PROMETHEE 2020 days

Comparative Approach using PROMETHEE based GIS and Remote Sensing for Forest Fire Risk Assessment in Western Algeria

S9: GIS & MCDA

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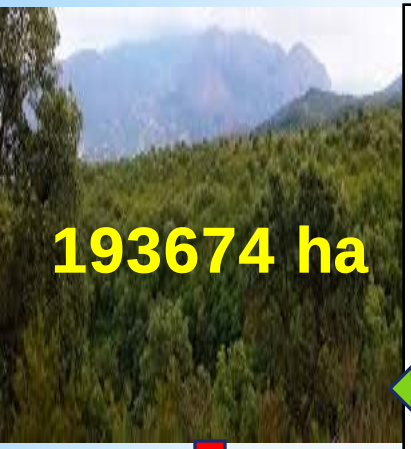
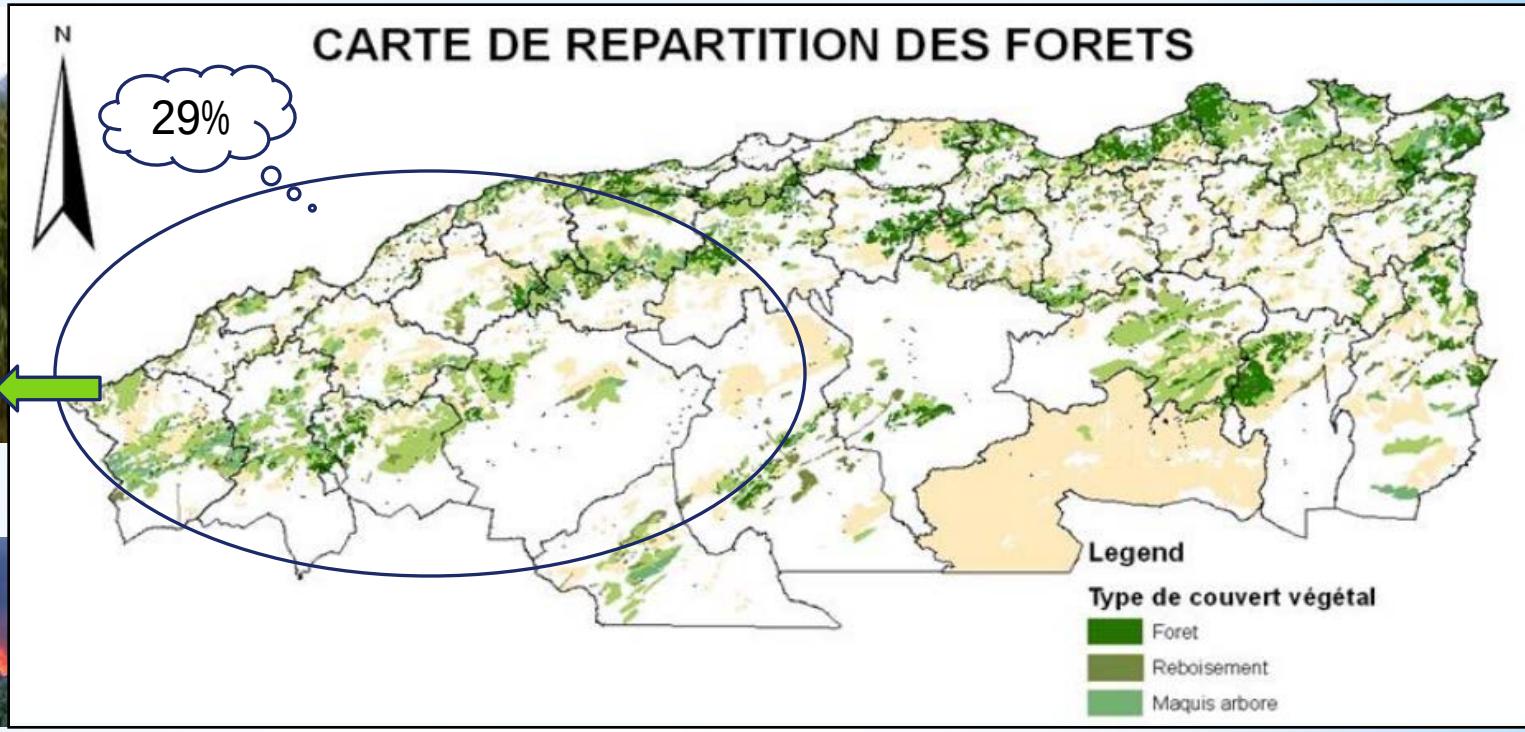
Outline

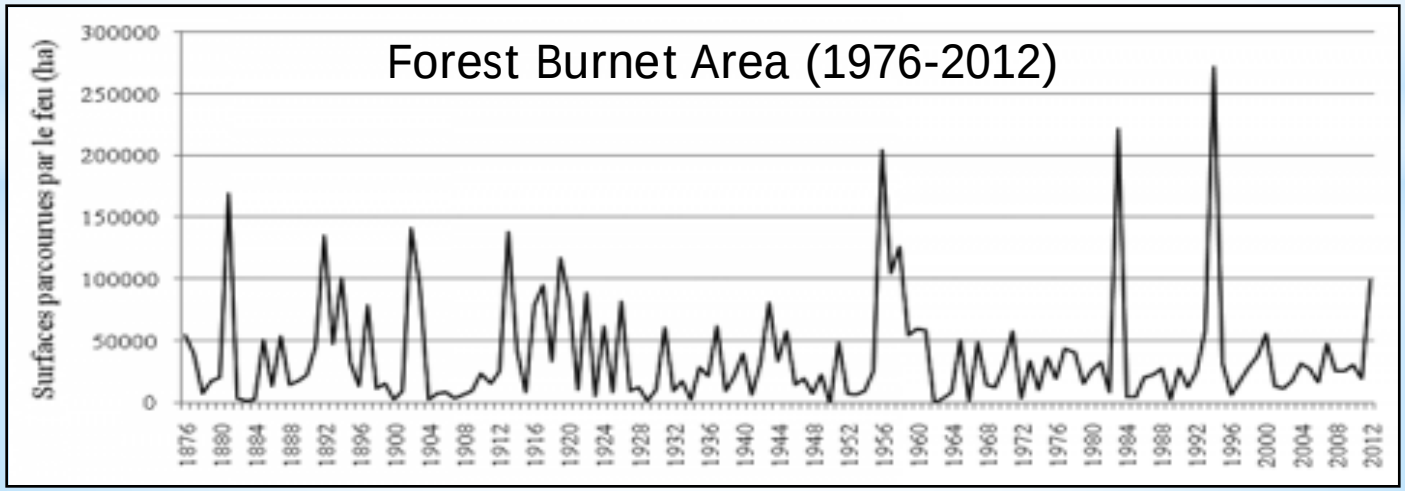
- Overview
  - Problematic
    - GIS-MCDA
      - Methodology
        - Results
          - ✓*GIS-AHP Model*
          - ✓*Remote sensing Model*
          - ✓*Promethee Ranking*
        - Conclusion

Overview


193674 ha


24725 ha (13%)


CARTE DE REPARTITION DES FORETS
N
29%
Legend
Type de couvert végétal
Foret
Reboisement
Maquis arbore


Forest Burnet Area (1976-2012)
Surfaces parcourues par le feu (ha)
300000
250000
200000
150000
100000
50000
0
1876
1880
1884
1888
1892
1896
1900
1904
1908
1912
1916
1920
1924
1928
1932
1936
1940
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
2004
2008
2012

Problematic

- Can we assess and spatialize the risk of forest fires?
- Which model and which factors can we take into account?
- How GIS, RS and MCDA methods can improve FFR assessment?
- What the PROMETHEE method can bring to evaluate the GIS-based and RS FFR assessment
- What can FFR mapping make to forest decision makers and managers?

GIS-MCDA

- ✓ Decision making using expert judgement and knowledge in the case of more, usually conflicting criteria and finite set of alternatives or actions
- ✓ handling with qualitative and quantitative data
- ✓ making the right decision even in the case of missing data and lack of field research.

- **AHP** Analytical Hierarchy Process
- **ELECTRE** ELimination and Choice Expressing REality
- **PROMETHEE** Preference Ranking Organisation

METHod for Enrichment Evaluations

PROMETHEE method

The Preference Ranking Organization METHod for Enrichment Evaluations

PROMETHEE I

Partial ranking

PROMETHEE II

Compleate ranking

Qualities: clear method with simple conception and possibilities to check the stability of the results.

Methodology

Sources

Sentinel2 MSI

DTM

Google Earth

Landsat 7 ETM+

Processing

NDVI

DEM

Slope

Aspect

Roads, Farms Setlements

Calibration

Spectral Reflectance

Raster Math

NBR_Pre

NBR_post

Weighting

V

E

S

A

R

T

F

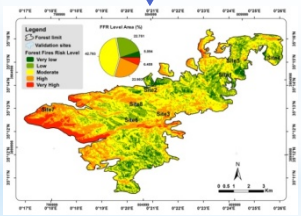
Difference pre-post

dNBR

Reclassify

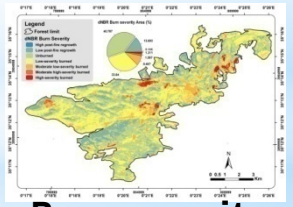
Overlay

FFR = 7*V + 5*(E + S + A) + 3*(R + T + F)



FFR level

Site selection



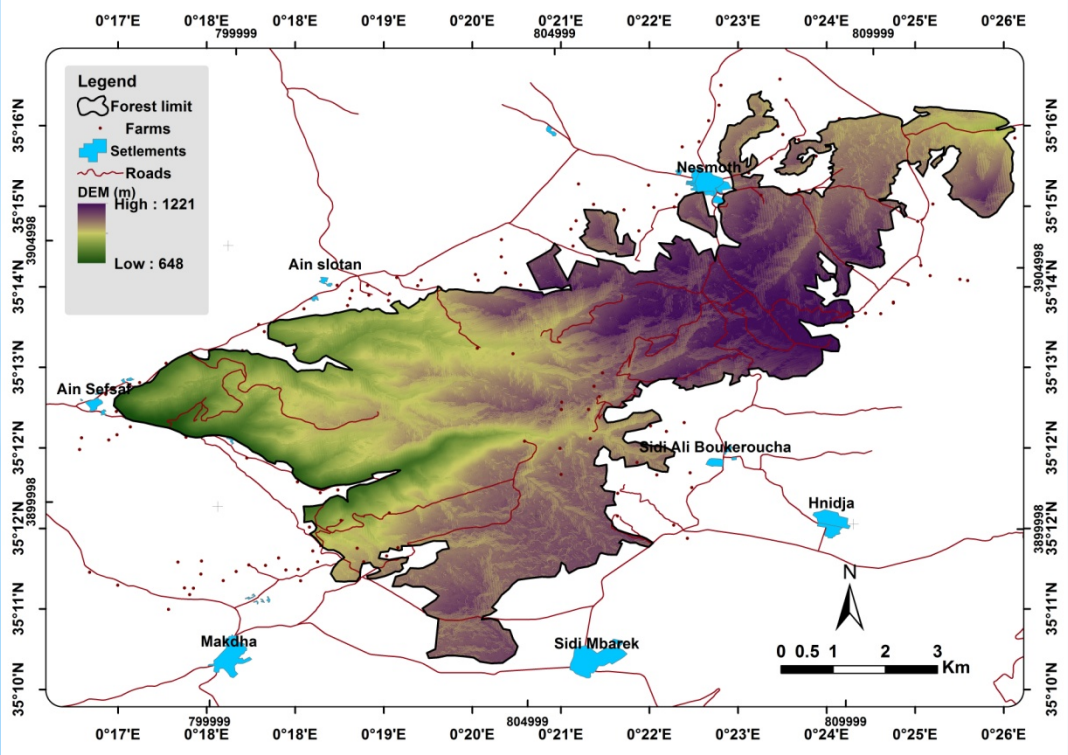
Burn severity

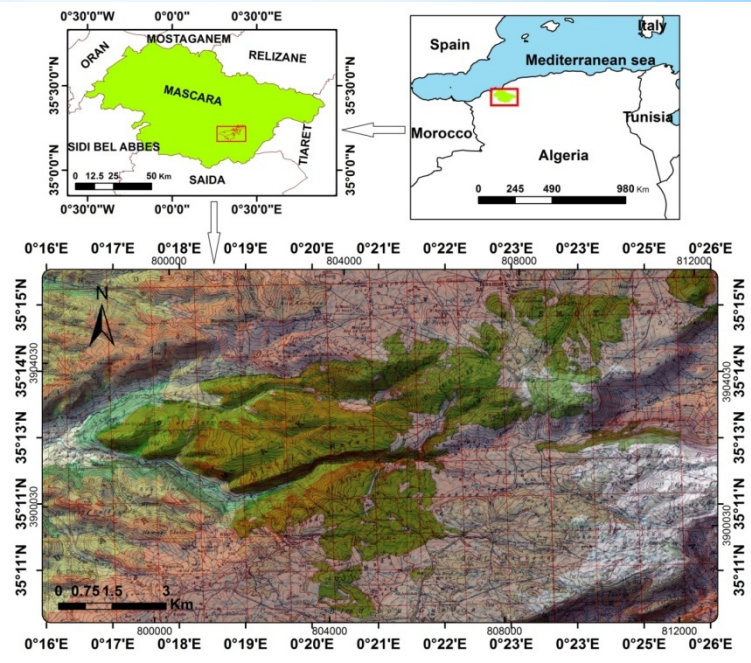
PROMETHEE METHODS

Vulnerable site

Study area characteristics:

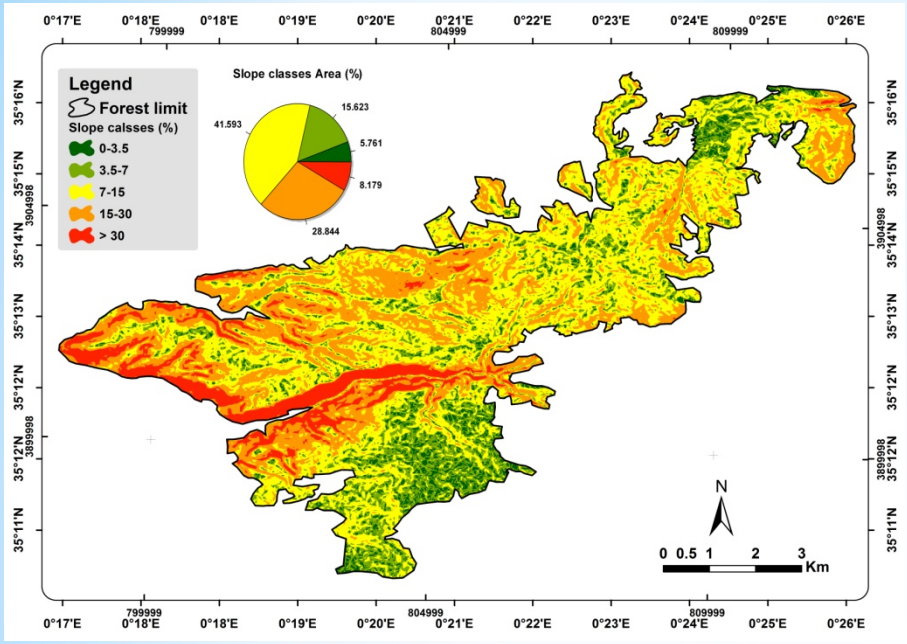
Elevation: 684-1221 m
Avg. Annual Rainfall: 418 mm
Temperature: Hot : 34°, cold: 0°
Forest type: domanial
Dom. Species: Pinus halepensis, Eucalyptus globulus, Tetraclinis articulata

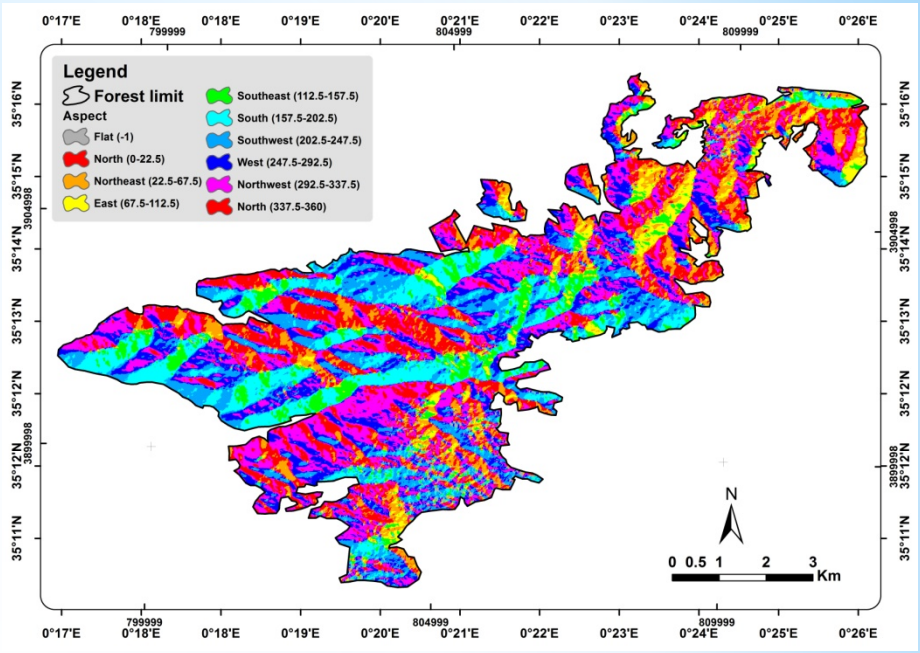


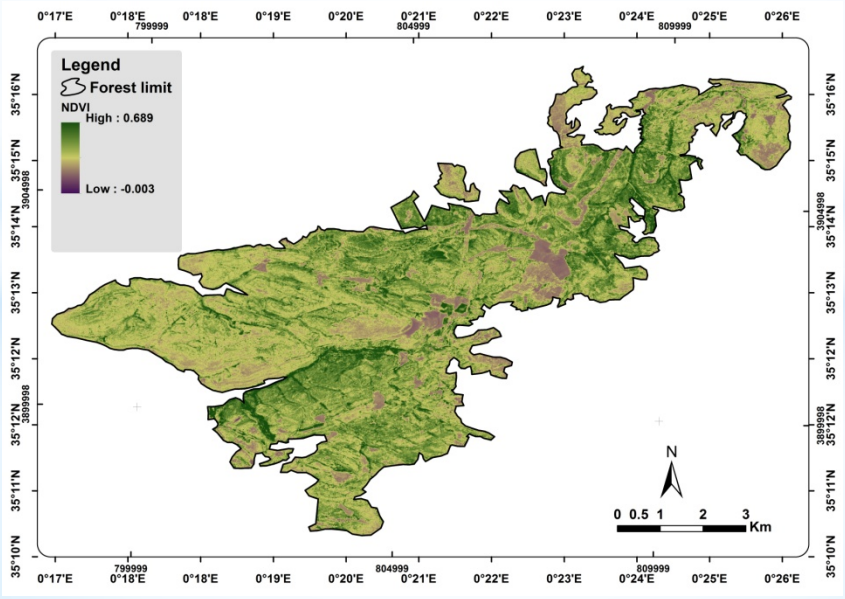


Historical fires events

Longitude (DMS)	Latitude (DMS)	Date
0°23'16.21"E	35°15'08.00"N	26/08/2014
0°23'19.30"E	35°15'05.41"N	29/08/2014
0°22'32.60"E	35°13'46.60"N	26/07/2016
0°22'29,1"E	35°14'22,9"N	01/08/2016
n-a	n-a	02/08/2016
0°24'19,24"E	35°15'17,56"N	27/08/2016
0°23'43.85"E	35°15'16.42"N	05/09/2016
0°19'56.01"E	35° 9'15.20"N	06/07/2017
0°24'2,48"E	35°12'11,66"N	26/07/2019
0°24'1,69"E	35°14'47,32"N	06/08/2019
0°22'16.29"E	35°14'0.58"N	14/08/2019


Legend
Forest limit
Slope calsses (%)
0-3.5
3.5-7
7-15
15-30
> 30
Slope classes Area (%)
15.623
5.761
8.179
28.844
41.593
N
0 0.5 1 2 3
Km


Legend
Forest limit
Aspect
Flat (-1)
North (0-22.5)
Northeast (22.5-67.5)
East (67.5-112.5)
Southeast (112.5-157.5)
South (157.5-202.5)
Southwest (202.5-247.5)
West (247.5-292.5)
Northwest (292.5-337.5)
North (337.5-360)
N
0 0.5 1 2 3
Km


Legend
Forest limit
NDVI
High : 0.689
Low : -0.003
N
0 0.5 1 2 3
Km

risk

Variables	Weights	Classes	Values	Fire Risk Relating Classes
Vegetation	7	Very easy	3	High Risk
		Medium	2	Medium Risk
		Very hard	1	Low Risk
Slope	5	>35	5	Very High Risk
		25–35	4	High Risk
		10–25	3	Medium Risk
		5–10	2	Low Risk
		0–5	1	Very Low Risk
Aspect	5	South(136–225°)	4	Very High Risk
		West (226–315°)	3	High Risk
		East(46–135°)	2	Medium Risk
		North(316–45°)	1	Low Risk
Altitude	5	0–600m (except 0)	5	Very High Risk
		600–700m	4	High Risk
		700–850m	3	Medium Risk
		850–1000m	2	Low Risk
		>1000m	1	Very Low Risk
Distance from Roads	3	0–200m	5	Very High Risk
		200–400m	4	High Risk
		400–600m	3	Medium Risk
		600–1000m	2	Low Risk
		>1000m	1	Very Low Risk
Distance from Farmlands	3	0–100m	5	Very High Risk
		100–400m	4	High Risk
		400–1000m	3	Medium Risk
		1000–2000m	2	Low Risk
		>2000m	1	Very Low Risk
Distance from Settlements	3	0–1000m	5	Very High Risk
		1000–2000m	4	High Risk
		2000–3000m	3	Medium Risk
		3000–4000m	2	Low Risk
		>4000m	1	Very Low Risk

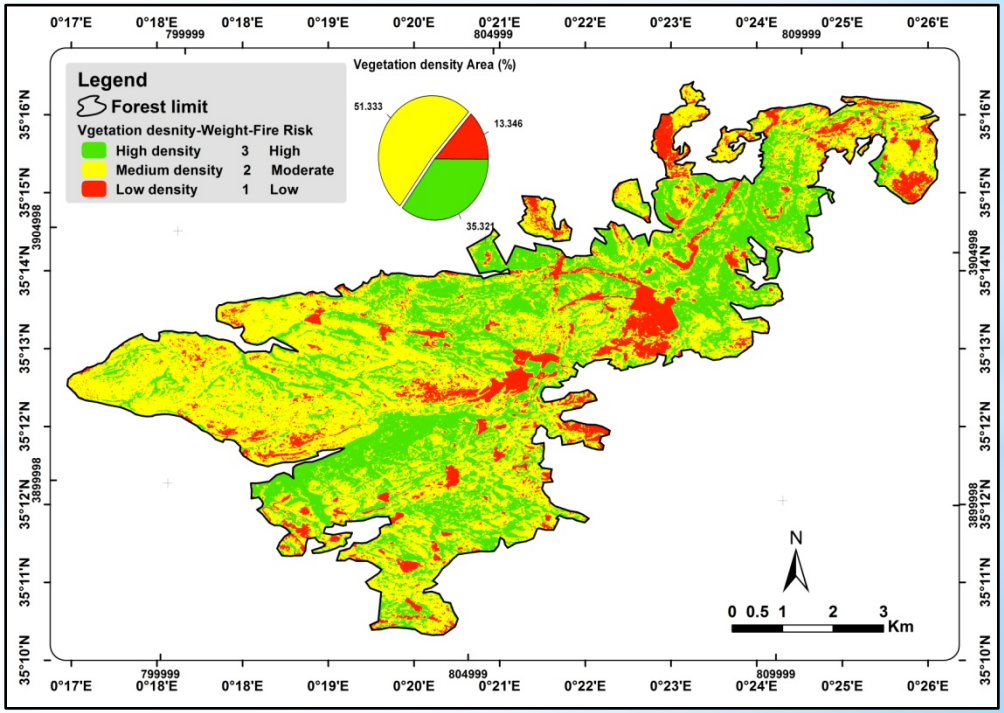
Forest Fires Risk (FFR) Assessment:

$$FFR = f(VF, TF, HF)$$

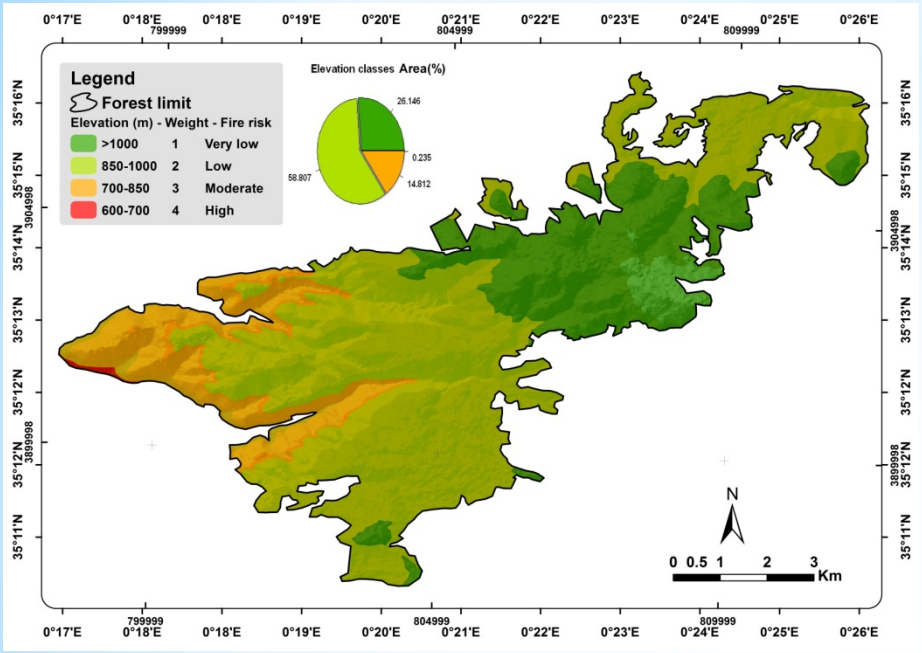
Where

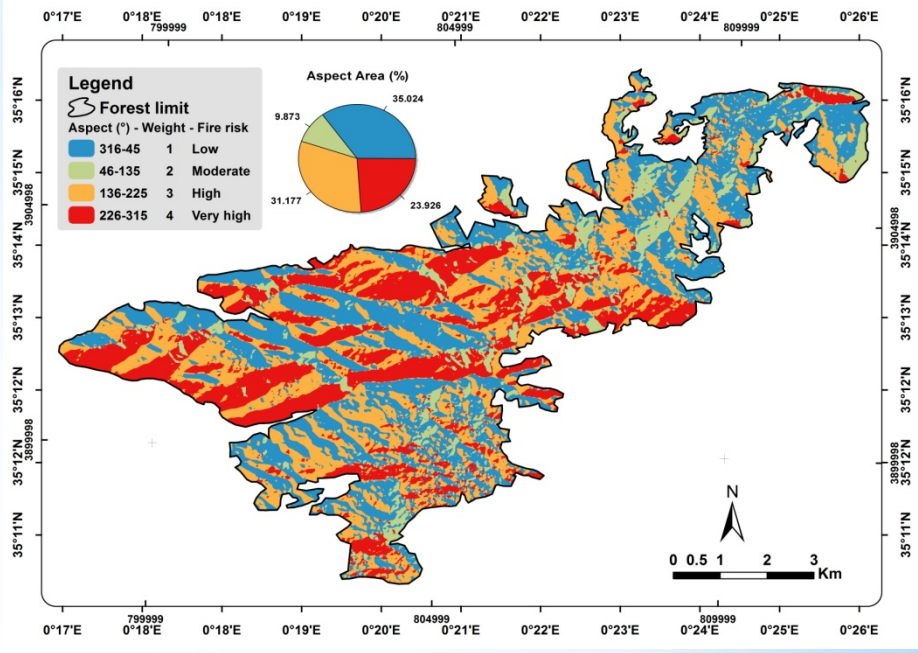
VF = g(Vegetation density)
TF = h(Elev, Slope, Aspect)
HF = e(Roads, Setlements, Farms)

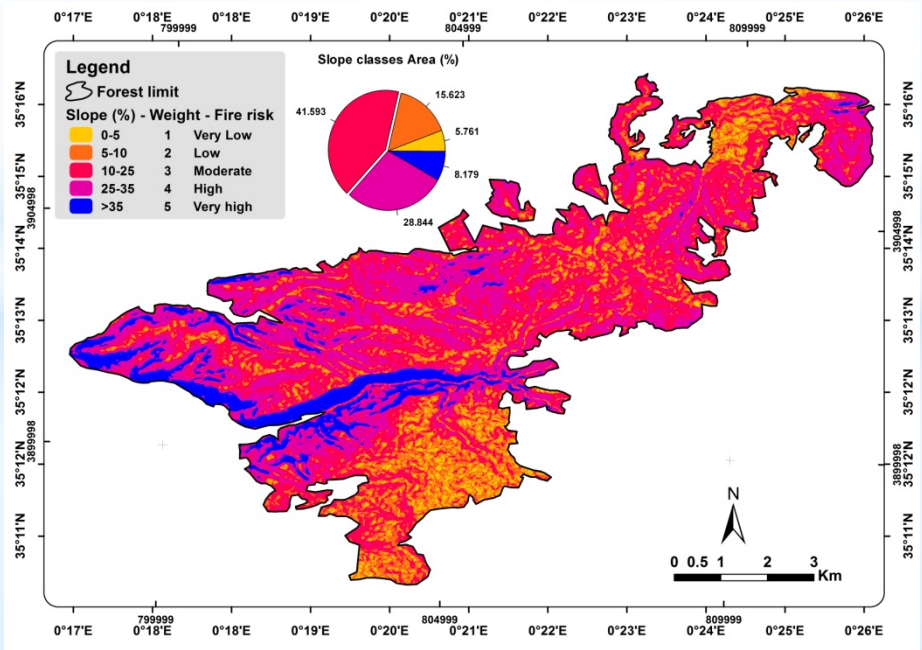
VF: Vegetation Factor



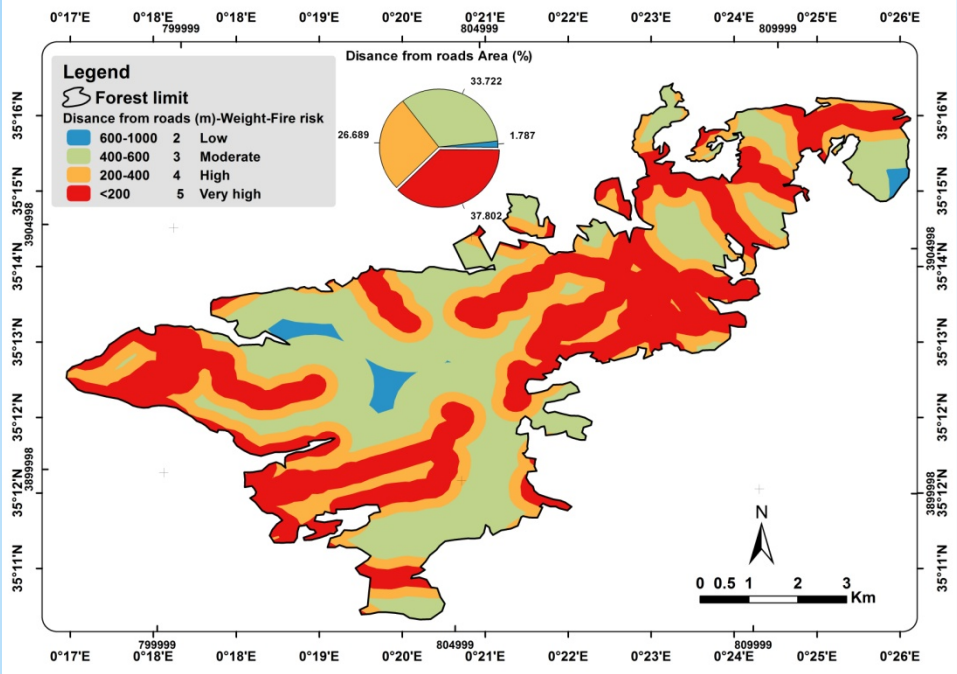
TF: Topographic Factor

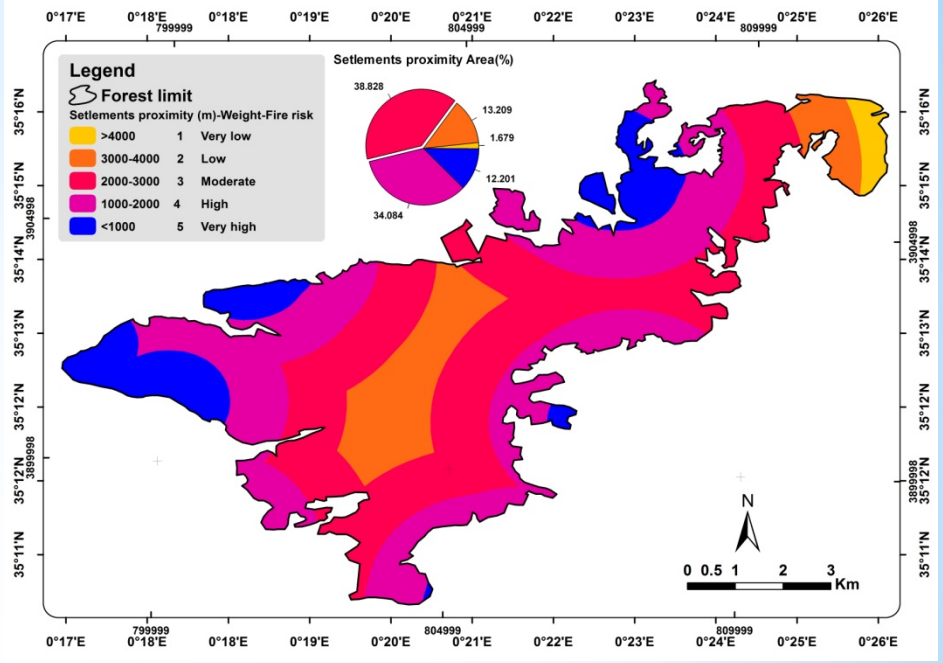


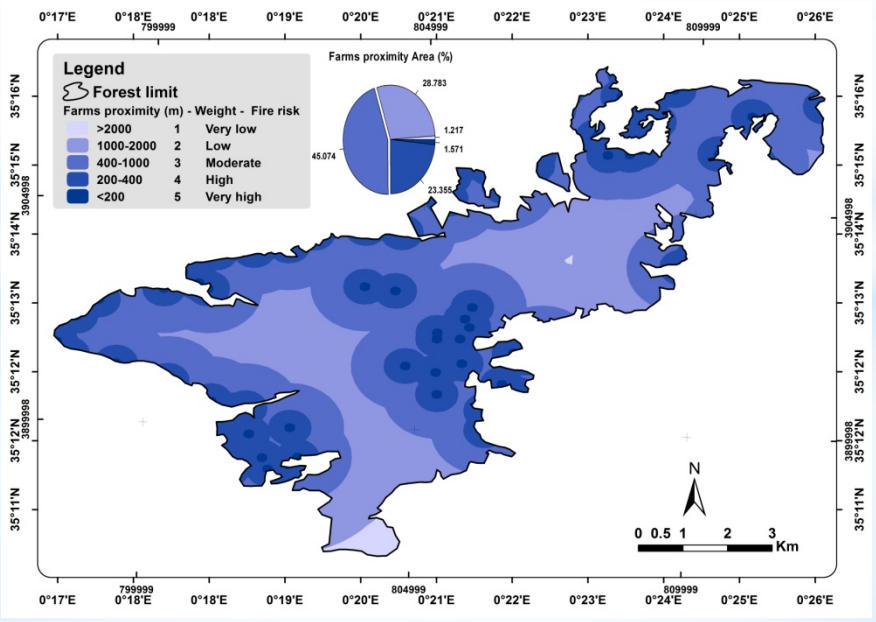




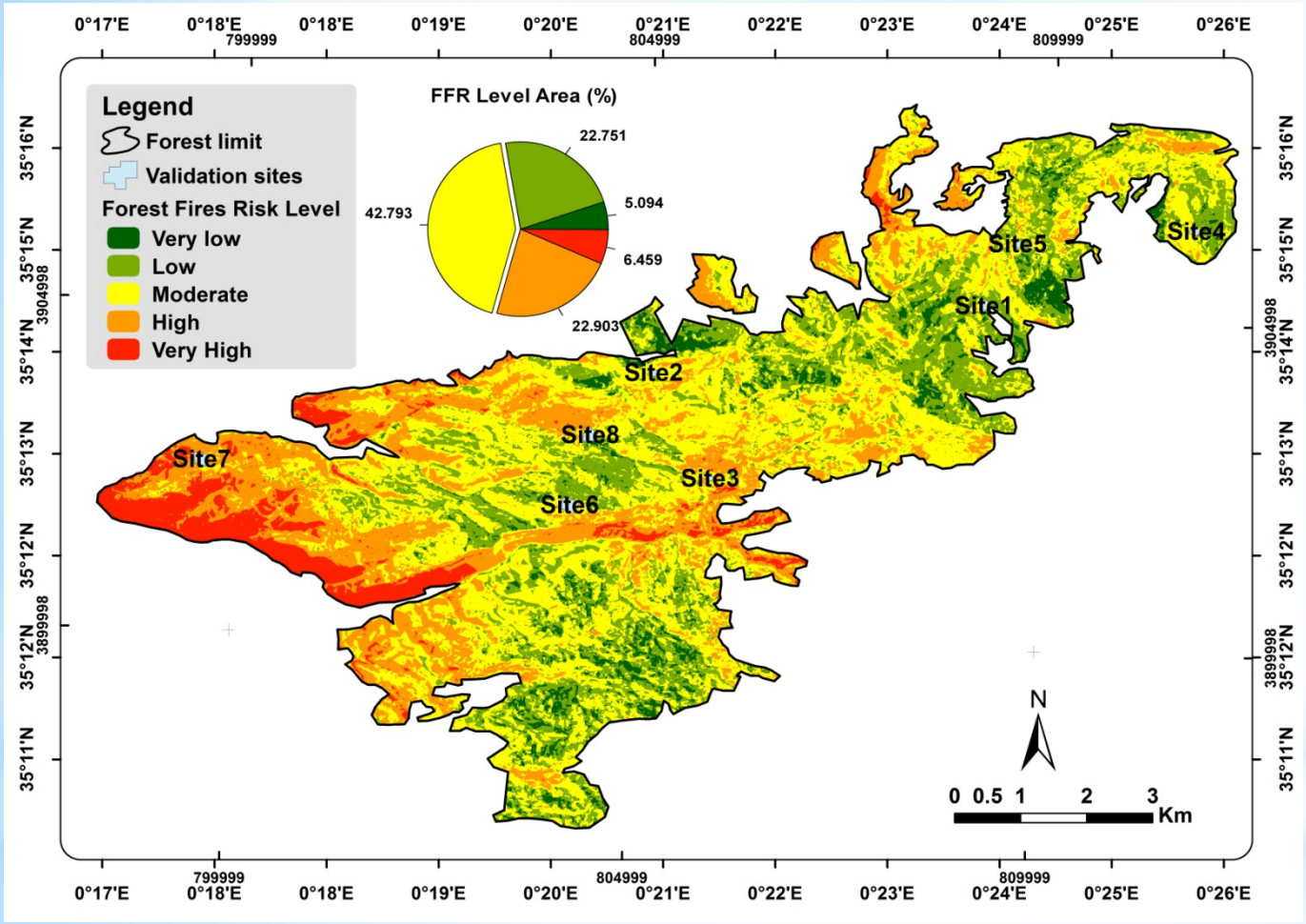
HF: Human Factor



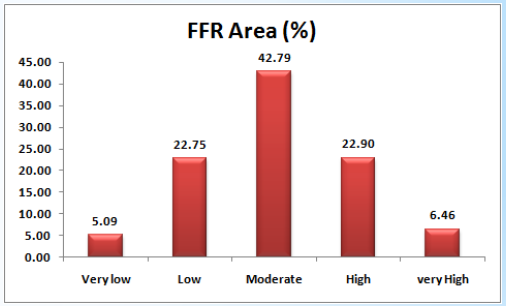




GIS-based FFR map



FFR Level	Area (ha)	Area (%)
Very low	252.18	5.09
Low	1126.31	22.75
Moderate	2118.52	42.79
High	1133.84	22.90
very High	319.75	6.46

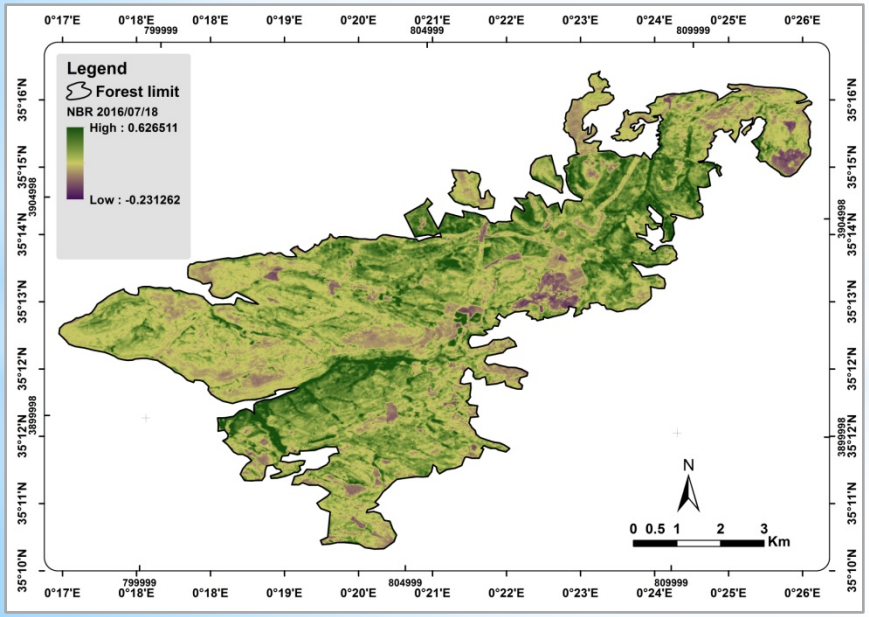


Remote sensing based Burn severity mapping

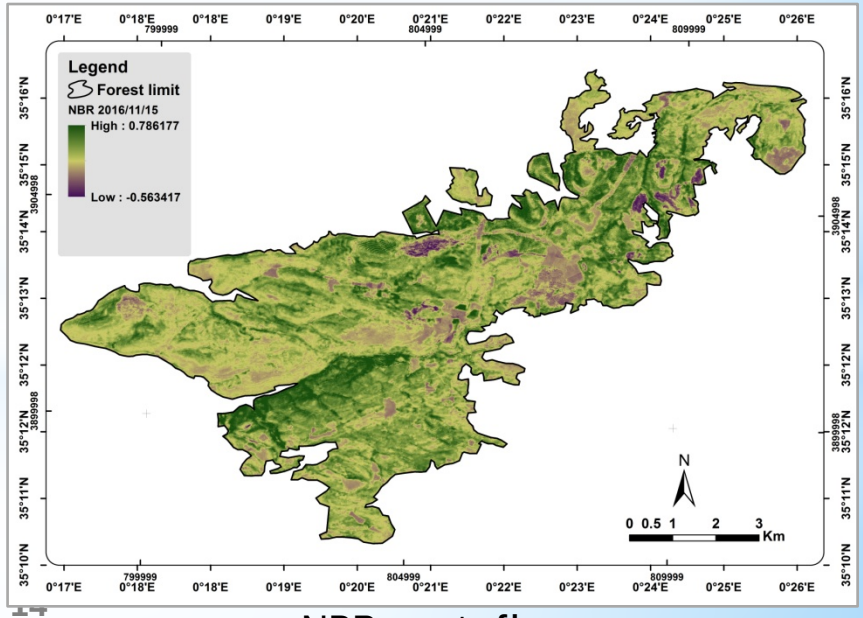
Calculate Normalized Burn ratio index for pre and post fire events.
Fires recored in 2016 are selected to map burn severity.
Pre fire Landsat 7 ETM+ image: 2016/07/18
Post fire Landsat 7 ETM+ image:: 2016/11/15

$$NBR = \frac{\rho_{nir} - \rho_{swir}}{\rho_{nir} + \rho_{swir}} = \frac{B_4 - B_7}{B_4 + B_7}$$

$$dNBR = NBR_{pre} - NBR_{post}$$



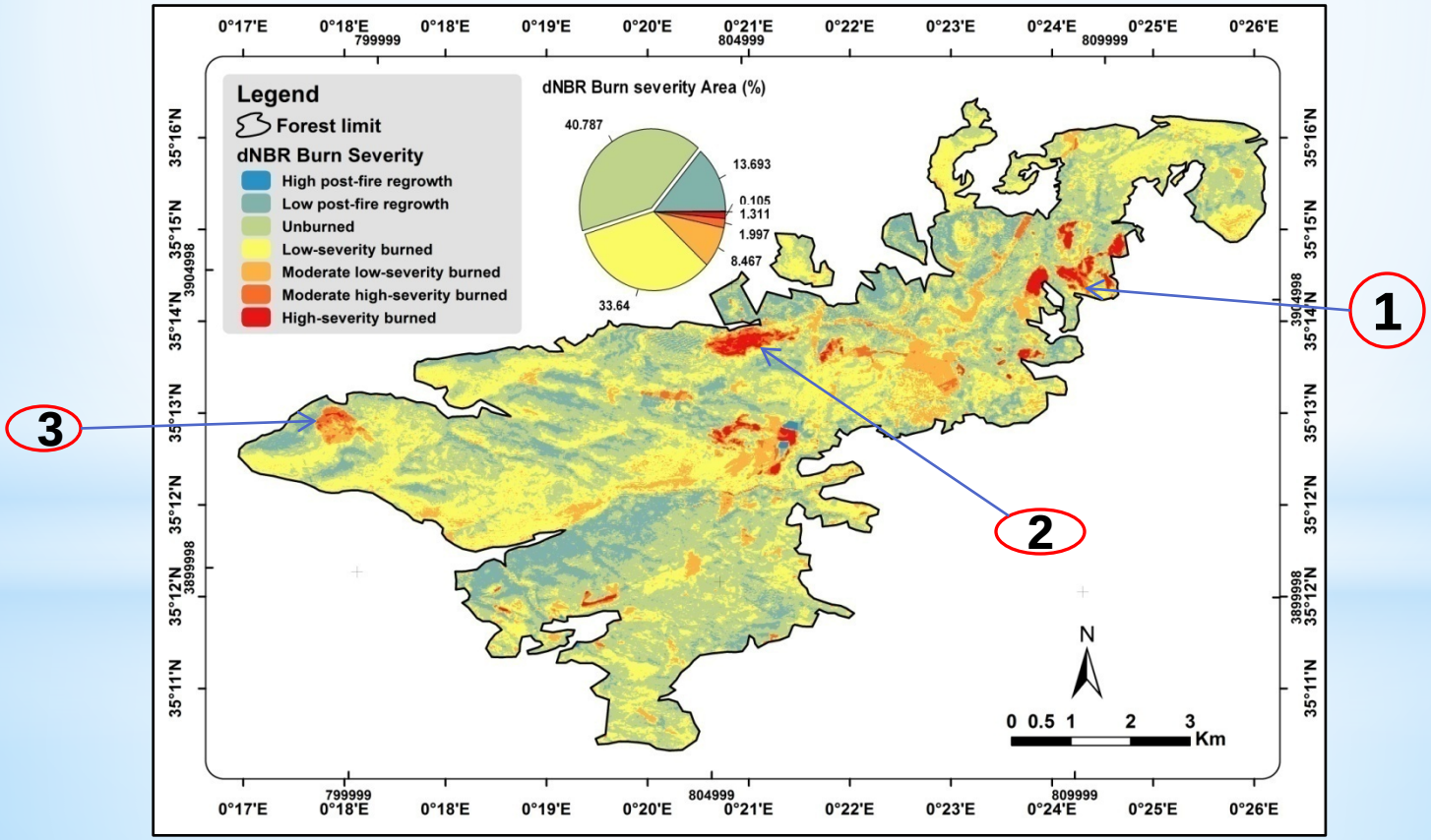
NBR pre_fire



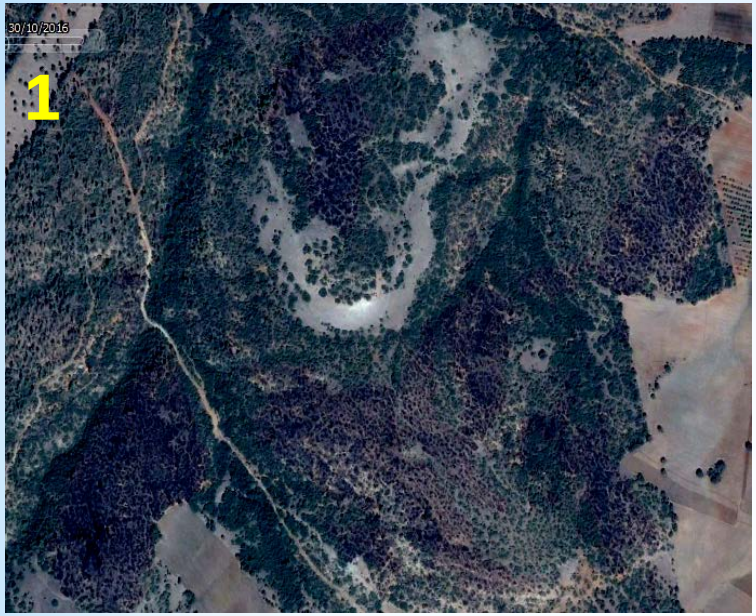
NBR post_fire

dNBR reclassification vs Burn severity

dNBR	Burn Severity
< -0.25	High post-fire regrowth
-0.25 to -0.1	Low post-fire regrowth
-0.1 to +0.1	Unburned
0.1 to 0.27	Low-severity burn
0.27 to 0.44	Moderate-low severity burn
0.44 to 0.66	Moderate-high severity burn
> 0.66	High-severity burn



Burn severity map


30/10/2016
1


30/10/2016
2


30/10/2016
2020
3

Fuzzy AHP Weighting

3 Major criterian

	Vegetation N	Topography	Antropedemi
Vegetation Nature	1	8	3
Topography	0.125	1	0.14285714
Antropedemic	0.333333333	7	1
Sum	**1.458**	**16.000**	**4.143**

	Vegetation N	Topography	Antropedemi	**Weight**	
Vegetation Nature	0.686	0.500	0.724	0.637	3.191
Topography	0.086	0.063	0.034	0.061	3.016
Antropedemic	0.229	0.438	0.241	0.302	3.111

	Criteria	Fuzzy weigh
Crit1	Vegetation Natur	0.643
Crit2	Topography	0.059
Crit3	Antropedemic	0.298

CI	0.058	0.089
RI	0.58	
CR	**0.100**	0.154

•Topgraphic sub-critieria

	Criteria	Fuzzy weigh
Crit1	Slope	0.643
Crit2	Aspect	0.059
Crit3	Elevation	0.298

CI	0.058	0.089
RI	0.58	
CR	**0.100**	0.154

•Anthropogenic sub-criteria

	Criteria	Fuzzy weigh
Crit1	Distance To road	0.667
Crit2	Setelements Proximity	0.111
Crit3	Farms proximity	0.2222

CI	0.501	0.505
RI	0.58	
CR	**0.864**	0.8705

Forest Fire Vulnerability analysis using PROMETHEE method

Classify 8 selected sites according to Fire vulnerability from high to low

Define criterias:

Criteria	Scale	Unit	Min/Max
Vegetation	Numeric	%	Max
Elevation	Numeric	meter	Min
Slope	Numeric	%	Max
Aspect	Qualitative	5-point	Max
Dist. to Roads	Numeric	meter	Min
Setlements Prox.	Numeric	meter	Min
Dist. To Farms	Numeric	meter	Min

One Scenario for 8 actions (Sites) :

- ***Burned area: Site1, Site2, Site3, Site5, Site7, Site 8***
- ***Unburned area: Site4, Site6***

Visual PROMETHEE Academic used Software

Visual PROMETHEE Academic - V_promethee_proj.vpg (saved)

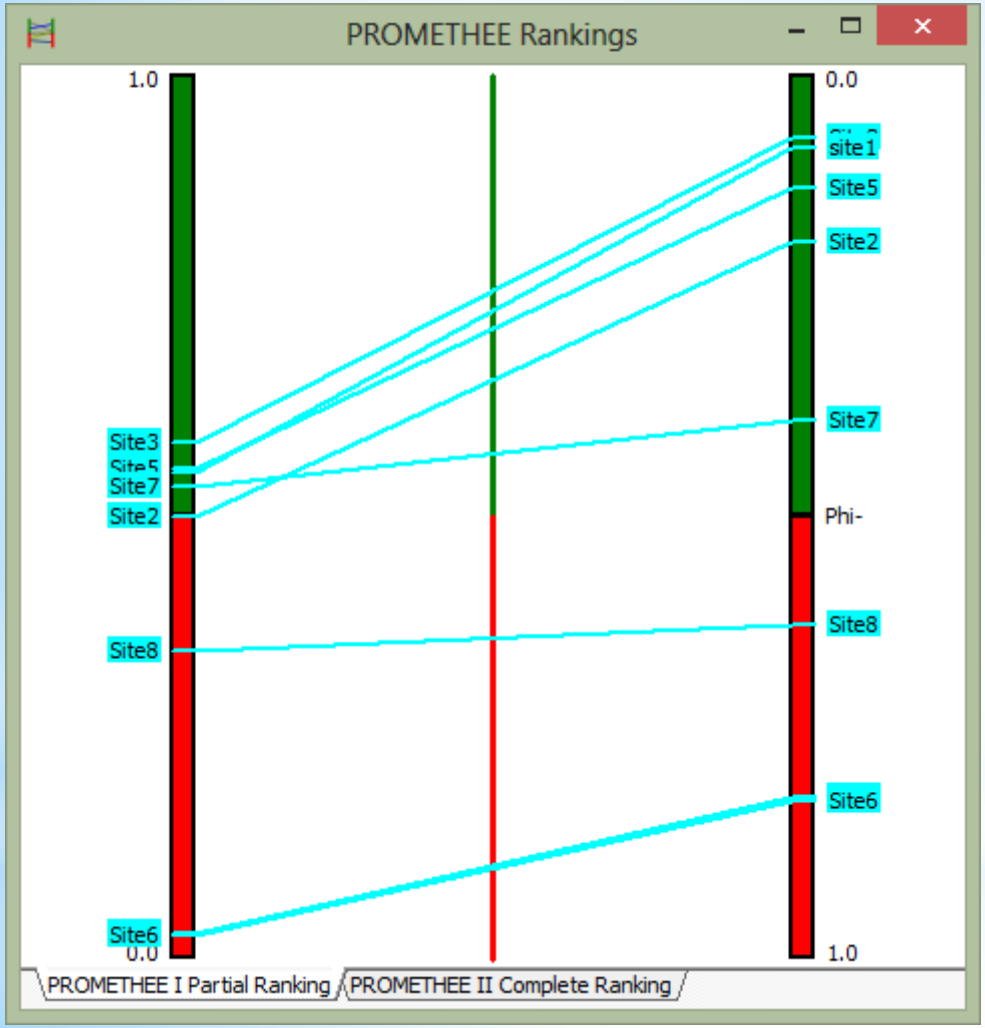
File Edit Model Control PROMETHEE-GAIA GDSS GIS Custom Assistants Snapshots Options Help

Scenario1	vegetation	elevation	slope	aspect	roads	Setlements	farms
Unit	%	meter	%	5-point	meter	meter	meter
Cluster/Group	◆	◆	◆	◆	◆	◆	◆
Preferences							
Min/Max	max	min	max	min	min	min	min
Weight	0,64	0,02	0,04	0,00	0,20	0,03	0,07
Preference Fn.	Linear	Linear	Linear	Linear	Linear	Linear	Linear
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	2,0000	70,00	1,20	1,0000	50,00	120,00	100,00
- P: Preference	4,2000	100,00	2,20	1,5000	90,00	200,00	150,00
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics							
Minimum	24,1000	831,89	5,96	1,0000	190,13	1004,85	68,27
Maximum	56,0000	1025,36	21,74	4,0000	890,88	3933,33	1154,35
Average	42,4375	964,98	12,88	1,8750	436,78	2504,05	610,31
Standard Dev.	12,7548	64,39	5,09	0,9270	267,41	929,21	337,58
Evaluations							
site1	54,0000	1025,36	17,05	bad	211,76	1685,36	1154,35
Site2	54,3000	1008,97	21,74	very bad	494,37	3071,93	622,23
Site3	53,5000	977,61	5,96	bad	199,09	2231,93	68,27
Site4	24,1000	1025,27	13,59	good	846,79	3933,33	801,13
Site5	56,0000	989,37	12,05	bad	286,27	1749,30	704,63
Site6	26,1000	970,28	10,72	bad	890,88	3368,31	864,37
Site7	39,5000	831,89	15,96	very bad	190,13	1004,85	505,45
Site8	32,0000	891,11	5,96	very bad	374,97	2987,43	162,08

All Scenario1 Scenario2 Scenario3 Scenario4 Scenario5

Actions: 8 (8 active) Criteria: 7 (7 active) Scenarios: 5 (5 active) Locale: Belgium [€/,] Saved

Visual PROMETHEE Analysis results



PROMETHEE Flow Table

Rank	action	Phi	Phi+	Phi-
1	Site3	0,5124	0,5837	0,0713
2	site1	0,4683	0,5496	0,0813
3	Site5	0,4275	0,5556	0,1281
4	Site2	0,3125	0,5004	0,1879
5	Site7	0,1423	0,5342	0,3919
6	Site8	-0,2757	0,3477	0,6233
7	Site4	-0,7899	0,0274	0,8173
8	Site6	-0,7974	0,0255	0,8229

Conclusion

- *we note the effective contribution of GIS and remote sensing to assess FFR*

- *Assessing and spatializing FFR can succefully help forest managers to get an idea about spatial disribution of the vulnerable zones to fires and take the bet decision.*

- ***The integration of MCDA methods with GIS can considerably improve the quality and the precision of FFR mapping.***

- ***The weighted ranking using PROMETHEE method to select vulnerable area to forest fire ignition could be very usefull to foret managers to fight against Forest fires and reduce damages.***

Thank you

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