

## Developing Criteria and Indicator Set for Quality Assessment of Forest Roads



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### Definition & Terminology

- ? What is qualified forest road (or)
- ? What is forest road quality



### Decision making

- ? Which road is qualified
- ? How is to be decided whether qualified or not

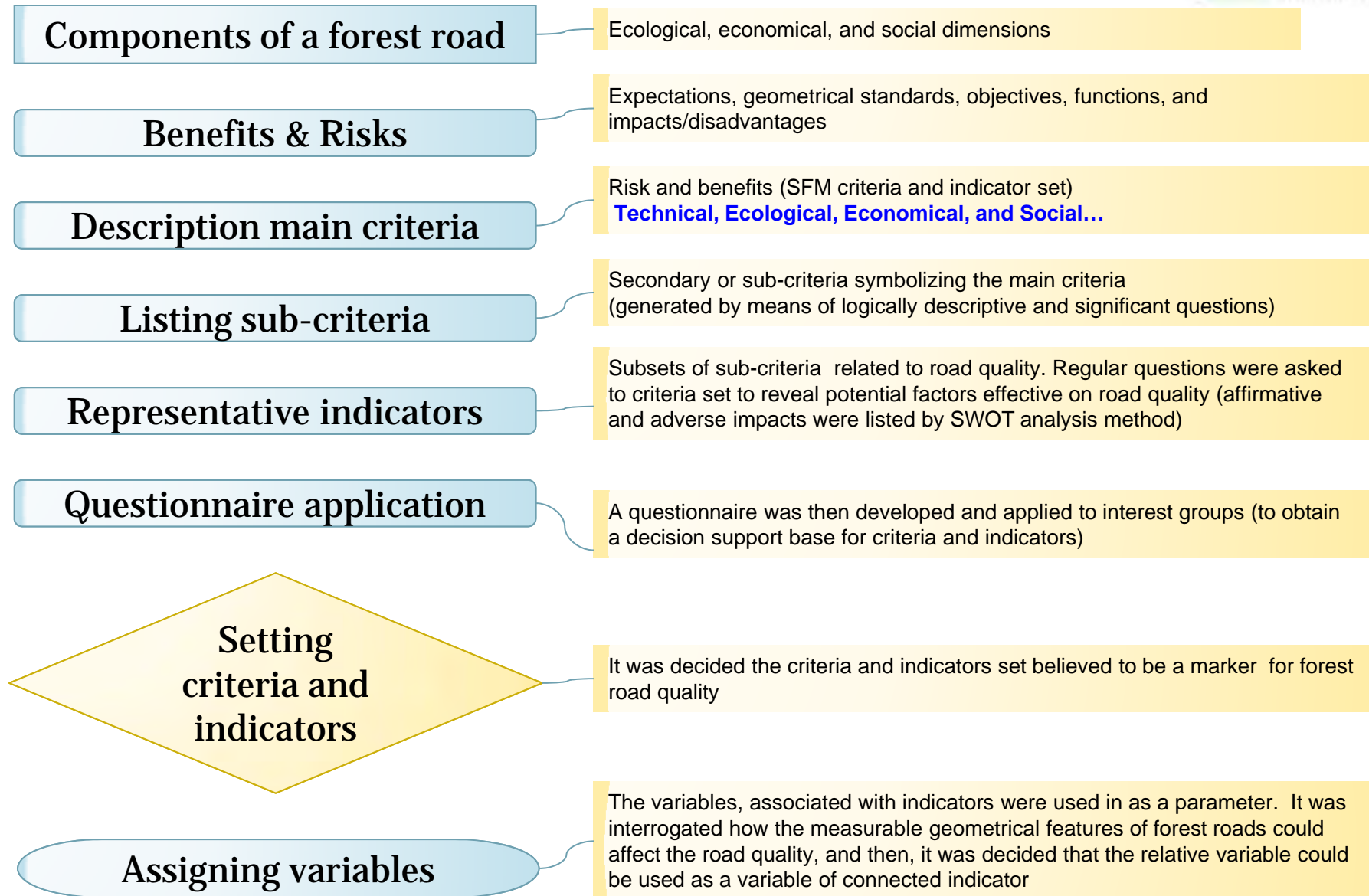


### Determination

- ? How is to be determined the quality for forest road
- ? How is to be measured the quality of a forest road

### Classification

- ? Classifying of the forest road (current) quality
- ? How is to be done leveling the quality of a forest road



## ➤ B-Type Secondary Forest Road

The geometrical standards of forest roads in Turkish Forestry

Forest Road Type	Unit	Main Forest Road	Secondary Forest Road Types				Tractor Road
			A-Type	B-Type			
				SBT	NBT	EBT	
Platform width	m	7	6	5	4	3	3.50
Strip number	piece	2	1	1	1	1	1
Maximum slope	%	8	10	9	12	12	20
Minimum curve radius	m	50	35	20	12	8	8
Strip width	m	3	3	3	3	3	3
Shoulder width	m	0.50	0.50	0.50	0.50	0.50	-
Ditch width	m	1.00	1.00	1.00	1.00	0.50	-
Superstructure width	m	6	5	4	3	3	-

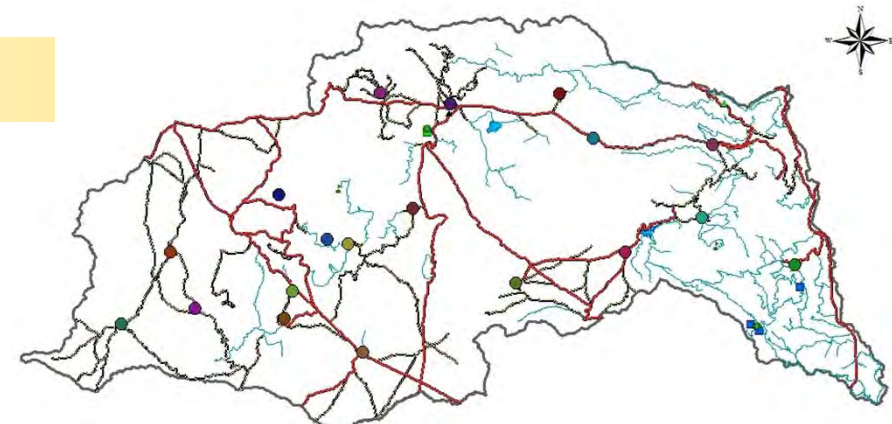
**SBT:** Upgraded size

**NBT:** Normal size

**EBT:** Extreme size

## ➤ Project Level (Road Network Level)

## ➤ Existing forest road



## The definition of forest road quality

If a forest road is;

- Technically viable
- Economically reasonable
- Ecologically friendly
- Societally acceptable



Then, it can be mentioned from

«QUALIFIED FOREST ROAD»

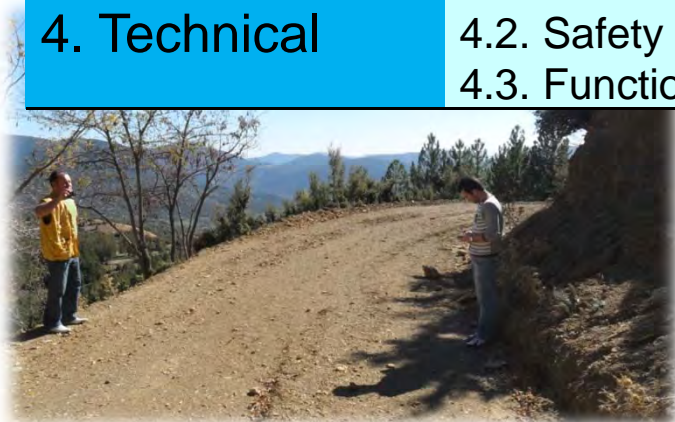
## For road quality assessment

- 4 main criteria
- 12 sub-criteria



The criteria set for forest road quality analysis

Criteria (I. Level)	Sub-Criteria (II. Level)
1. Ecology	1.1. Hydrology 1.2. Habitat conservation 1.3. Losses of growing areas 1.4. Forest fires
2. Economy	2.1. Good and service production 2.2. Costs
3. Social	3.1. Impacts on historical, cultural, and valuable areas 3.2. Aesthetic values of the forest road 3.3. Accessibility for public transport
4. Technical	4.1. Geometrical attributes 4.2. Safety 4.3. Functionality



**For road quality assessment**  
13 Indicators for only ecological criteria

The Ecology criterion and its indicators set (1/2 of Table)

Criteria	Subcriteria	Indicators	Variables
<b>1. Ecology</b>	1.1.Hidrology	1.1.1. Surface and groundwater hidrology	1.1.1.1. Road length
			1.1.1.2. Position on the hillside of the road
			1.1.1.3. Stream channel proximity
			1.1.1.3. Road-stream intersect number
			1.1.1.5. The number and density of state-of-the-arts
			1.1.1.6. Road aspects
		1.1.2. Erosion	1.1.2.1. Position on the hillside of the road
			1.1.2.2. Stream channel proximity
			1.1.2.3. Road-stream intersect number
			1.1.2.4. Slope class
			1.1.2.5. Ground type
			1.1.2.6. Road slope
	1.1.3.Sediment and Mass movement	1.1.2.7. Superstructure type	
		1.1.2.8. Erosion factor	
		1.1.2.9. Road length on soil conservation area	
		1.1.3.1. Position on the hillside of the road	
		1.1.3.2. Slope class	
		1.1.3.3.The structure and functions of the ditches	
	1.1.4. Water quality and impacts on stream channels	1.1.3.4. Stabilization of cutslope and fillslope	
		1.1.3.5. Superstructure type	
1.1.3.6. Road width			
1.1.3.7. Hight of the cutslope			
1.1.5. Water pollution	1.1.3.8. Relationship ground type and cutslope		
	1.1.4.1. Stream channel proximity		
1.2. Habitat conservation	1.2.1. Aquatic habitats	1.1.4.2. Road-stream intersect number	
		1.1.4.3. The number of state-of-the-arts and availability	
	1.2.2. Terrestrial habitats (animal and plant)	1.1.4.4. Road length on water conservation area	
		1.1.5.1. Road-stream intersect number	
		1.1.5.2. Protection of water resources	
		1.2.1.1. Stream channel proximity	
	1.2.3. Sensitive ecosystems	1.2.1.2. Road-stream intersect number	
		1.2.2.1. Nature conservation	
1.2.2.2. Road construction area width			
1.2.4. Rehabilitation	1.2.2.3. Road width		
	1.2.2.4. Connected area by the forest roads		
	1.2.3.1. Road length on protected area		
	1.2.3.2. Road length on wildlife conservation area		
	1.2.3.3. Road length on sensitive ecosystem		
	1.2.4.1. Road length in rehabilitation area		

## For road quality assessment

13 Indicators for only ecological criteria

The Ecology criterion and its indicators set

(1/2 of Table)

Criteria	Subcriteria	Indicators	Variables	
1. Ecology	1.3. Losses of growing areas	1.3.1. Losses of forest areas	1.3.1.1. Road construction area width	
			1.3.1.2. Opening-up area (site index)	
	1.4. Forest Fires	1.3.2. Landslide areas		1.3.2.1. The number of landslide and slope flow
				1.3.2.2. Ground type
		1.4.1. Fire prevention and fire fighting		1.4.1.1. Road length
				1.4.1.2. Opening-up area (length of fire hosepipe)
				1.4.1.3. Connection by firebreaks
				1.4.1.4. The fire strips on roadsides
1.4.2. Fire risks		1.4.2.1. Connected areas by the forest road		
		1.4.2.2. Opening-up areas		
		1.4.2.3. Accessibility by road (Energy line, telephone line, etc)		





## For road quality assessment

5 Indicators for only economical criteria

### The Economy criterion and its indicators set

Criteria	Subcriteria	Indicators	Variables
<b>2. Economy</b>	2.1. Production	2.1.1. Wood and nonwood production	2.1.1.1. Road length and opening-up area
			2.1.1.2. Accessibility in all season/trafficability
			2.1.1.3. Road length on economical functions
		2.1.2. Service production (Recreation input)	2.1.2.1. Access to recreational areas
	2.2. Costs	2.2.1. Construction Costs	2.2.1.1. Position on the hillside of the road
			2.2.1.2. Slope class
			2.2.1.3. Ground type
			2.2.1.4. Superstructure type
			2.2.1.5. The number of state-of-the-arts and vilability
			2.2.1.6. Road length
			2.2.1.7. Construction area width
		2.2.2. Maintenance and repair costs	2.2.2.1. Position on the hillside of the road
			2.2.2.2. Slope class
			2.2.2.3. Ground type
			2.2.2.4. Superstructure type
			2.2.2.5. The number of state-of-the-arts
		2.2.3. Transportation costs	2.2.3.1. Road slope
			2.2.3.2. Winding factor (horizontal)
			2.2.3.3. Sinouity factor (vertical)
			2.2.3.4. Reverse slope
2.2.3.5. Vertical curve			
2.2.3.6. Density of horizontal curves			
2.2.3.7. Ground type			
2.2.3.8. Deformations on road surface			

## For road quality assessment 8 Indicators for only societal criteria

### The Social criterion and its indicators set

Criteria	Subcriteria	Indicators	Variables	
<b>3. Social</b>	3.1. Impacts on historical, etc. areas	3.1.1. Adverse impacts	3.1.1.1.Road length	
		3.1.2. Openin-up of the areas	3.1.2.1.Road length on conservation areas	
	3.2. Aesthetic values of the forest road	3.2.1. Driving pleasure		3.2.1.1.Diffrent tree species
				3.2.1.2.Variation on slope along the road
				3.2.1.3.Alteration on land use along the roadside
				3.2.1.4.Winding of road route
				3.2.1.5.Stabilization of cut and fillslopes
		3.2.2. Suitability of the road for forest structure		3.2.2.1.Visibility of road in forest composition
				3.2.2.2.Hight of cutslope
				3.2.2.3.Stabilization of cut and fillslopes
		3.2.2.4.Construction area width		
		3.2.2.5.Roadbed position in elevation model		
	3.3. Accessibility for public transport	3.2.3. Proximity to aesthetic area	3.2.3.1.Road length on aesthetic value areas	
		3.3.1. Proximity to scientific area	3.3.1.1. Road length on scientific orientated area	
		3.3.2.Accessibility for villages	3.3.2.1.The number of village opened by roads	
3.3.3. Opening agricultural area		3.3.3. 1.Road length on agricultural areas		

## For road quality assessment 6 Indicators for only technical criteria

### The Technical criterion and its indicators set

Criteria	Subcriteria	Indicators	Variables
<b>4. Technical</b>	4.1. Geometrical attributes (standards)	4.1.1. Geometrical standards of road prism	4.1.1.1.Road width
			4.1.1.2.Road slope
			4.1.1.3.Horizontal curve radius
			4.1.1.4.Strip width
			4.1.1.5.Shoulder width
			4.1.1.6.Ditch width
			4.1.1.7.Superstructure width
		4.1.2. Other technical features	4.1.2.1.Road breadthways slope
			4.1.2.2.Visibility distance (winding factor)
			4.1.2.3.Encounter-standstill placement
			4.1.2.4. Road length on positive cardinal points
			4.1.2.5.Existence caution signs along roadside
			4.1.2.6.Reverse slope
			4.1.2.7.The number of state-of-the-arts
	4.2. Safety	4.2.1. Traffic safety	4.2.1.1.Road width
			4.2.1.2.Road slope
			4.2.1.3.Vertical curve and sinosity
			4.2.1.4.Reverse slope
			4.2.1.5.Sharp and tight curves
			4.2.1.6.Visibility distance
		4.2.2. Building safety	4.2.2.1.Landslide and subsidence
4.2.2.2.Holes, wheel tracks, ondulations on road			
4.2.2.3.Deterioration on hydraulic buildings			
4.2.2.4.Road aspects			
4.3. Functionality	4.3.1. Opening-up of functional areas	4.2.2.5.Superstructure type	
		4.2.2.6.Distance between nearest tree and road	
		4.2.2.7. Ground type	
		4.3.1.1.Accessible managed forest types	
	4.3.2. Accessibility	4.3.1.2.Functions of the road	
		4.3.1.3.Existence of alternative road	
		4.3.1.4.Connectivity other roads	
4.3.2.1.Superstructure type			
4.3.2.2.Permission of accessibility on road			
4.3.2.3. Landslide,rolling, etc potential on slope			

## The variables list

### Ecology

Road length  
Position on the hillside of the road  
Stream channel proximity  
Road-stream intersect number  
The number and density of state-of-the-arts  
Road aspects  
Position on the hillside of the road  
Stream channel proximity  
Slope class  
Ground type  
Road slope  
Superstructure type  
Erosion factor  
Road length on soil conservation area  
The structure and functions of the ditches  
Stabilization of cutslope and fillslope  
Road width  
Height of the cutslope  
Relationship ground type and cutslope  
The number of state-of-the-arts and availability  
Road length on water conservation area  
Protection of water resources  
Nature conservation  
Road construction area width  
Connected area by the forest roads  
Road length on protected area  
Road length on wildlife conservation area  
Road length on sensitive ecosystem  
Road length in rehabilitation area  
Opening-up area (site index)  
The number of landslide and slope flow  
Opening-up area (length of fire hosepipe)  
Connection by firebreaks  
The fire strips on roadsides  
Accessibility by road (Energy line, telephone line, etc)

### Economy

Road length and opening-up area  
Accessibility in all season/trafficability  
Road length on economical functions  
Access to recreational areas  
The number of state-of-the-arts and vilability  
Winding factor (horizontal)  
Sinoucity factor (vertical)  
Reverse slope  
Road length  
Vertical curve  
Density of horizontal curves  
Deformations on road surface  
Construction area width  
Position on the hillside of the road  
The number and density of state-of-the-arts  
Position on the hillside of the road  
Slope class  
Ground type  
Road slope  
Superstructure type

### Social

Road length on conservation areas  
Diffrent tree species  
Variation on slope along the road  
Alteration on land use along the roadside  
Winding of road route  
Stabilization of cut and fillslopes  
Visibility of road in forest composition  
Height of cutslope  
Construction area width  
Roadbed position in elevation model  
Road length on aesthetic value areas  
Road length on scientific orientated area  
The number of village opened by roads  
Road length on agricultural areas

### Technique

Road width  
Horizontal curve radius  
Strip width  
Shoulder width  
Ditch width  
Superstructure width  
Road breadthways slope  
Visibility distance (winding factor)  
Encounter-standstill placement  
Road length on positive cardinal points  
Existence caution signs along roadside  
Sharp and tight curves  
Landslide and subsidence  
Holes, wheel tracks, ondulations on road  
Deterioration on hydraulic buildings  
Road aspects  
Distance between nearest tree and road  
Accessible managed forest types  
Functions of the road  
Existence of alternative road  
Connectivity other roads  
Permission of accessibility on road  
Landslide,rolling, etc potential on slope  
The number of state-of-the-arts  
Reverse slope  
Road length  
Vertical curve  
Ground type  
Road slope  
Superstructure type

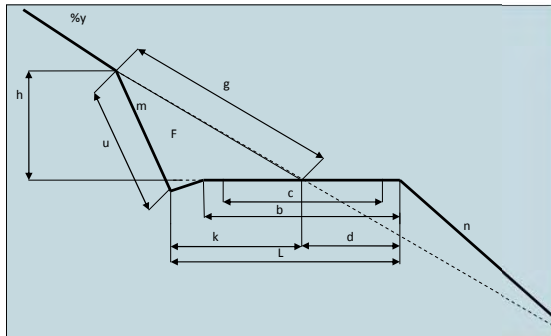
## Measurement and Assessment Procedure

Example: Scaling of a variable

Point	Risk	Benefit
0	No adverse impact	No benefit (non-function)
9 (5)	Very low impact risk	Very high level benefit
7 (4)	Low impact risk	High level benefit
5 (3)	Modarate impact risk	Modarate level benefit
3 (2)	High impact risk	Low level benefit
1 (1)	Very high impact risk	Very low level benefit

Variables	Scale (If the road slope is between)	Ecology	Economy	Technique	Social
		Score			
Road slope	%2-%4	9	9	9	-
	%4-%6	7	7	7	-
	%6-%8	5	5	5	-
	%8-%10	3	3	3	-
	%10-%12	1	1	1	-

Total Score	Road Quality Level
1,00 – 0,666	High quality level
0,665 – 0,333	Medium quality level
0,333 > -	Low quality level



ÖLÇÜT	Ölçü Birimi	ALT ÖLÇÜT	Alt Ölçü Birimi	GÖSTERGE	Gösterge Birimi	DEĞİŞKİNLİKLER	Değişken Birimi
1.1. HİDROLOJİ		0,649		1.1.1. Yüzey ve Yer Altı Hidrolojisi	0,741	1.1.1.1. Yol uzunluğu	1,000
						1.1.1.2. Yolun yamaçtaki pozisyonu	0,596
						1.1.1.3. Dereye (Akarsu yataklarına) yakınlık	0,773
						1.1.1.4. Yolun akarsu yataklarını (derinleri) kesme sıklığı/sıklığı	1,000
						1.1.1.5. Sahnin yamaçları ve eğimliliği	0,111
						1.1.1.6. Bakı	1,000
				1.1.2. Erozyon	0,630	1.1.2.1. Yolun yamaç yeri (Yamaçtaki pozisyonu)	0,596
						1.1.2.2. Akarsu yataklarına yakınlık	0,773
						1.1.2.3. Akarsu yataklarını kesme sayısı	1,000
						1.1.2.4. Yolun geçidi yamaç eğimi	0,596
						1.1.2.5. Yolun geçidi zemin (toprak) kalınlığı	0,773
						1.1.2.6. Yolun eğim	0,111
				1.1.3. Sediment ve Kilit Hareketlerinin Ölçümü	0,375	1.1.3.1. Yolun yamaç yeri (Yamaçtaki pozisyonu)	0,596
						1.1.3.2. Yolun geçidi yamaç eğimi	0,596
						1.1.3.3. Hedeflerin yamaç eğimi	0,111
1.1.3.4. Şevlerin stabilizasyonu	0,111						
1.1.3.5. Yolun yamaçlama faktörü	0,111						
1.1.3.6. Yolun genişliği (Performans noktası-şev uzunluğu)	0,333						
1.1.4. Su Kalitesi ve Akarsu Yataklarında Üzerindeki Etkiler		0,500		1.1.4. Su Kalitesi ve Akarsu Yataklarında Üzerindeki Etkiler	0,500	1.1.4.1. Dereye (Akarsu yataklarına) yakınlık	0,111
						1.1.4.2. Akarsu yataklarını kesme sayısı	0,773
						1.1.4.3. Sahnin yamaçları ve eğimliliği	1,000
						1.1.4.4. Su kaynaklarının korunma oranı	0,111
						1.1.5. Kilit (Su Kırığı)	1,000
						1.1.5.1. Akarsu yataklarını kesme sayısı	1,000
				1.1.5.2. Su kaynaklarının korunması	1,000		
				1.2.1. Suda (Suda yaşayan) Helyoterler	0,889	1.2.1.1. Akarsu yataklarına yakınlık	0,773
						1.2.1.2. Akarsu yataklarını kesme sıklığı	1,000
						1.2.1.3. Doğal Koruma	1,000
						1.2.1.4. İnsani etkiler	0,773
						1.2.2. Karasal (Karasal yaşayan) Helyoterler	0,773
						1.2.2.1. Yolun genişliği	0,773
				1.2.3. Hassas Ekosistemler	0,704	1.2.3.1. Yolun ulaşım alanından geçmesi	1,000
						1.2.3.2. Yolun ulaşım alanından geçmesi	1,000
1.2.3.3. Yolun hassas ekosistemlerden geçmesi	0,111						
1.2.4. Orman Ekosistemlerinin İstikrarlılığı	1,000						
1.2.4.1. Yolun orman ekosistemini (geçirme alanından geçmesi)	1,000						
1.2.4.2. İnsani etkiler	0,773						
1.3. Heyelanlı Alanlar	0,773	1.3.1. İnsani etkiler	0,773				
		1.3.1.1. İnsani etkiler	0,773				
		1.3.1.2. İnsani etkiler (yolun geçidi) bantları	1,000				
		1.3.2. Heyelanlı alanlar	0,773				
		1.3.2.1. Yolun ulaşım alanından geçmesi	0,773				
		1.3.2.2. Zemin kalitesi	0,773				
1.4. Yangın Riski	0,324	1.4.1. Yangın Riski	0,167				
		1.4.1.1. Yangın Riski	0,167				
		1.4.1.2. İnsani etkiler (yolun mesafesi)	0,333				
		1.4.1.3. Yangın riski (yolun geçidi) ve bağlanması	0,111				
		1.4.1.4. Yol kenarlarının etrafı (Yangın koruma zonu)	0,111				
		1.4.2. Yangın Riski	0,481				
1.4.2.1. Yolun ulaşım alanından geçmesi	1,000						
1.4.2.2. İnsani etkiler	0,333						
1.4.2.3. Yolun telefon hattı su kanalları BvHne ulaşım sağlanması	0,111						

### It could be developed

- a quality assessment infrastructure for forest road
- the components of the road quality procedure
- a monitoring system because of control checklist
- a relative priority
- a preferred mechanism for certification process
- a methodology for case study on a forest road



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