SUSCEPTIBILITY PROFILES FOR VEHICULAR ACCIDENTS BASED ON PAVEMENT AND ENVIRONMENTAL CHARACTERISTICS

Presented by

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Objetive

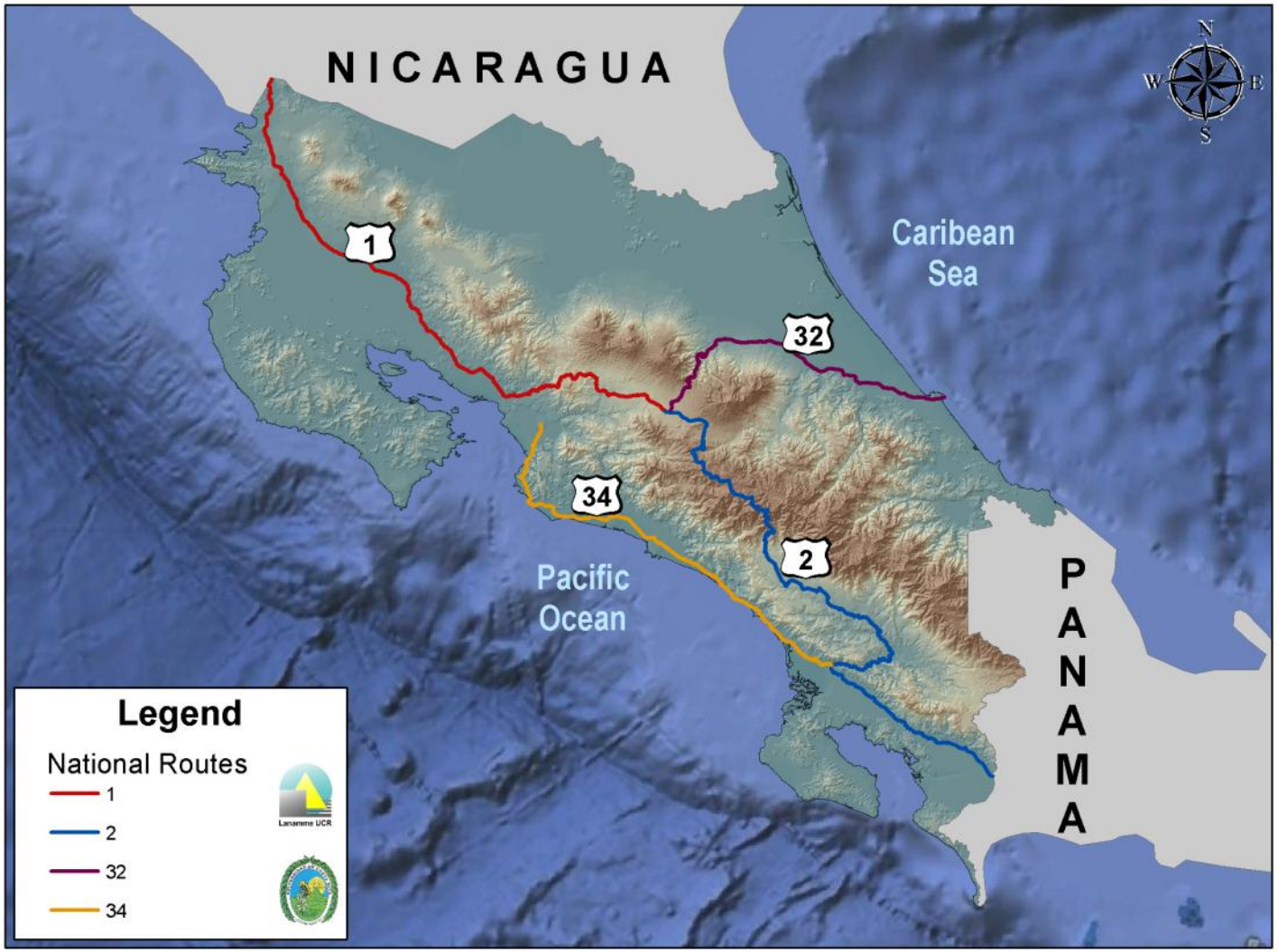
- **Using some measured and inherent factors, prioritize the management required in main roads based in susceptibility profiles of some pavement surface characteristics that contribute to generate a high level of exposure to crashes for the users.**

National Roads Selected

•Four national routes were selected for the study, routes 1, 2, 32 and 34.

• To create the profile, the analysis unit used were 100m segments.

•Using GIS systems, each study factor was assigned to the respective unit of analysis for subsequent combination.


NICARAGUA
Caribean Sea
Pacific Ocean
PANAMA
N
W
E
S
1
32
34
2
Legend
National Routes
1
2
32
34
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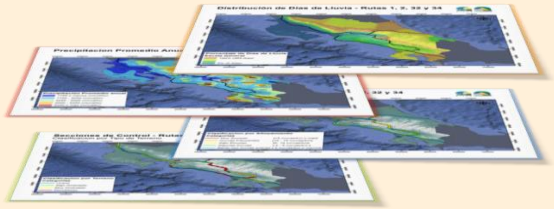
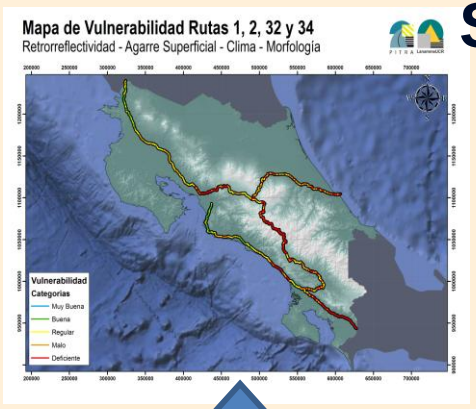
General Methodology

Methodological Framework

Factors

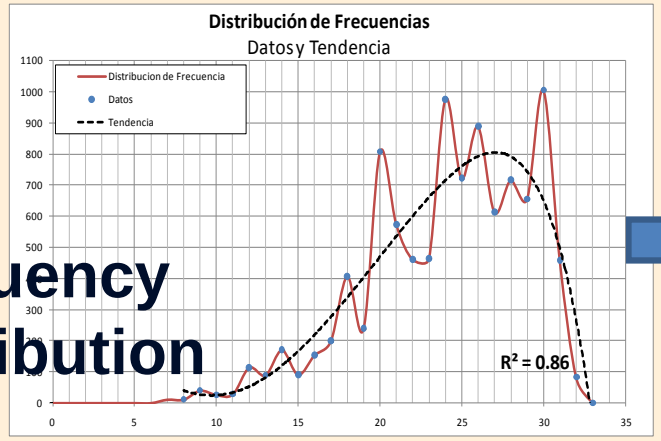


categories
weight

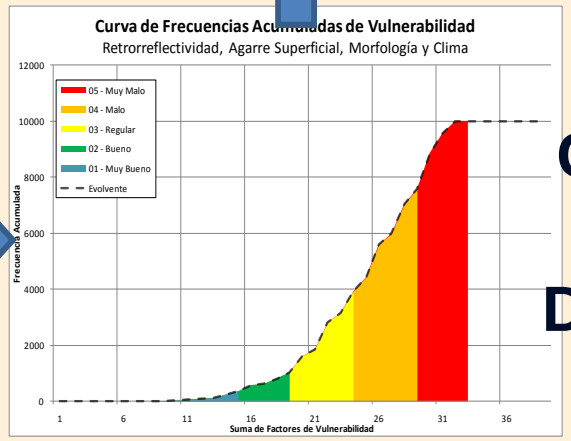


Susceptibility Profiles

GIS



Frequency Distribution



Cumulative Frequency Distribution

Susceptibility Profile - Components

The main components evaluated use the respective weight assigned for the selected classes and factors to create **Cumulative Frequency Distribution**

Class		Factor
Inherent	Geometric Components	Vertical Alignment
		Horizontal Alignment
	Climate Components	Rain Days per Year
		Average Annual Precipitation
Measured elements	Horizontal Pavement Markings	Center Line Retroreflectivity
		Border Line Retroreflectivity
	Surface Grip	Grip Number

Inherent Components

Inherent Geometric Components

To analyze the geometric components, we use categorized elements given by the administration using control sections:

Geometric Factor	Indicator
Vertical Alignment	Terrain categories
Horizontal Alignment	Control sections categories based on curves per kilometer

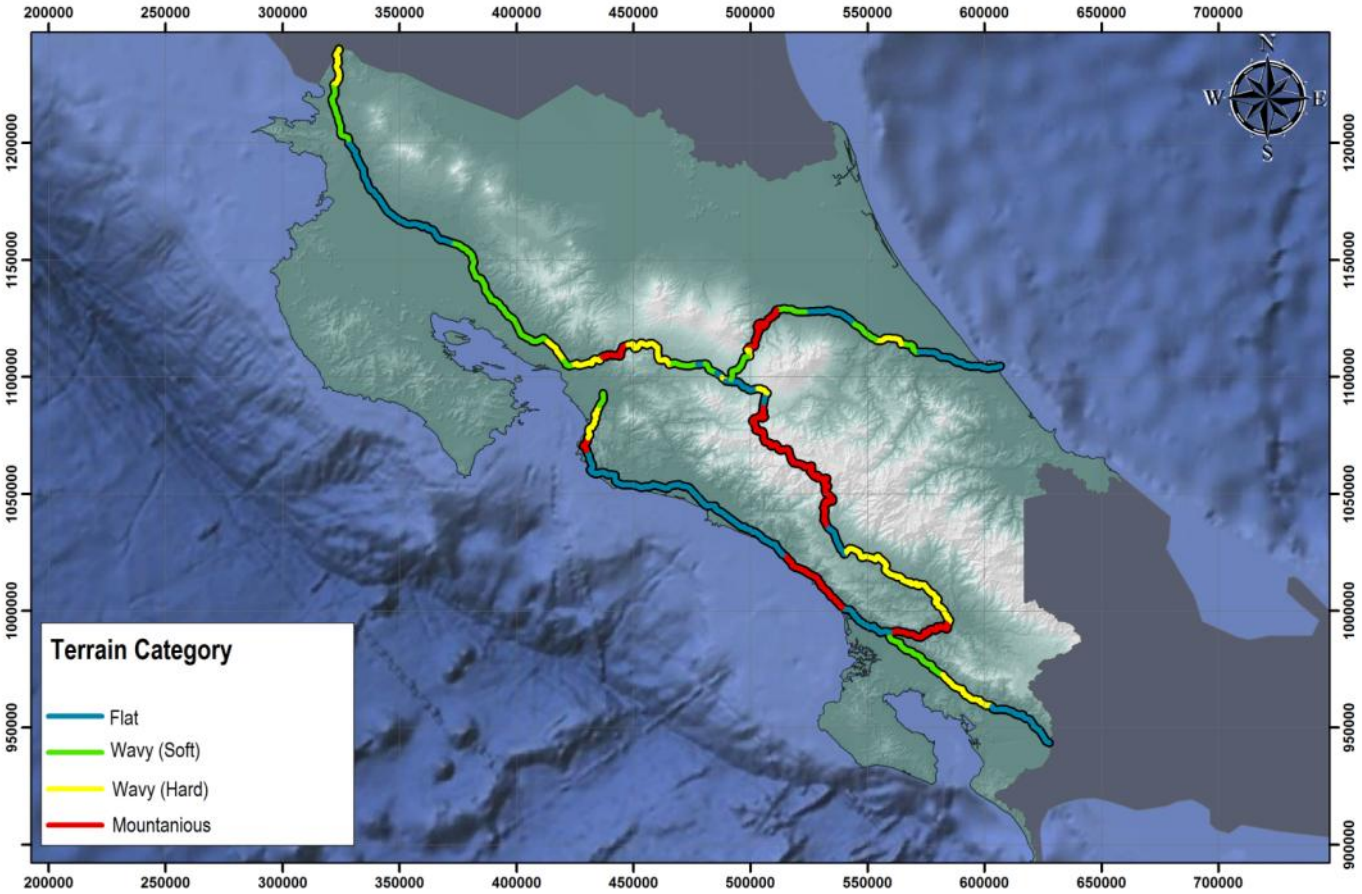
Terrain

The administration use 4 categories to classify the control sections:

Categories	Description
1	Flat
2	Wavy (Soft)
3	Wavy (Hard)
4	Mountanious

Control Sections

Terrain Category



Alignment

This parameter accounts the quantity of curves per kilometer in each control section, and uses the classes asigned by the administration

Categories	Description		
1	15 – more	[curves/km]	very sinuous road
2	10 – 15	[curves/km]	frequent curvy road
3	5 – 10	[curves/km]	road somewhat sinous with sharp curves
4	2 – 5	[curves/km]	road with a few curves
5	0 – 2	[curves/km]	straight road with soft curves

Control Sections

Alignment Category

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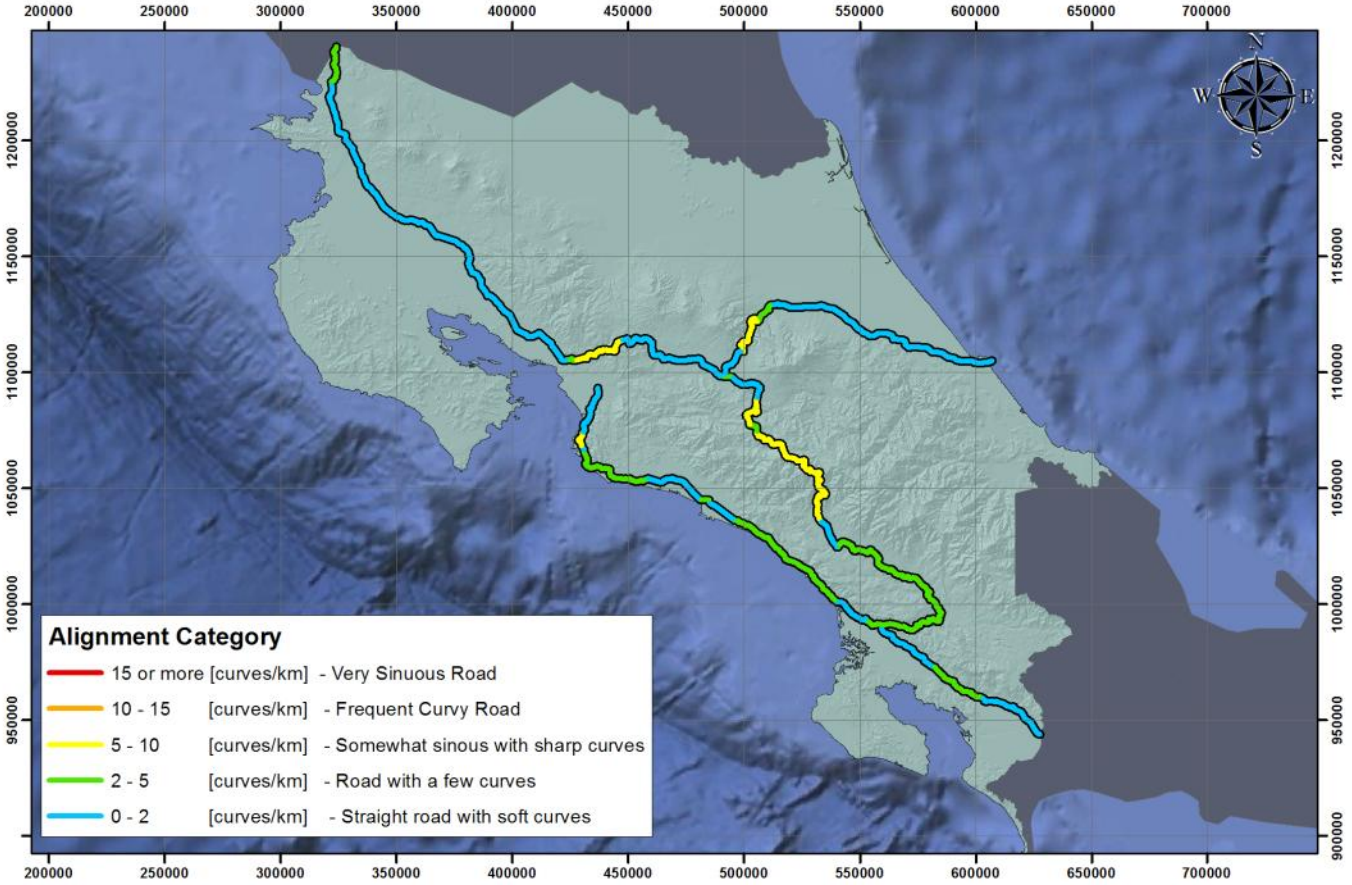


Inherent Climate Components

The climate conforms a random variable whose distribution requires the use of statistical data to ponder the behavior.

Climate Factor	Indicator
Temporal distribution	Rain Days per Year
Quantity distribution	Averaged Annual Precipitation

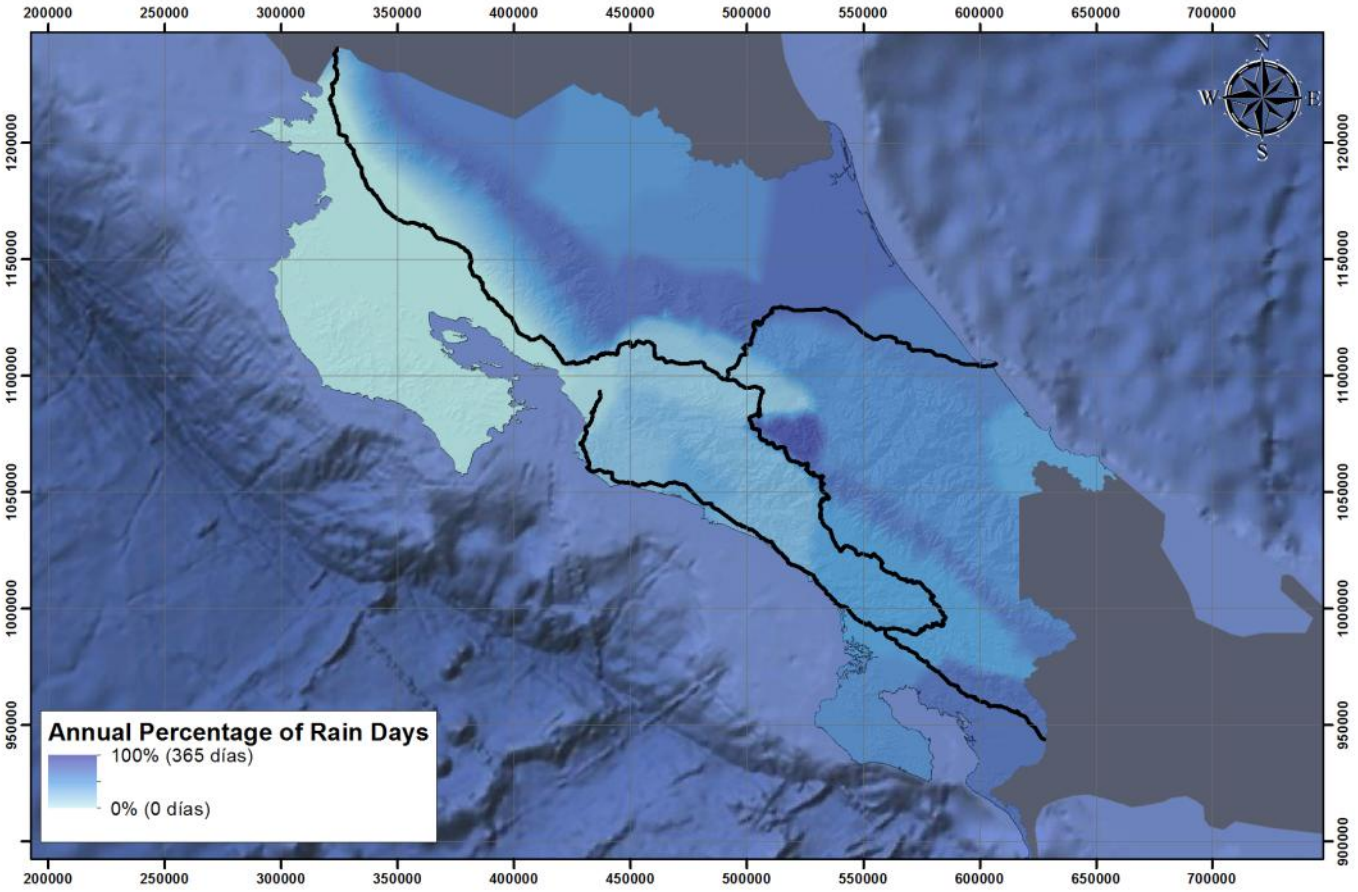
Rain Days per Year

This statistical data represents the rain temporal distribution which affects the retroreflective and grip characteristics.

Categories	Description	
1	0 – 20 % [rain days per year]	Very Low
2	20 – 40 % [rain days per year]	Low
3	40 – 60 % [rain days per year]	Regular
4	60 – 80 % [rain days per year]	High
5	80 – 100 % [rain days per year]	Very High

Control Section

Distribution of Annual Percentage of Rain Days

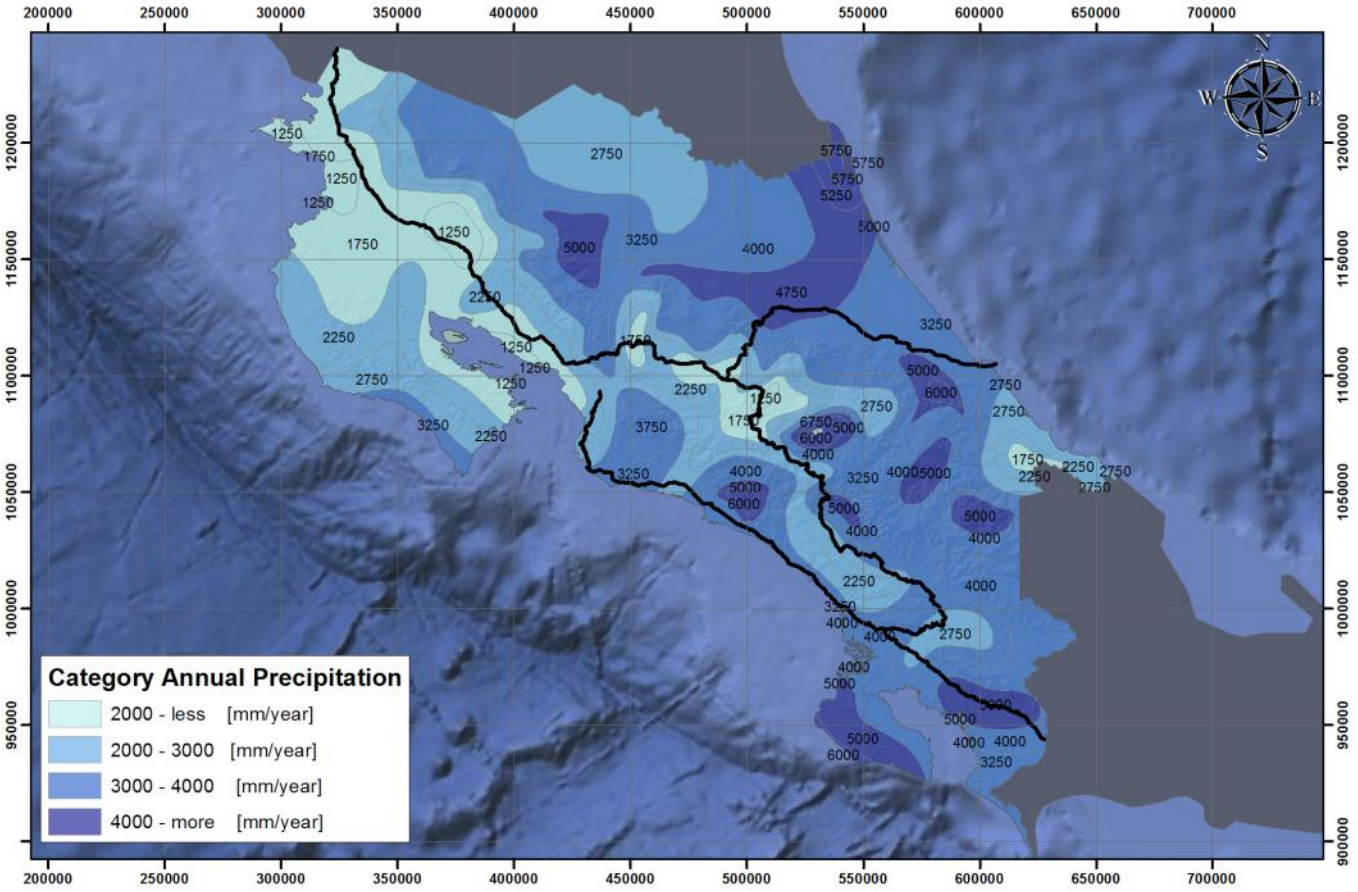


Averaged Annual Precipitation

This statistical data represents the quantity of annual precipitation, this information is derived from climatological studies for Costa Rica (Barrantes, 1986)

Categories	Description
1	2000 or less [mm/year]
2	2000 - 3000 [mm/year]
3	3000 - 4000 [mm/year]
4	4000 or more [mm/year]

Control Sections
Averaged Annual Precipitation



Inherent Components - Weight

It's during the feasibility and design stages, that the climatic and geometric components are dynamic elements in the mitigation of safety issues, but once the road is built these factors become implicit parameters of the road.

The weight given range: **0 to 3**

Based on Severity rating categories using 10 as max

Inherent Components - Weight

Class	Factor	Category	Weight
Inherent Geometric Components	Terrain (Vertical Alignment)	1	0
		2	1
		3	2
		4	3
	Alignment Categories (Horizontal Alignment)	5	0
		4	1
		3	2
		1 or 2	3
Inherent Climate Components	Rain Days per Year	1	0
		2	1
		3	2
		4 or 5	3
	Averaged Annual Precipitation	1	0
		2	1
		3	2
		4	3

Measured Components

Measured Components

To analyze the susceptibility profiles associated to vehicular crashes, characteristics were measured two elements related to road safety:

Class		Factor
Measured elements	Horizontal Pavement Marks	Center Line Retroreflective
		Border Line Retroreflective
	Surface Grip	Grip Number

Horizontal Pavement Marks

During night or dark conditions the retroreflectivity characteristic is the critical factor associated with the pavement marks. Categories based on the ASTM E 1710 for the laser equipment and the recommended minimum values (Debaillon C., Carlson et al, 2007)

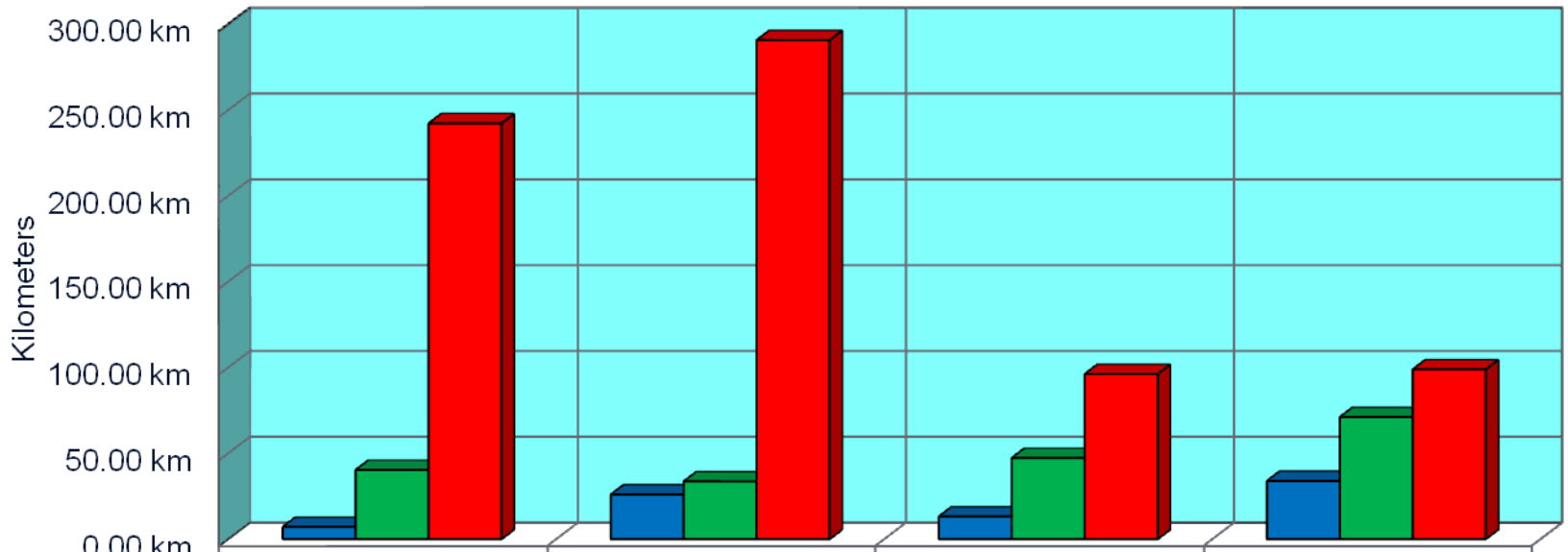
Condition	Color	Rural Roads < 40 mph	Secondary Roads 45 - 55 mph	Main Roads > 60 mph
With R.P.M.	White	30 mcd/lx/m^2	35 mcd/lx/m^2	70 mcd/lx/m^2
	Yellow	30 mcd/lx/m^2	35 mcd/lx/m^2	70 mcd/lx/m^2
Without R.P.M.	Blanco	85 mcd/lx/m^2	100 mcd/lx/m^2	150 mcd/lx/m^2
	Amarillo	55 mcd/lx/m^2	65 mcd/lx/m^2	100 mcd/lx/m^2

Retroreflectivity Category

To simplify the analysis, it is assumed the presence of RPM to set the minimum value to use, and provides that the maximum value used in the absence of RPM as an optimal condition, regardless of color.

Main Roads Category 80 km/h or more	**Description**	
3	70 or less [mcd/lx/m^2]	Bad
2	70 - 150 [mcd/lx/m^2]	Good
1	150 or more [mcd/lx/m^2]	Very Good

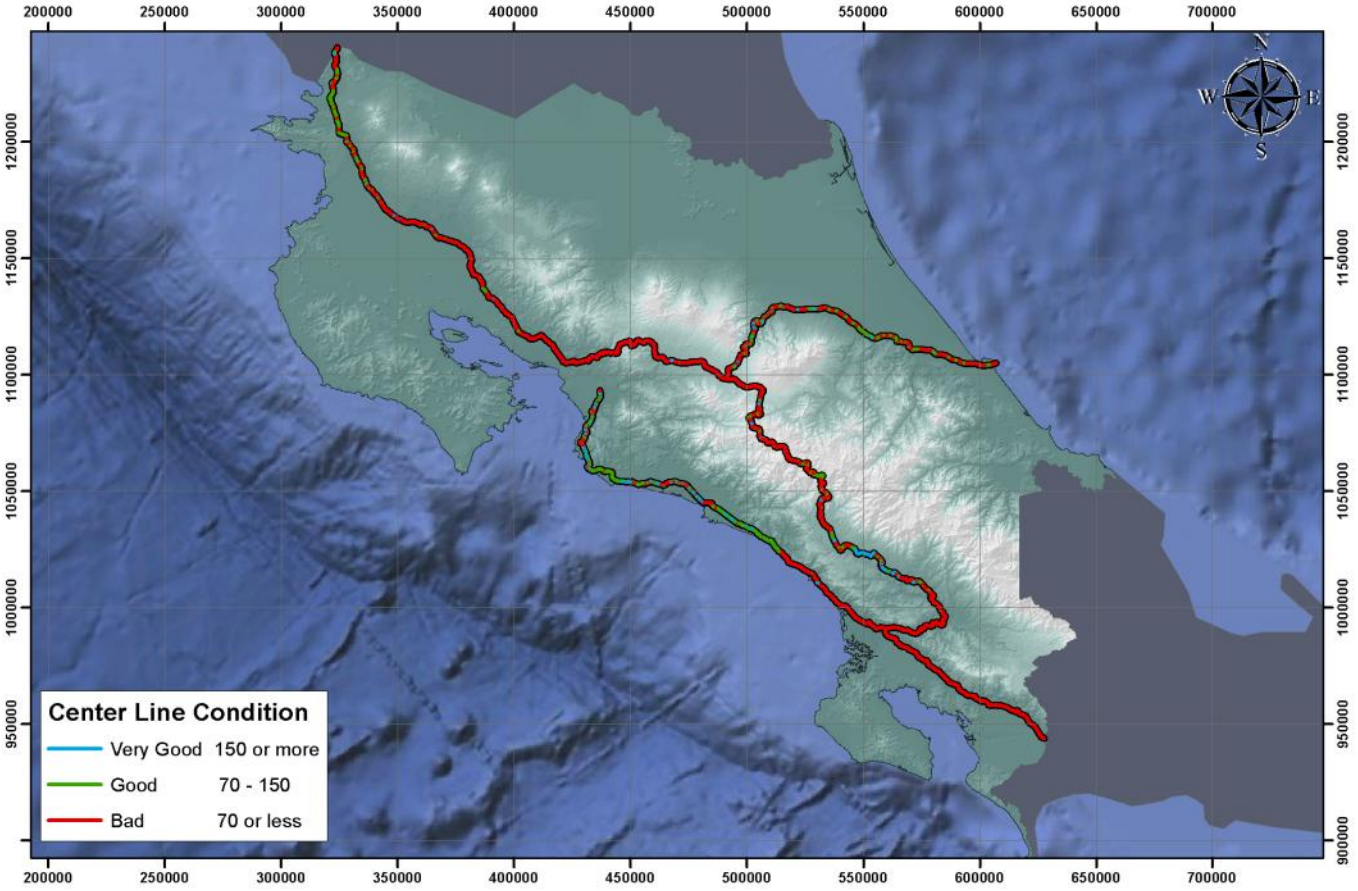
Center Line Retroreflective



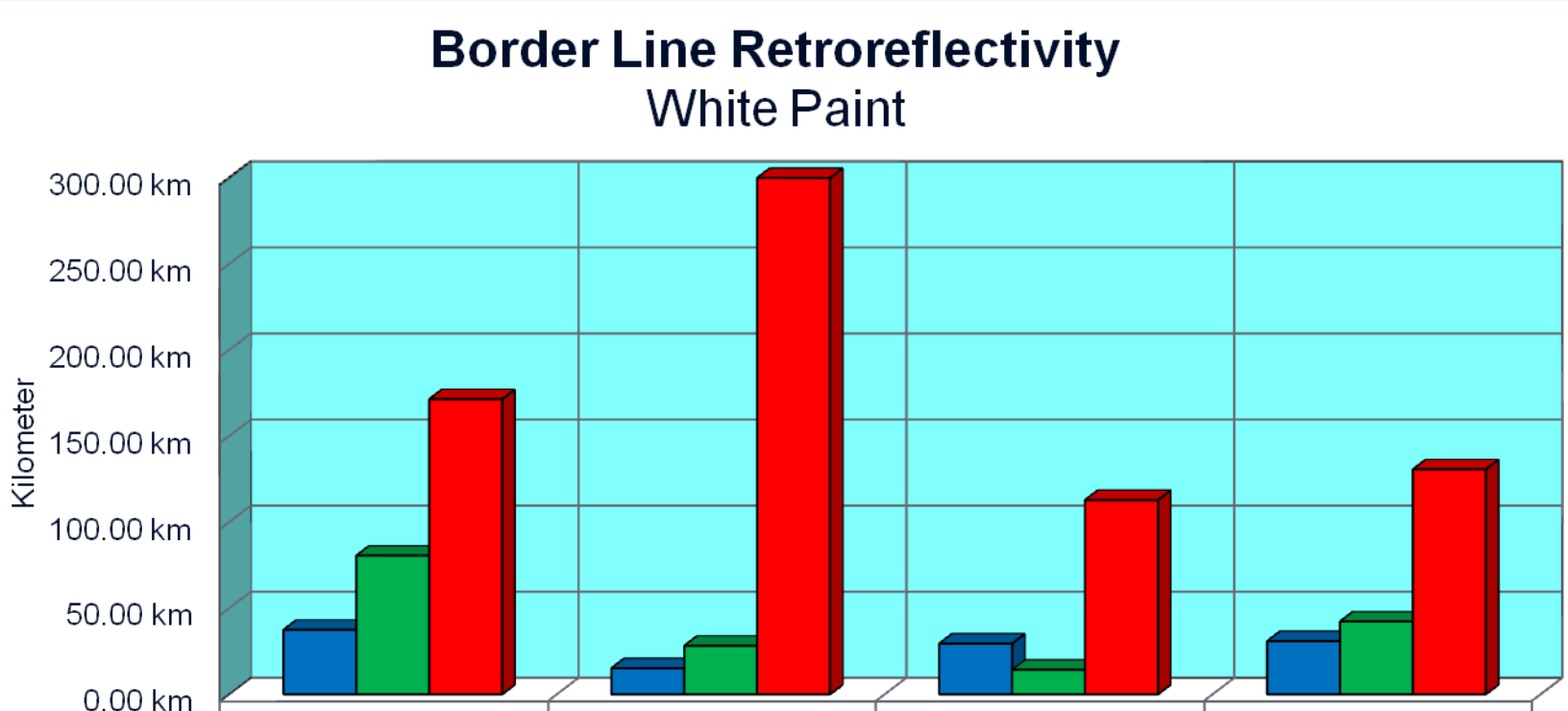
	1	2	32	34
Very Good	7.10 km	26.00 km	13.20 km	33.90 km
Good	40.30 km	33.60 km	47.30 km	71.10 km
Bad	242.20 km	290.70 km	96.16 km	98.90 km

Analysis Units

Center Line Retroreflective Category



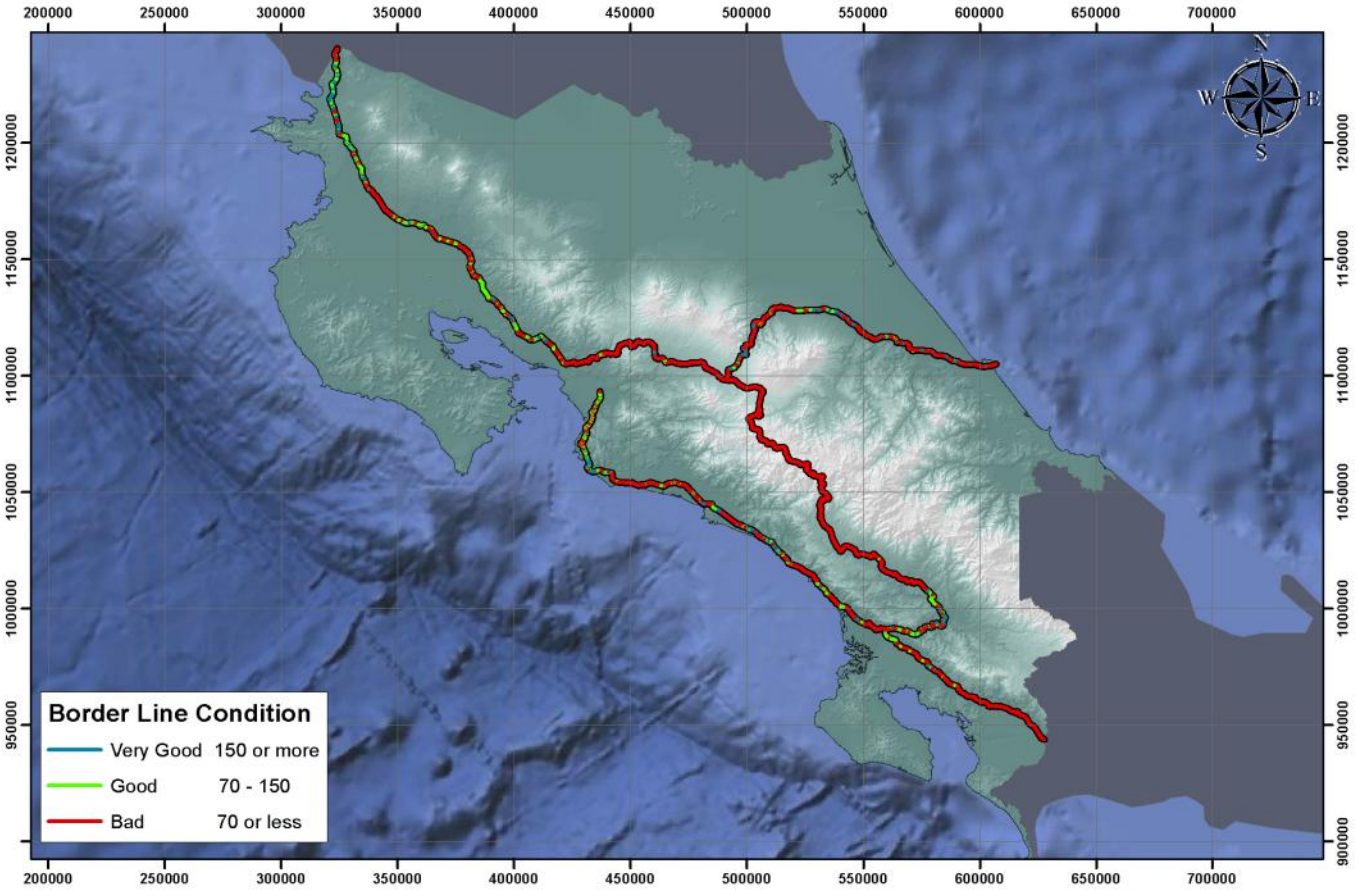
Border Line Retroreflective



	1	2	32	34
Very Good	37.50 km	15.20 km	29.50 km	30.90 km
Good	80.60 km	28.20 km	14.30 km	42.30 km
Bad	171.50 km	306.90 km	112.86 km	130.70 km

Analysis Units

Border Line Retroreflective Category

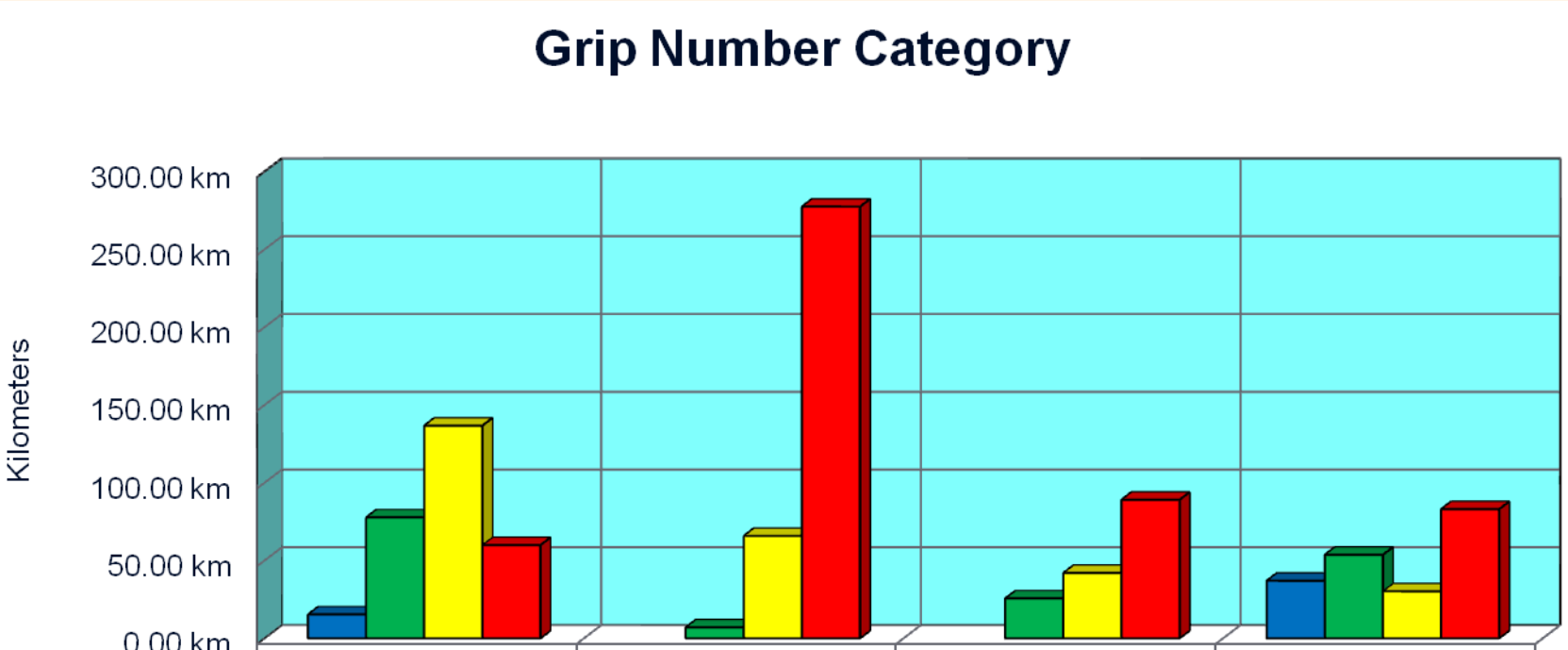


Surface Grip Category

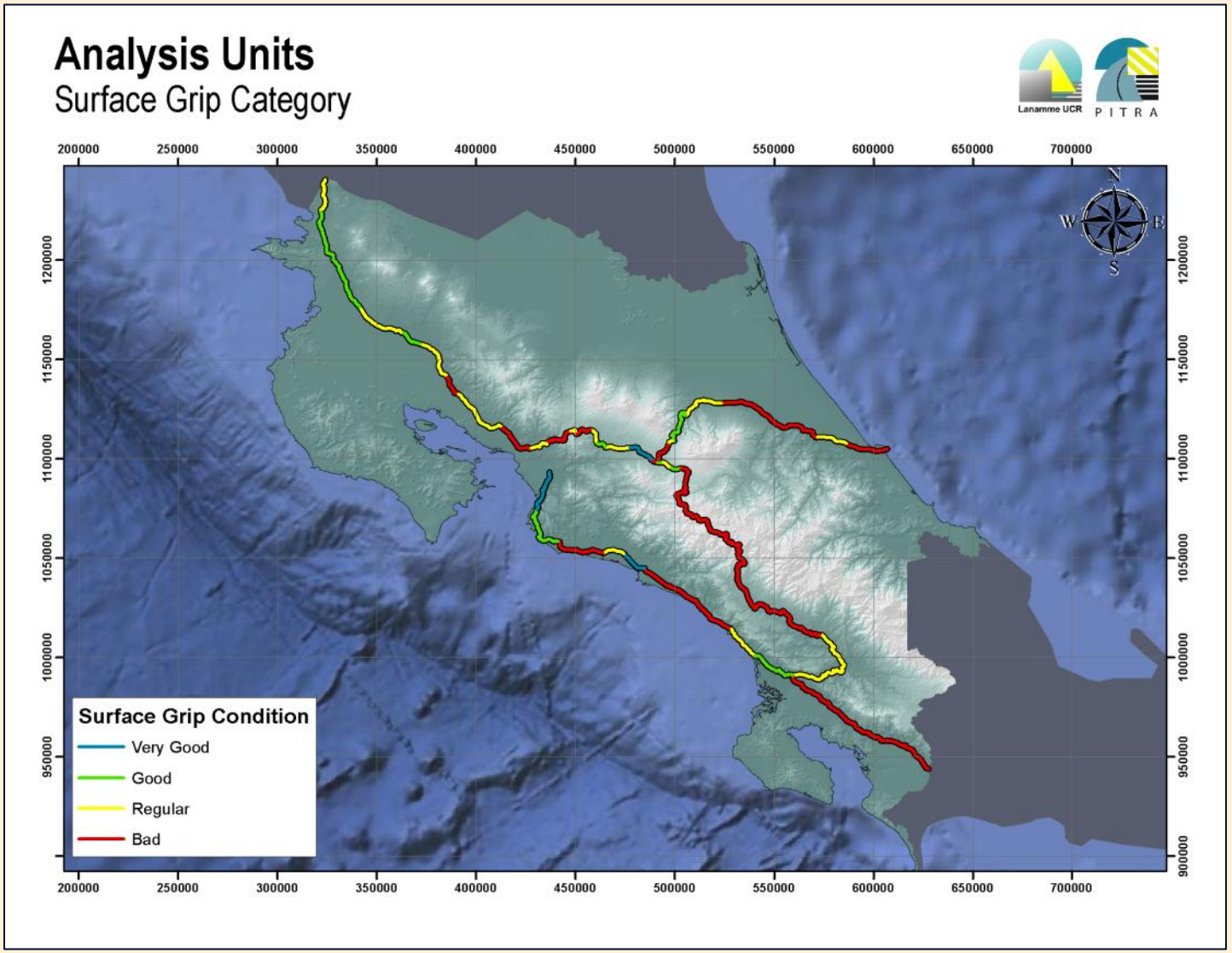
The Grip Number, measures microtexture characteristics associated with braking in rainy conditions, the categories used in the National Road Evaluation of Costa Rica:

Grip Number	Condition	Category
< 0.5	Bad	4
0.50 – 0.60	Regular	3
0.60 – 0.78	Good	2
> 0.78	Very Good	1

Grip Number



	1	2	32	34
Very Good	15.30 km			37.00 km
Good	77.70 km	7.00 km	25.60 km	53.70 km
Regular	136.70 km	65.80 km	42.00 km	30.20 km
Bad	59.90 km	277.50 km	89.06 km	83.00 km


Analysis Units
Surface Grip Category
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200000
250000
300000
350000
400000
450000
500000
550000
600000
650000
700000
1200000
1150000
1100000
1050000
1000000
950000
900000
N
W
E
S
Surface Grip Condition
Very Good
Good
Regular
Bad

Measured Components - Weight

the horizontal retroreflective signs and grip conditions are related to the level of maintenance they receive, and periodic measurements are required in order to establish the functional condition, are dynamic elements in the mitigation of safety issues.

The weight given range: **0 to 8**

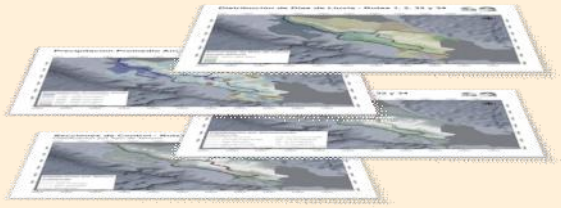
Based on Severity Rating Categories using 10 as max

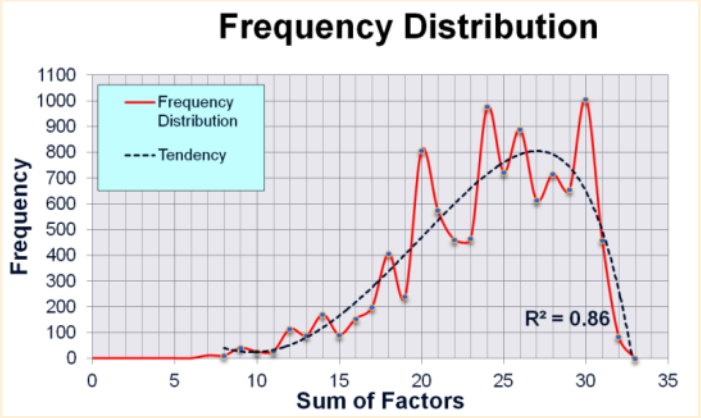
Measured Components - Weight

Class	Factor	Category	Weight
Horizontal Pevement Marks	Center Line Retroreflective	1	0
		2	4
		3	8
	Border Line Retroreflective	1	0
		2	4
		3	8
Surface Grip	Grip Number	1	2
		2	4
		3	6
		4	8

Frequency Distribution and Analysis

Spatial Combination

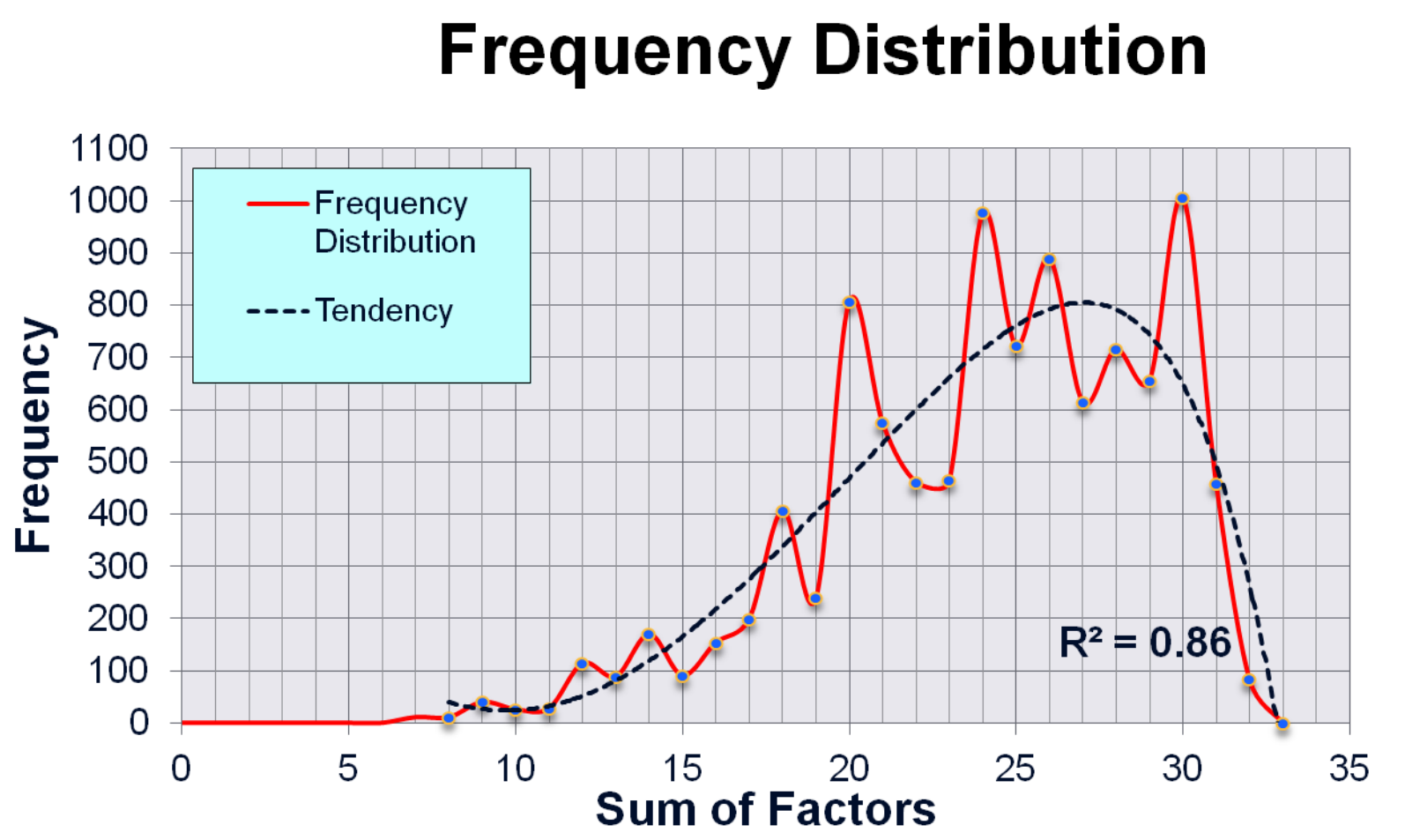




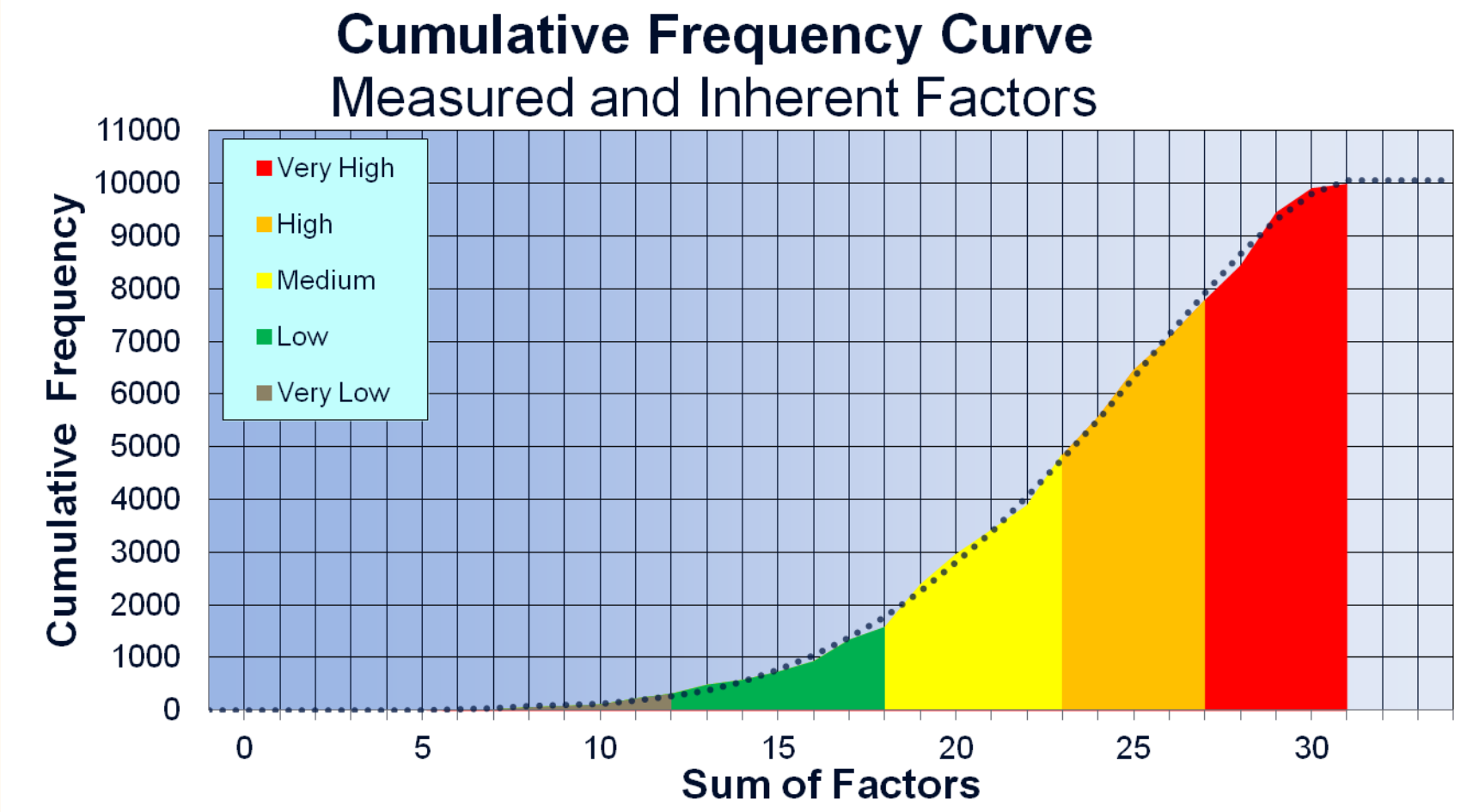
- Using GIS, we proceed to characterize the units of analysis.

- Each analysis unit combine the weights assigned to each measured or inherent factor to create a frequency distribution

Frequency Distribution

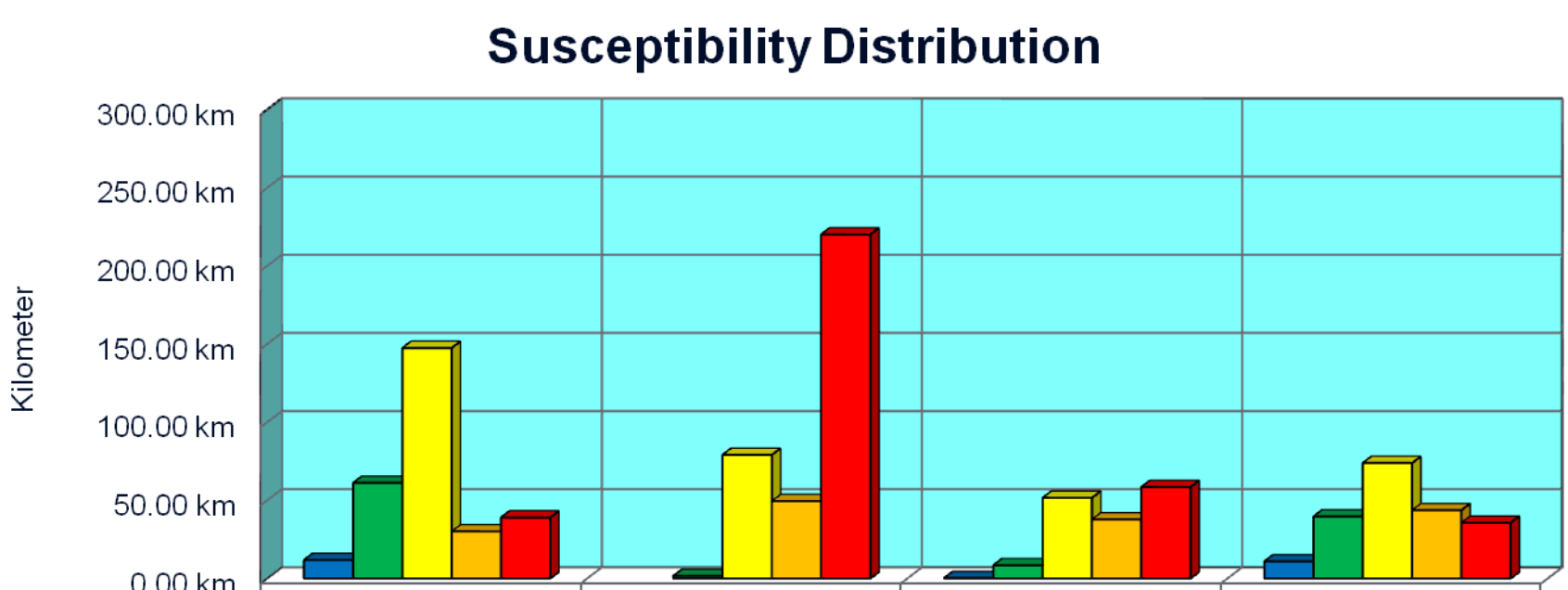


Cumulative Frequency Distribution



Susceptibility Profiles

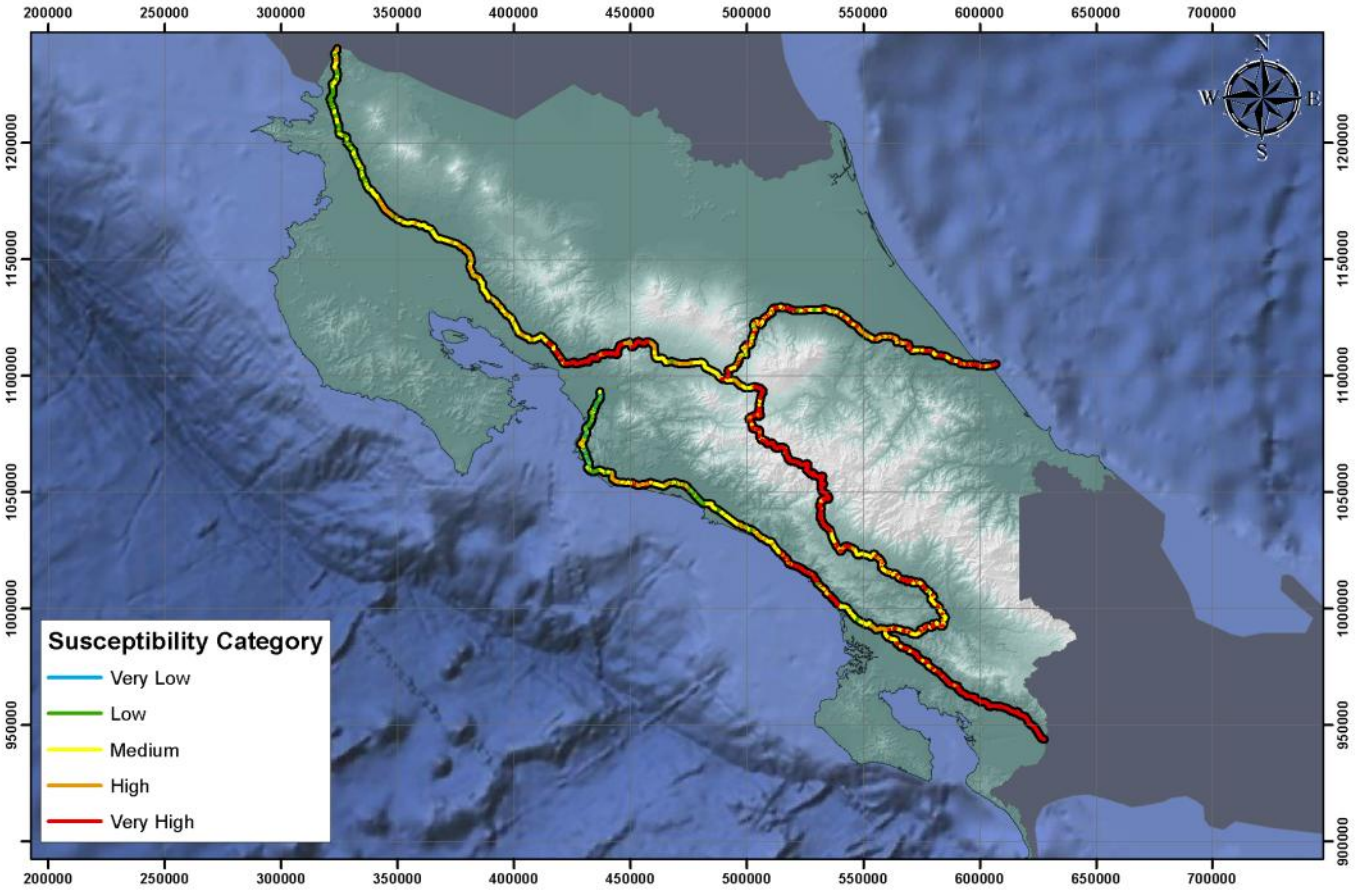
Susceptibility Distribution



	1	2	32	34
Very Low	11.80 km		0.30 km	10.90 km
Low	61.20 km	1.60 km	8.50 km	39.70 km
Medium	147.50 km	79.10 km	51.60 km	73.90 km
High	30.10 km	49.50 km	37.80 km	43.70 km
Very High	39.00 km	220.10 km	58.46 km	35.70 km

Analysis Units

Susceptibility Profiles

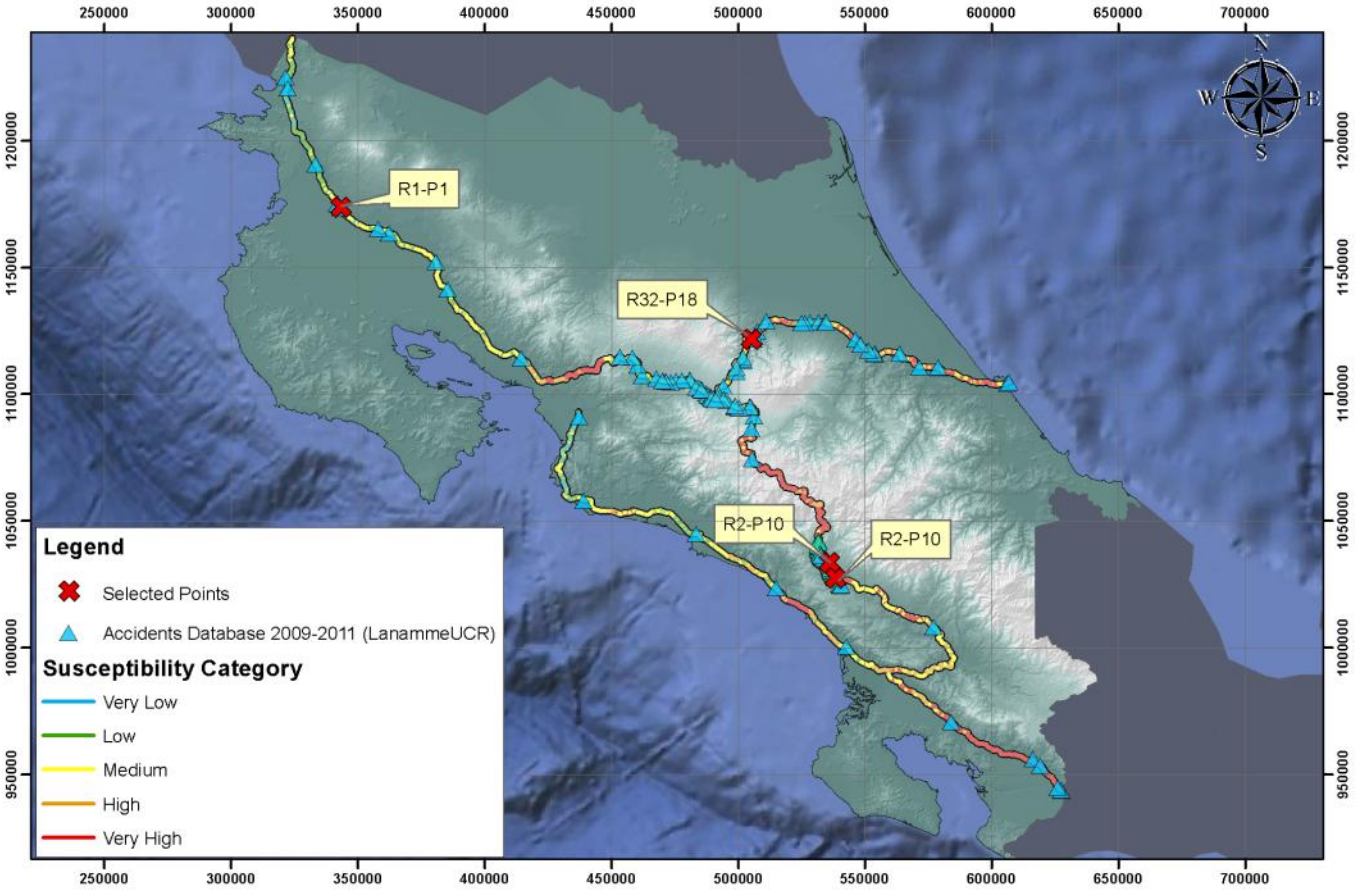


Analysis in Areas with Concentration of Accidents

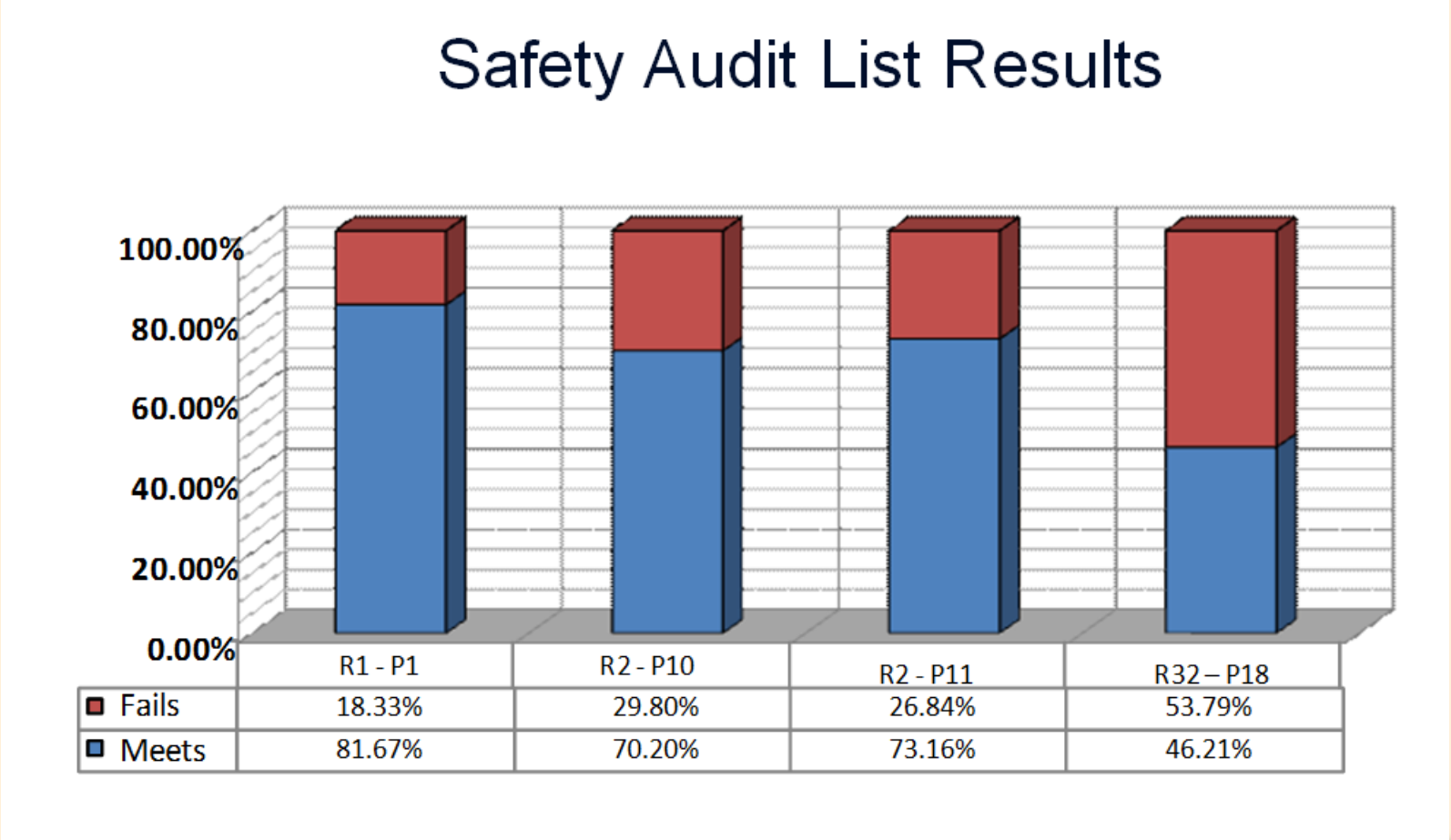
Project Level Information

Using visual auscultation systems and road safety audit lists to analyze very high susceptibility that match accident zones allows detailed information for the administration.

Susceptibility Profile - Accidents Concentration



Points Results



	R1 - P1	R2 - P10	R2 - P11	R32 – P18
Fails	18.33%	29.80%	26.84%	53.79%
Meets	81.67%	70.20%	73.16%	46.21%

Conclusions and Recommendations

Conclusions

- This methodology allows to identify sections with different levels of susceptibility for the user to events which lead to the accident.

- The results obtained allow us to objectively and scientifically, identifying stretches of roads where interventions are needed in a timely way.

- This methodology allows the possibility of achieving a significant impact in reducing the risk of accidents related to the convergence of the factors associated with the administration management.

Conclusions

- The 61% of the routes studied had conditions of high and very high susceptibility.

- The evaluation reveals a condition of high risk with regard to the braking of the vehicle under rainy conditions.

- The analysis using visual auscultation systems combined with road safety audit lists allows a project level information, useful to complement the management activities required from the administration.

Recommendations

- The methodology can be replicated to other routes, keeping the categories used for the factors, but the values and ranges of susceptibility to the analysis of frequencies vary and should match the behavior of the new study.

- Include other parameters or indicators of road safety, such as the presence of roadside barriers and shoulder width, etc., which are representative in the analyzes of accident concentration sections

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