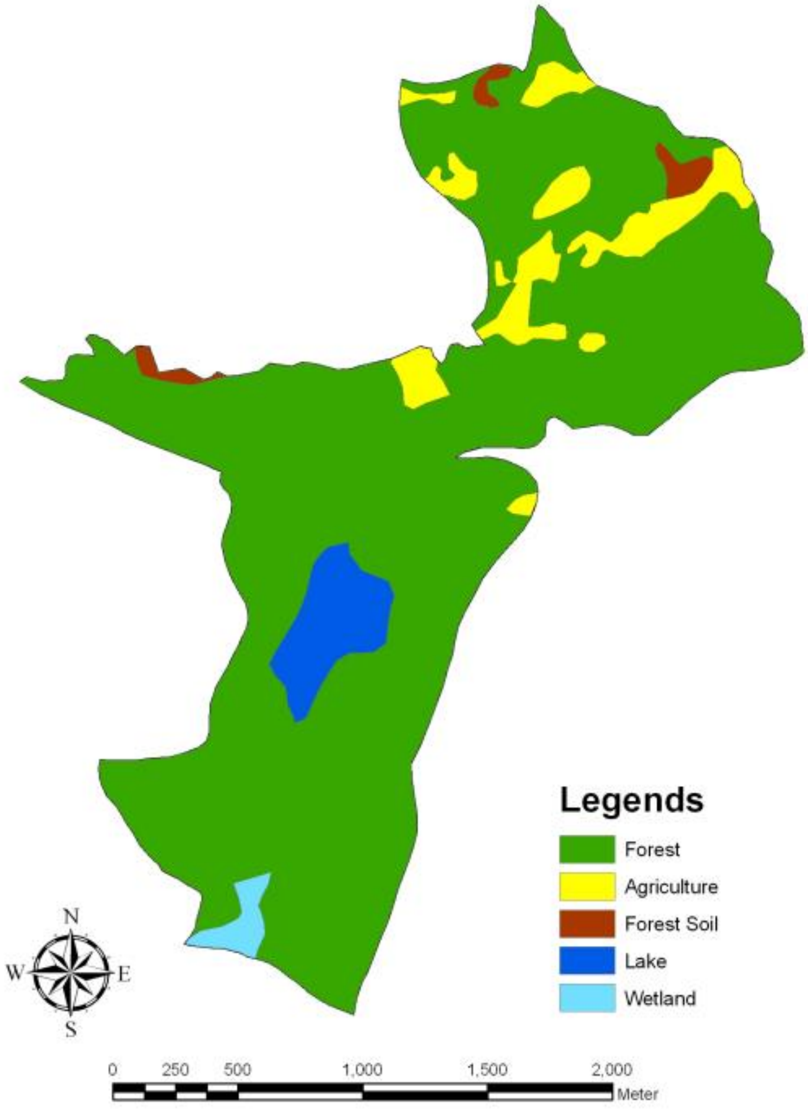

Figure 5. The land use types in the study area

Table 5. Percent area of land use types within the riparian zones

Land Use	Reserve Zone (%)	Management Zone (%)	Total (%)
Forest	3.40	79.29	82.69
Agriculture	1.84	5.62	7.46
Forest Soil	-	0.97	0.97
Lake	-	0.26	0.26
Wetland	-	8.62	8.62
Total	5.24	94.76	100.00

The results also indicated that only forested and agricultural areas existed in both reserved and management zones. The riparian forests located adjacent to surface water provide number of important benefits such as filtering nutrient, reducing soil loss, controlling sediment, stabilizing river banks, and improving water quality [19, 20, 21]. However, agricultural activities within the riparian zones are considered to be a major contributor to water quality degradation due to excess of nutrient caused by fertilizers, herbicides, pesticides and livestock wastes reached into the near by water bodies through runoff/discharges [22, 23, 24]. The excessive amount of nutrients can lead to eutrophication of streams and lakes, which threatens the plant and animal life in the water bodies [25]. The previous studies indicated that locating riparian zones between water bodies and agricultural activities dramatically reduces the nutrition concentration in water which passes through them [26, 27, 28].

The road sections were evaluated with respect to previously specified five ground slope classes (0-10%, 10-20%, 20-40%, 40-70%, and more than 70%) and their associated acceptable minimum distances from the surface water. The results indicated that total area of 103.54 ha could not be used to build roads since they were within the minimum distance from the surface water. However, it was found that about road sections of 712 m was located within the acceptable minimum distance. The forest roads can deliver the significant amount of sediment to surface water due to removal of forest vegetation layer within the riparian areas [29]. Besides, road construction may increase the surface runoff and landslides [30]. Therefore, necessary administrative measure should be taken to restrict road construction in the reserve zone and to minimize it within the management zone in the Research Forest. The results also indicated that about 586 m of these road sections were within the minimum distance of adjacent forested lands, while about 90 m and 23 m of the road sections were adjacent to agricultural areas and forest soils, respectively. Figure 6 indicates the road sections located within the minimum distance from the surface water over the reclassified slope map of the study area.

4. Conclusion

In this study, riparian buffer zones in Baskonus Research and Application Forest in Kahramanmaras Sutcu Imam University in Turkey, were assessed by using GIS techniques. This study was undertaken to evaluate the status of riparian forest areas and to delineate the buffer zones including reserve zone and management zone. The other land use types and road network in the study area were also evaluated with respect to riparian buffer zones. This study illustrated that GIS technology can provide effective analytical tools to visualize and quantify the riparian zones simply and quickly. It was found that about road sections of 712 m was located within the acceptable minimum distance.

In the study area, the most of the riparian zones along the water bodies were specified as the management zone. About 5.93% of the management zone was occupied by agricultural areas. However, agricultural areas cover more than one third of the reserved zone in which any human development, agriculture, and forestry operations ought to be restricted. The land transformation from forest lands to agricultural areas may cause considerable fragmentation in riparian vegetation. About 7.12% of the road network in the study area was within the acceptable minimum distance to the water bodies, which indicates the risk of sediment delivery from roads to the streams. Besides, road networks may also result in fragmentation in riparian vegetation and cause smaller and less connected vegetation patches.

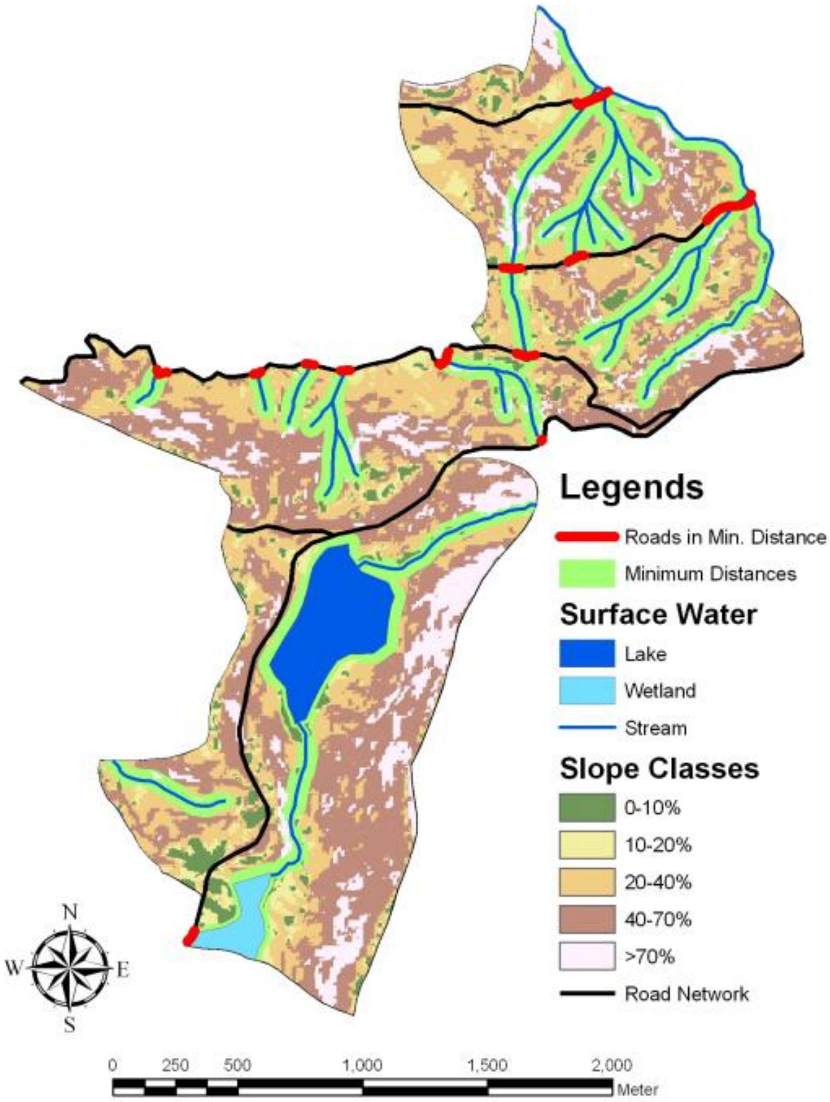

Figure 6. Slope classes and the road sections located within the minimum distance from the surface water

The riparian areas are one of the most important natural resources which provide a wide variety of productive, protective, and aesthetic benefits. In Turkey, most of the riparian forests are degraded since specific management plans have not been implemented for these areas. Thus, it is crucial that the planners, practitioners, and policy-makers at various disciplines (forestry, agriculture, fisheries, wildlife, etc.) should gather, based on the understanding of the importance of riparian forests, to develop specific strategies for these areas and to properly integrate them into the management plans. Some suggestions for future research on riparian forests shall include: measuring the actual benefits of riparian forests, estimating the cost of managing riparian zones, and developing land-use plans to restore degraded and misused riparian zones.

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