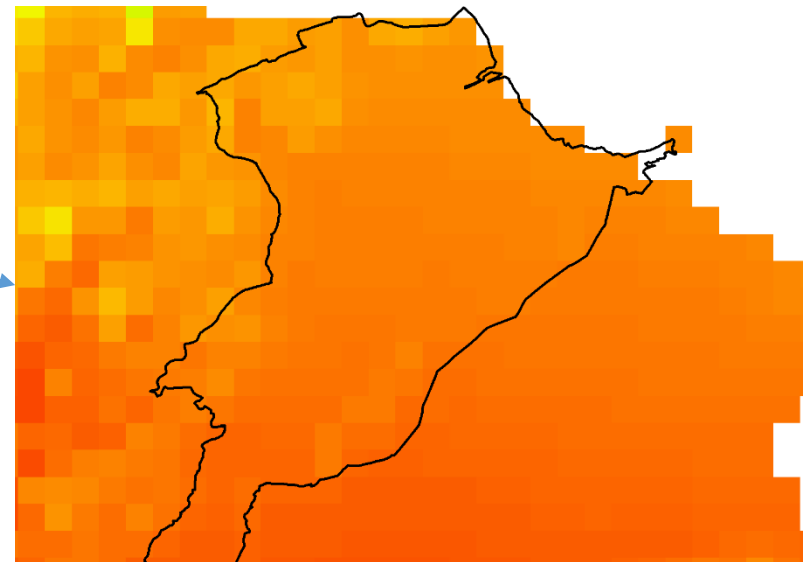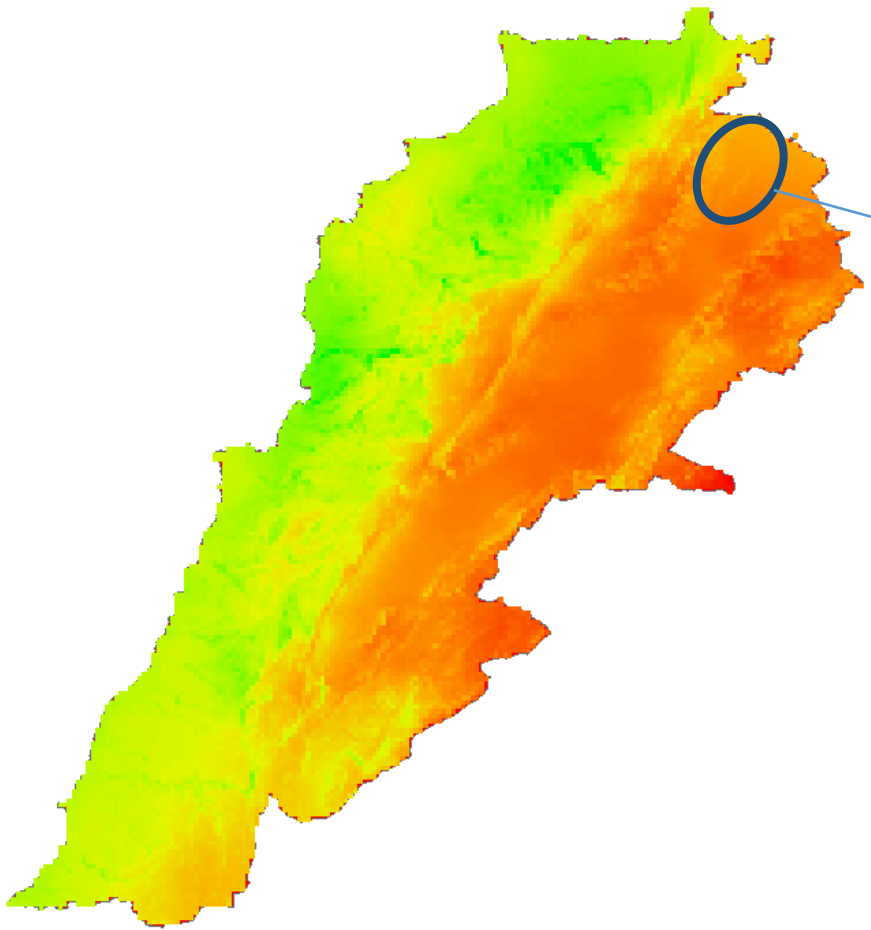# Solar System Assessment for Hermel
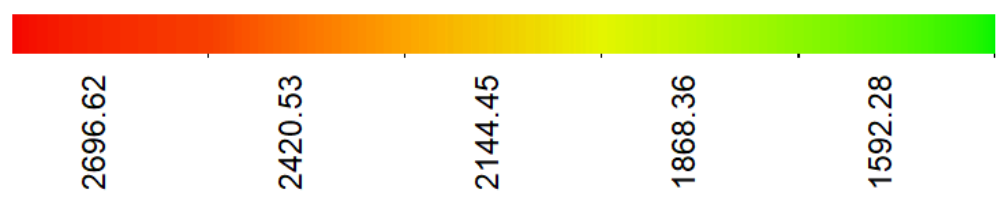
Done by:
Ali Dawi
Jaafar sirhan

Solar Irradiation in Lebanon

N

The average annual solar irradiation in Hermel = **2346 kwh/m2.**

Yearly Solar Irradiation in KWh/m2

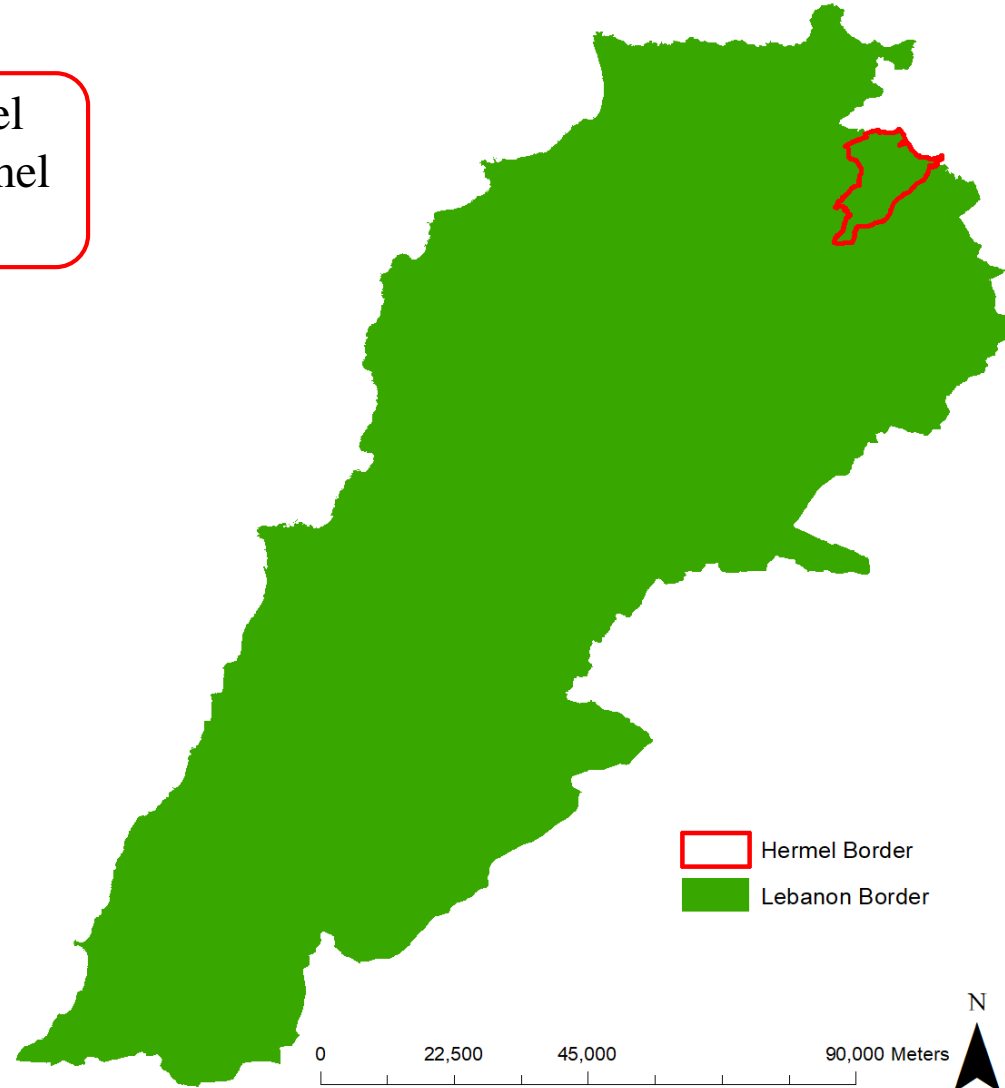2696.62   2420.53   2144.45   1868.36   1592.28

Detailed Description for the land

Geo-Location for Hermel

Hermel is Located in Baalbak-Hermel
Governorate and specifically in Hermel
District.

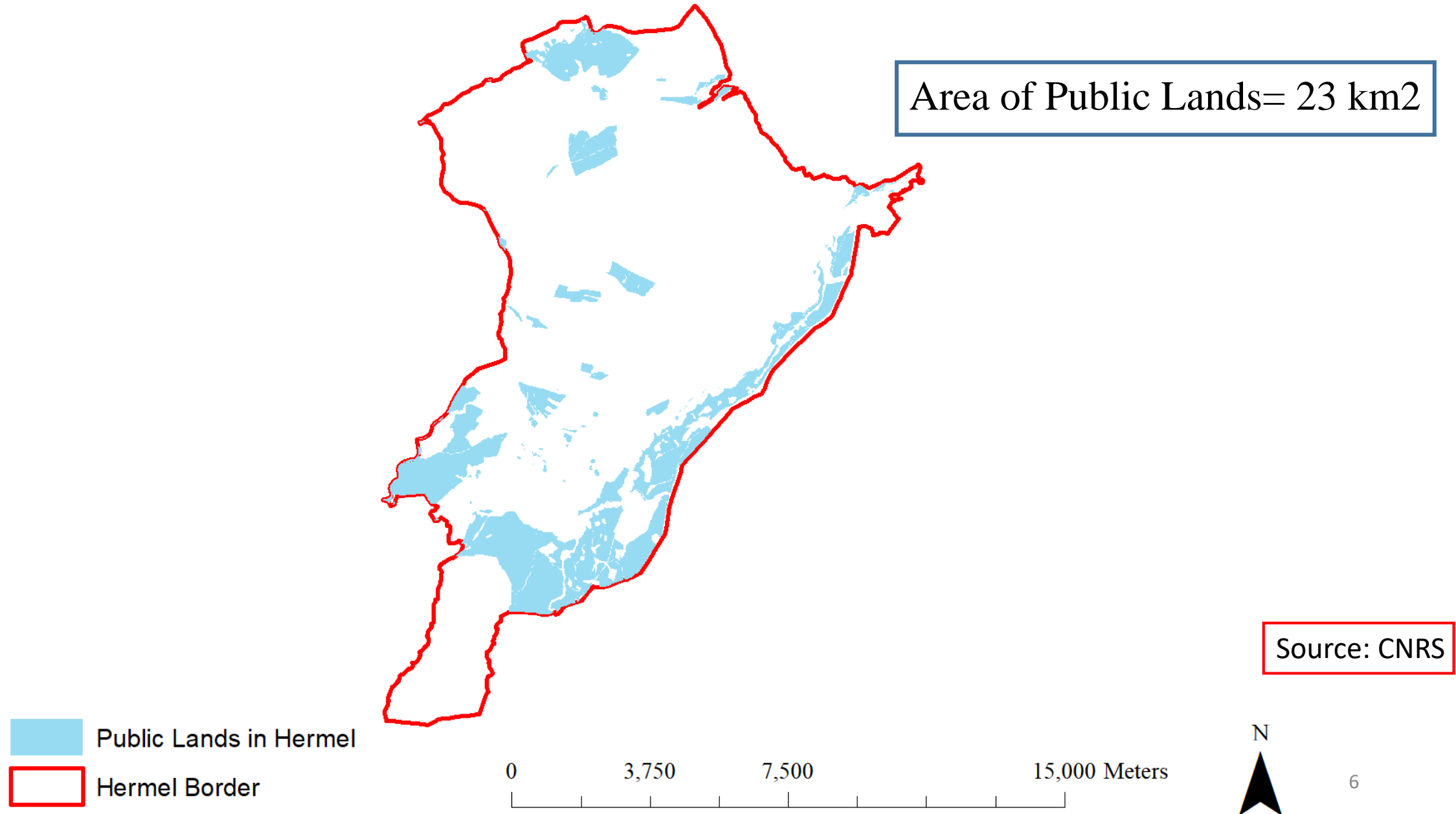36° 24' 57.16" E
34° 26' 1.104" N

Hermel Border

Lebanon Border

N

0   22,500   45,000   90,000 Meters

Hermel Boundary

Total area = 131.3 km2

Hermel Border

0   3,750   7,500   15,000 Meters

N

5

Public Lands in Hermel

Area of Public Lands= 23 km2

Source: CNRS

Public Lands in Hermel

Hermel Border

0   3,750   7,500   15,000 Meters

N

6

Elevation in Hermel

Profile

Elevation

Distance

Source: CNRS

Elevation (m)

- 340 - 600
- 600 - 800
- 800 - 1100
- 1100 - 1300

0   3,750   7,500   15,000 Meters

N

7
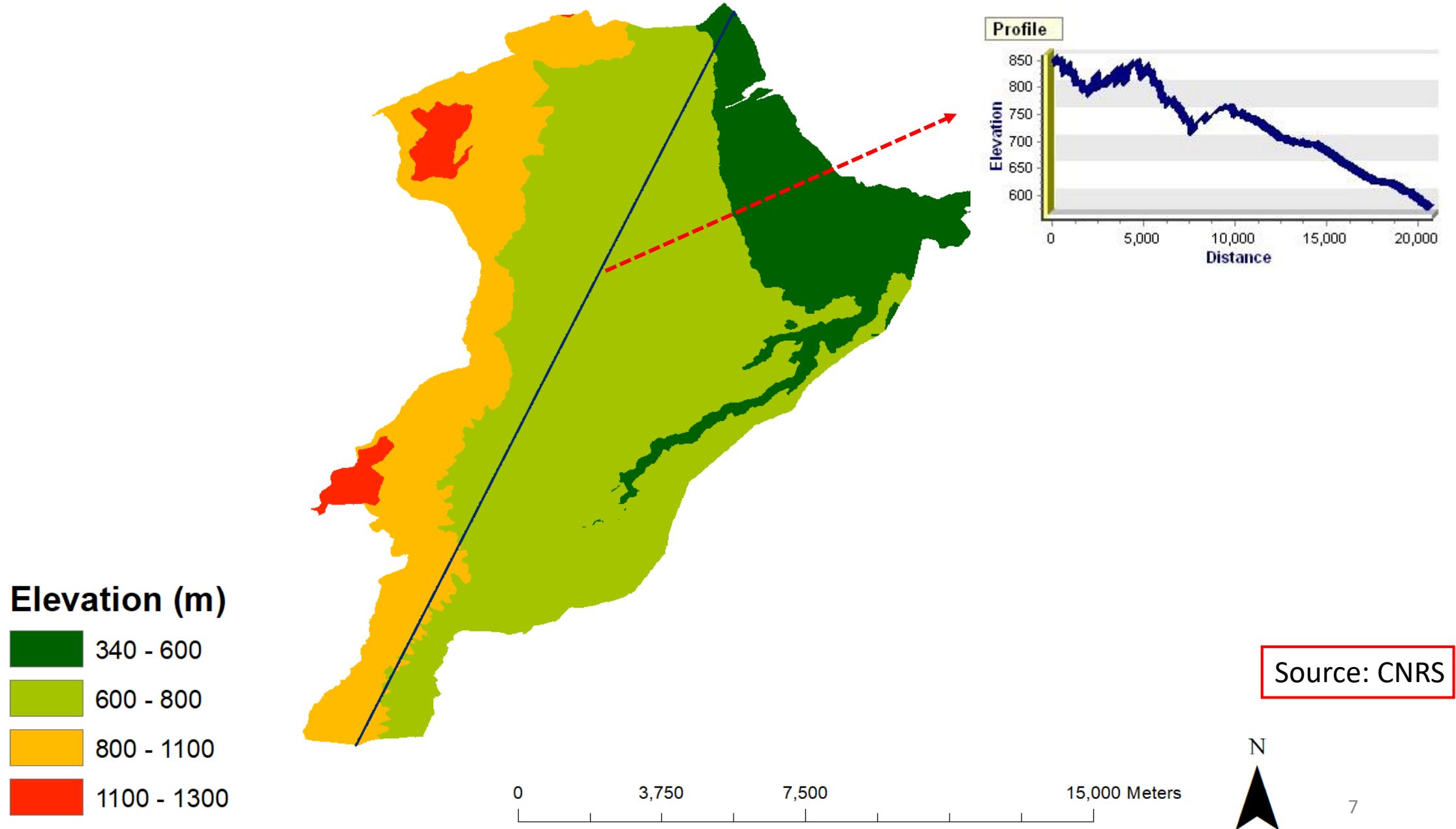
Slope in Hermel

Slope (degree)

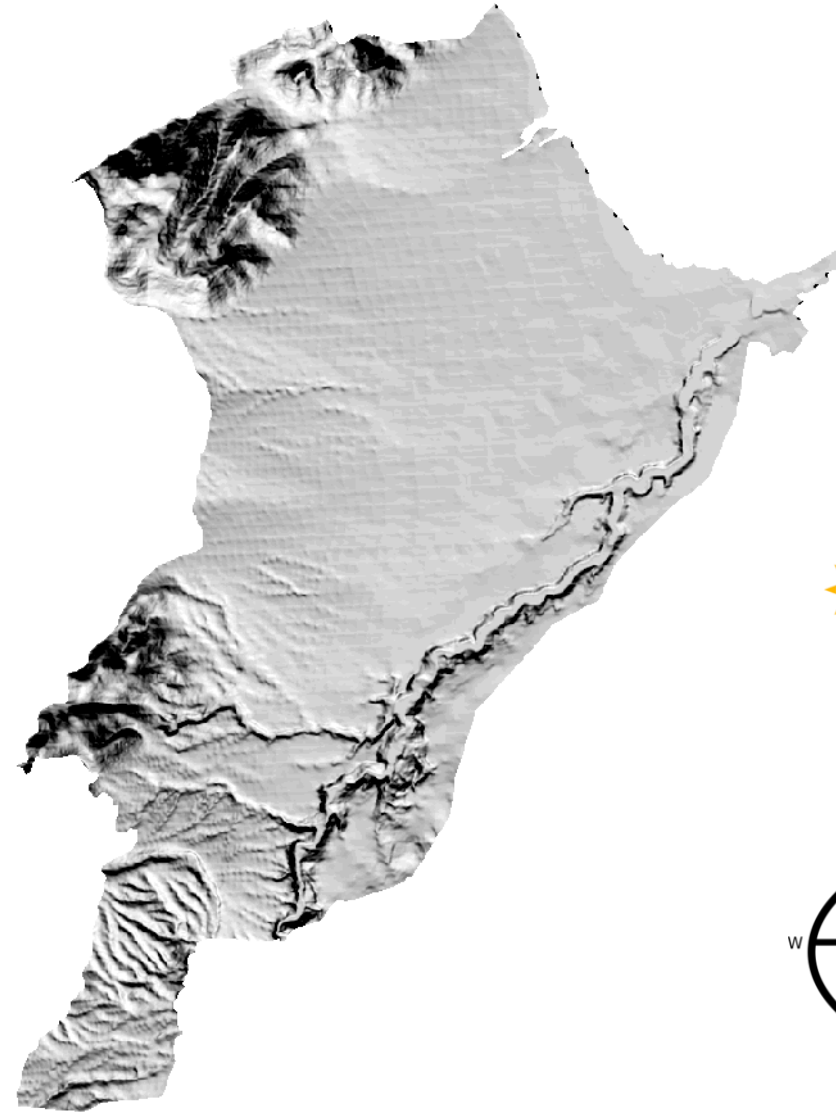|	
■	0 - 5.7
■	5.7 - 11.3
■	11.3 - 16.6
■	16.6 - 21.8
■	21.8 - 26.5
■	26.5 - 86

0   3,750   7,500   15,000 Meters
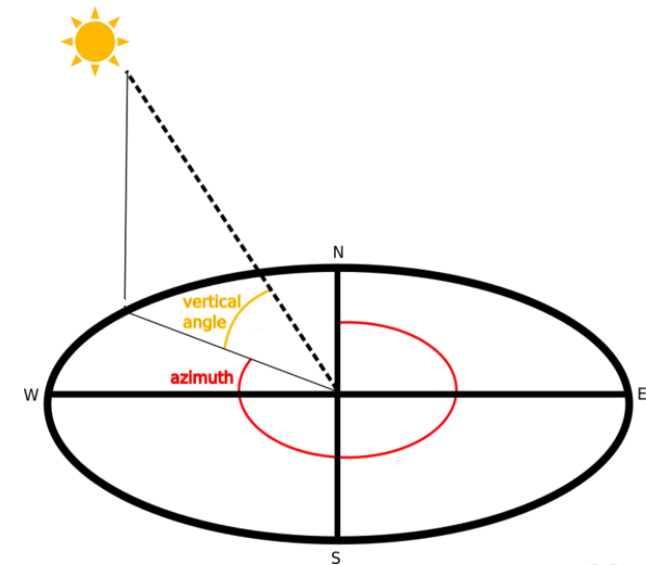
N

8
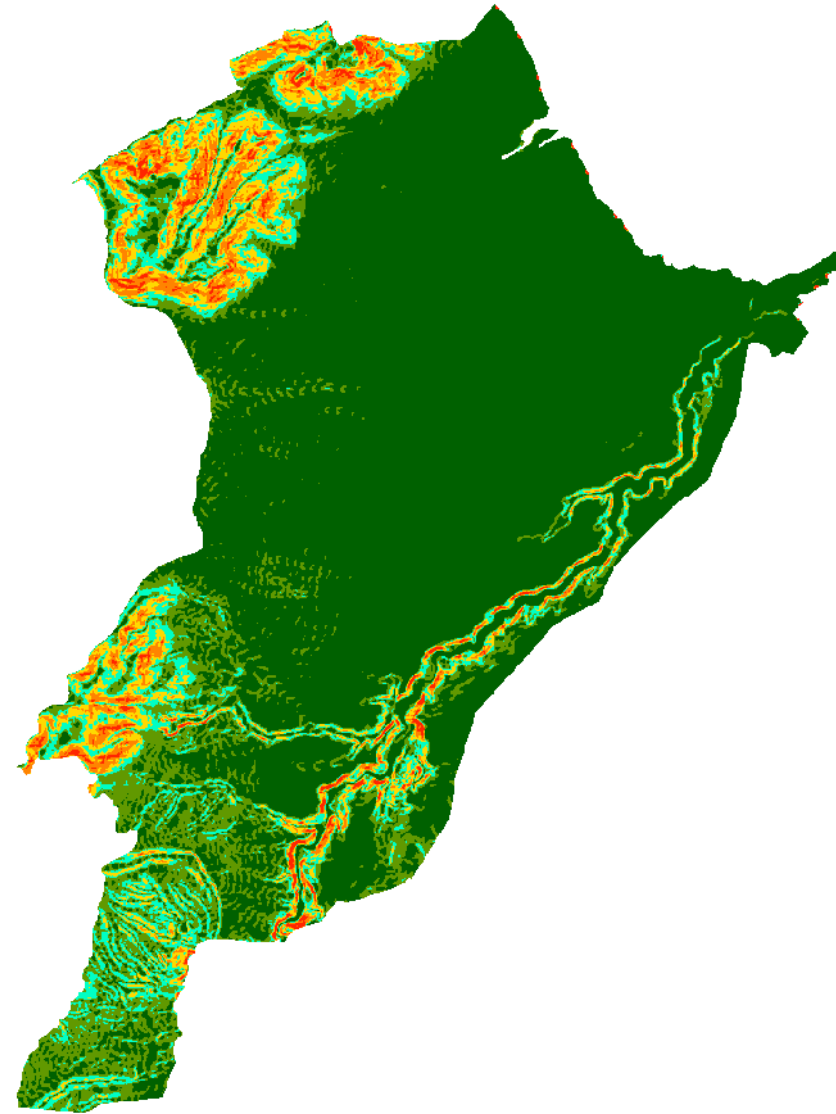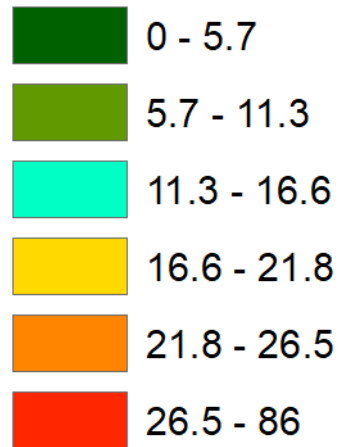
HillShade in Hermel

HillShade was calculated when the sun was at it's peak position.

Altitude = 78 degree.
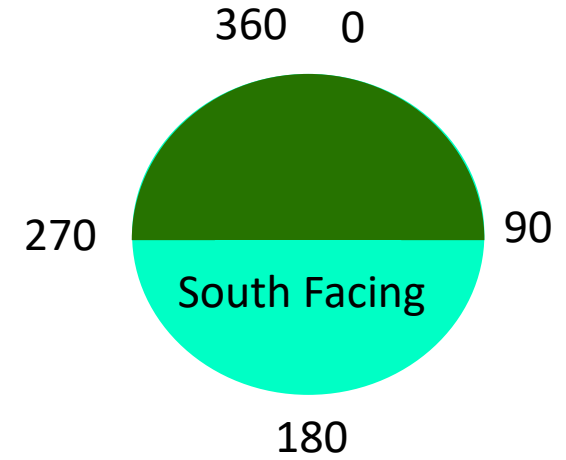**Azimuth** = 200 degree

HillShade

- High Shade
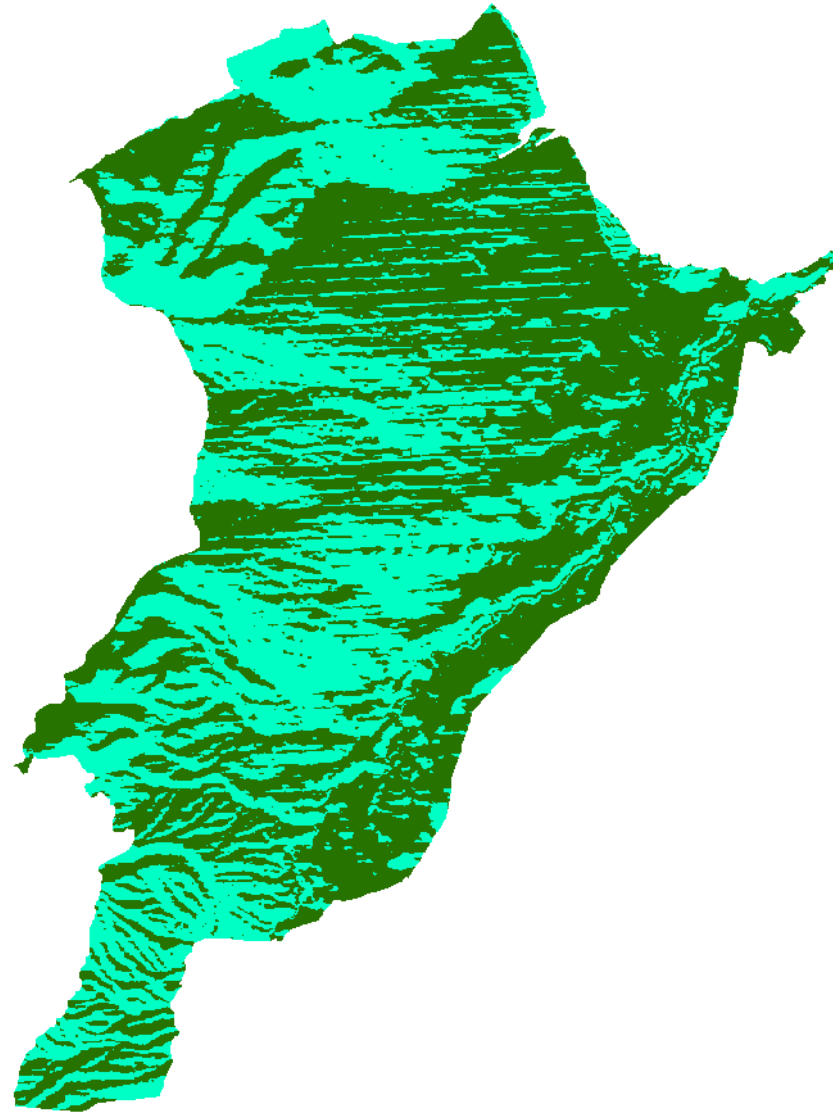- Moderat Shade
- Low Shade
- No Shade

0   3,750   7,500   15,000 Meters

N
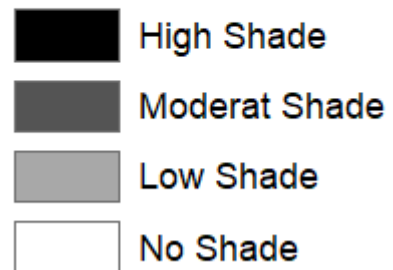
Slope Direction in Hermel

360   0

270   90

South Facing

180

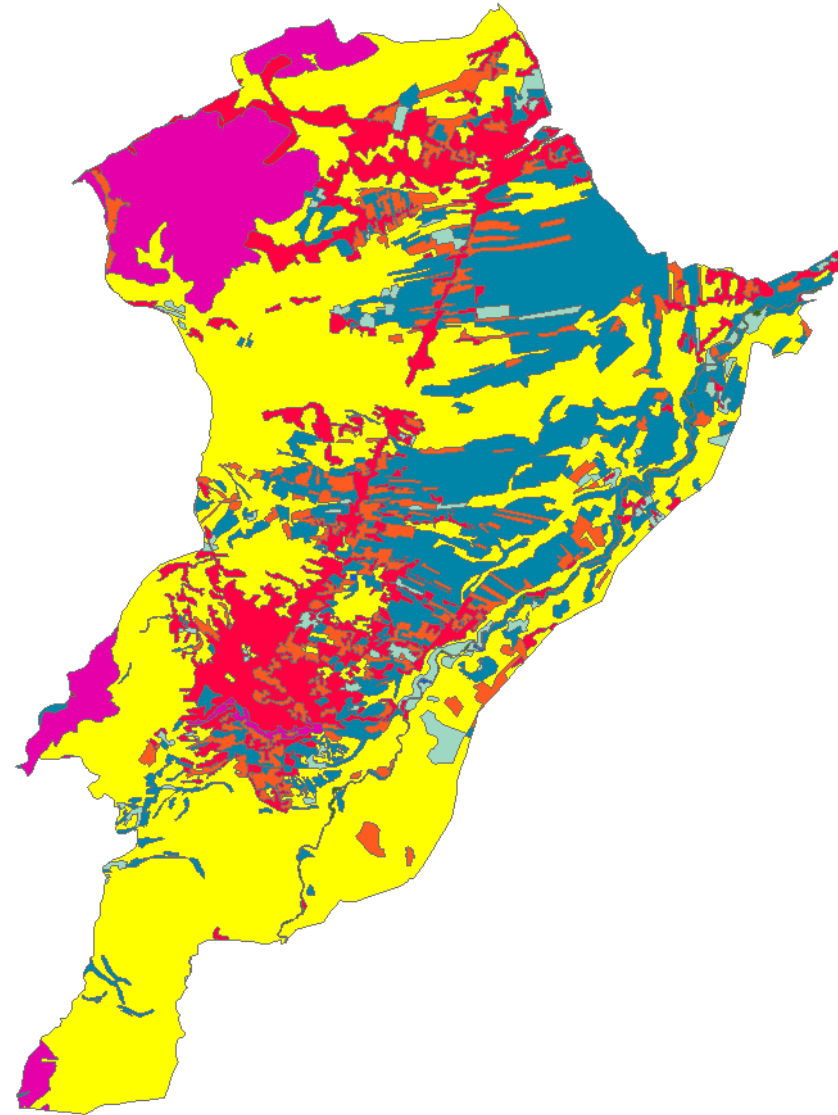**Slope Direction**

North Facing

South Facing

0   3,750   7,500   15,000 Meters

N

10

Land Use in Hermel

- Scale: 1/20,000
- Done at year 2017
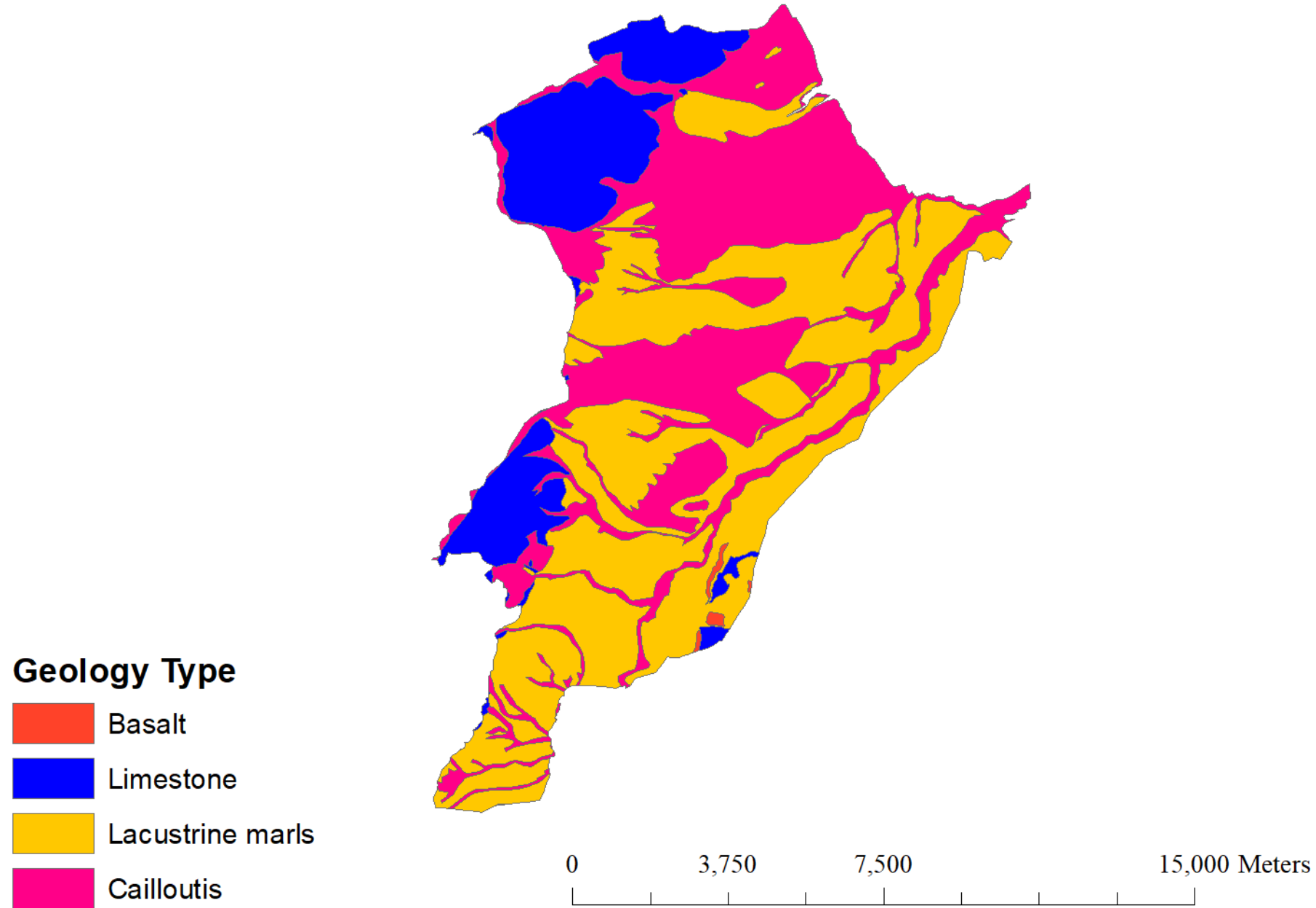- Minimal Mapable Unit = 10,000 m2

Land Use Type

- Clear Oaks
- Urban Settlement
- Field Crops
- Fruit Trees
- Lake
- Olives
- River
- Natural Lands

Source: CNRS

0   3,750   7,500   15,000 Meters

N

11

Geological Study for Hermel

Geology Type

- Basalt
- Limestone
- Lacustrine marls
- Cailloutis

0   3,750   7,500   15,000 Meters

N

12

Soil Map for Hermel

Soil Type

- Andosols
- Anthrosols
- Calcisols
- Fluvisols
- Leptosols
- Luvisols
- Regosols

0   3,750   7,500   15,000 Meters

N

13
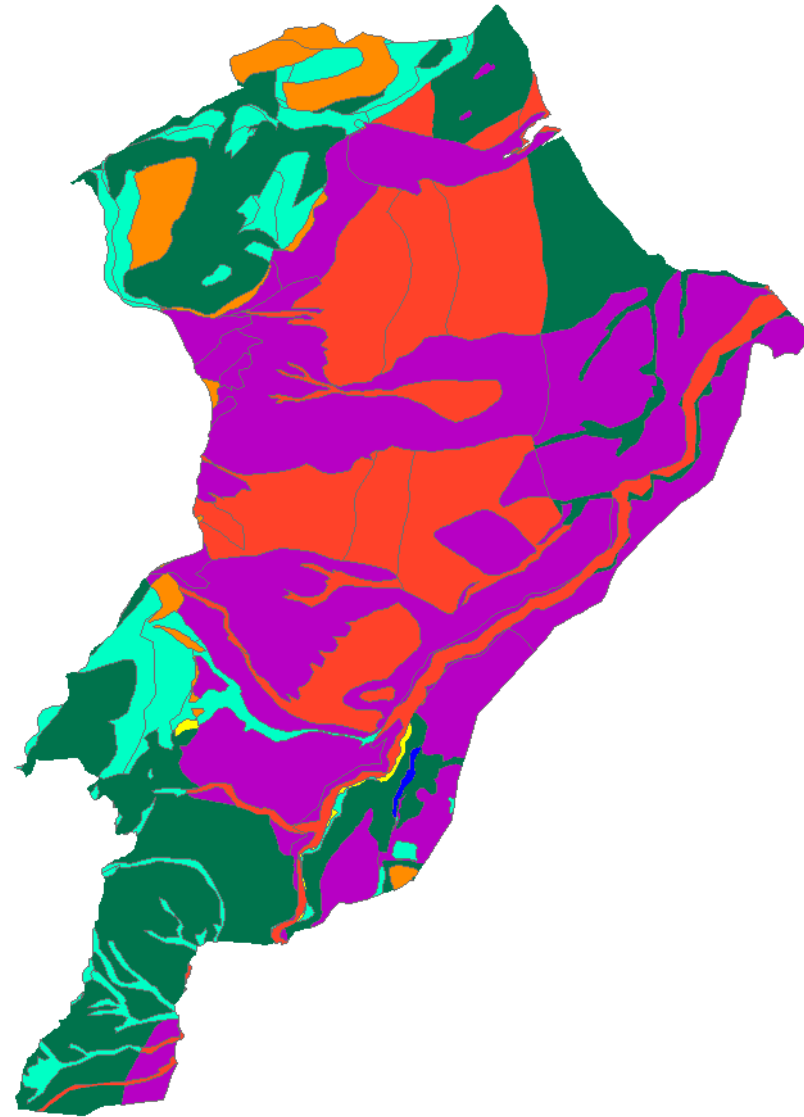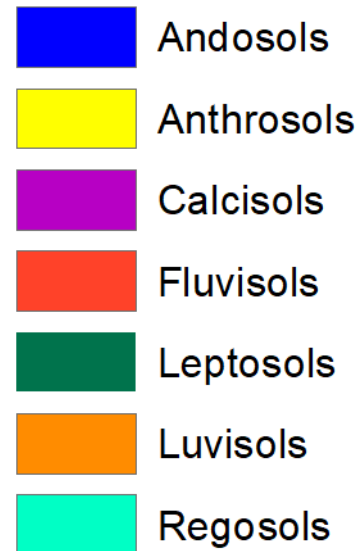
Hazardeous in Hermel

Hazard Range

- No Hazard
- Very Low
- Low
- Moderate
- High
- Very High

Source: CNRS

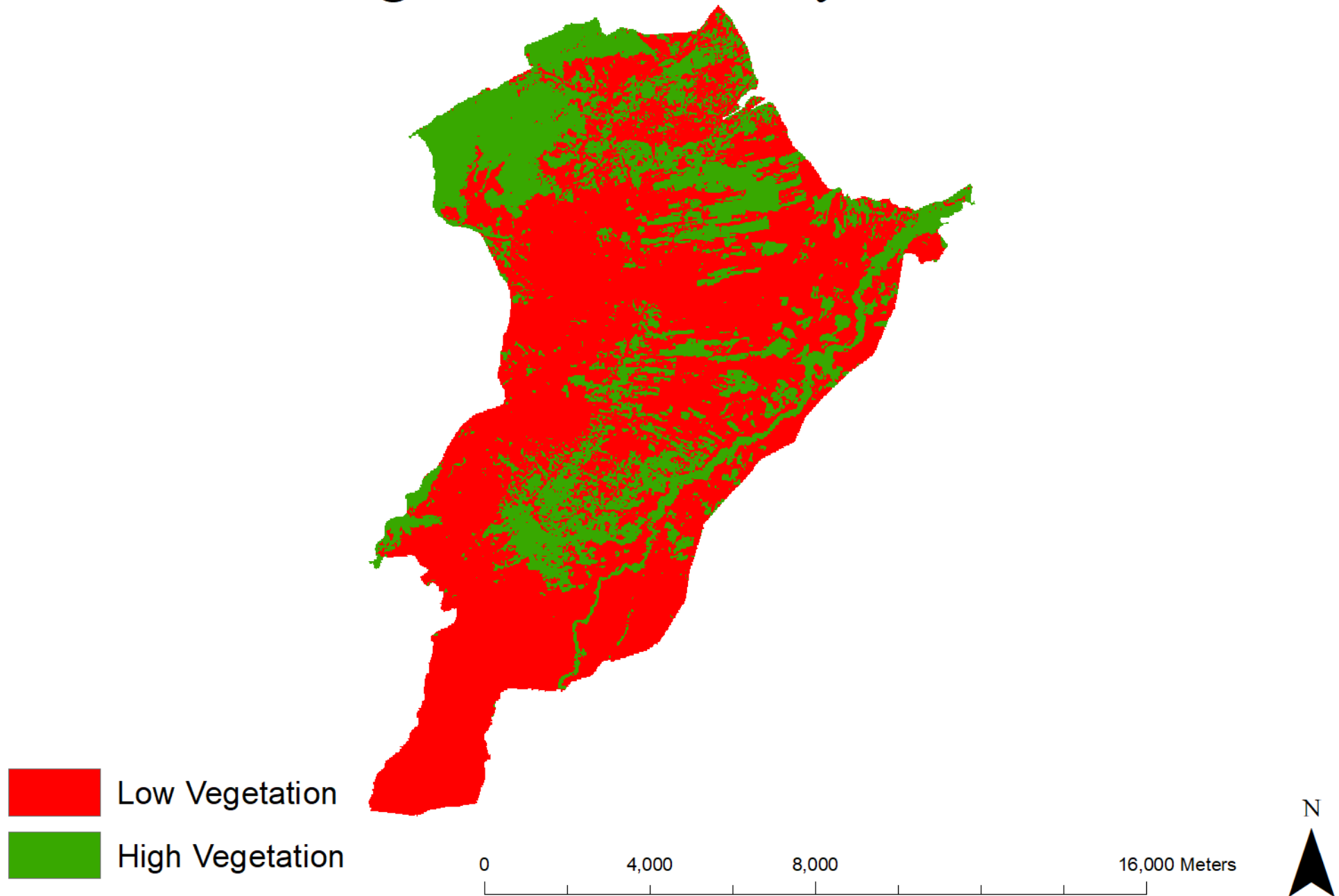0   3,750   7,500   15,000 Meters

N

14
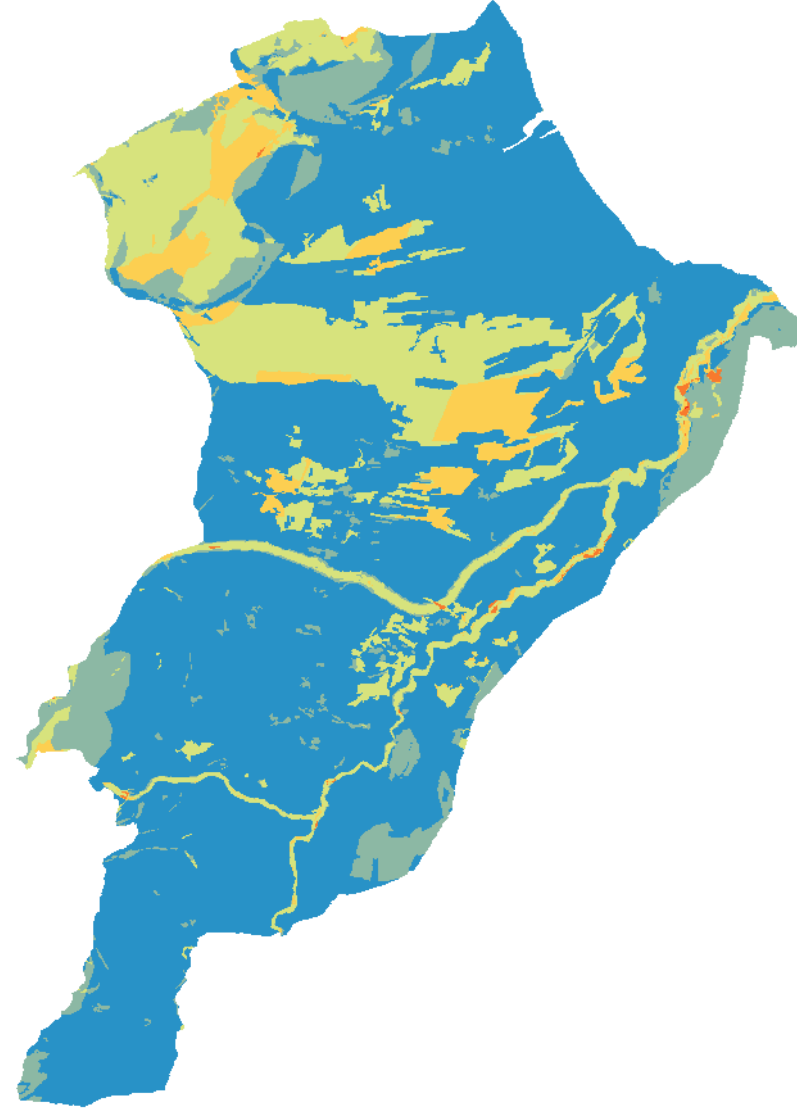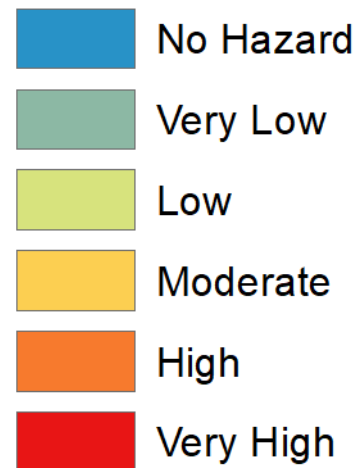
Vegetation Density Study

A study (Vegetation Density) is done for the forest to decide if we can replace the trees in the forest with solar farms and replant those trees in the perimeter of the selected area.
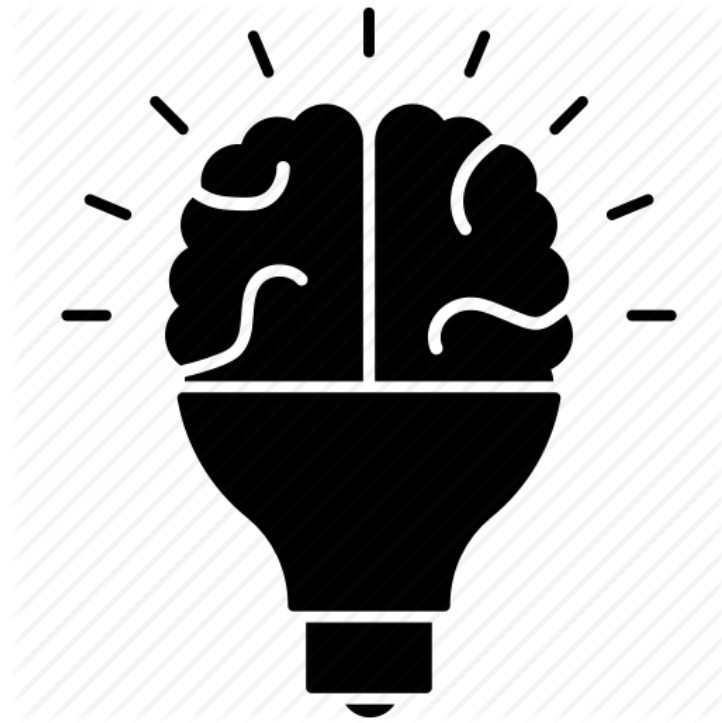
Vegetation Density Process:

1   NDVI for Harbata is Calculated from a Satellite image (Sentinel-2) .

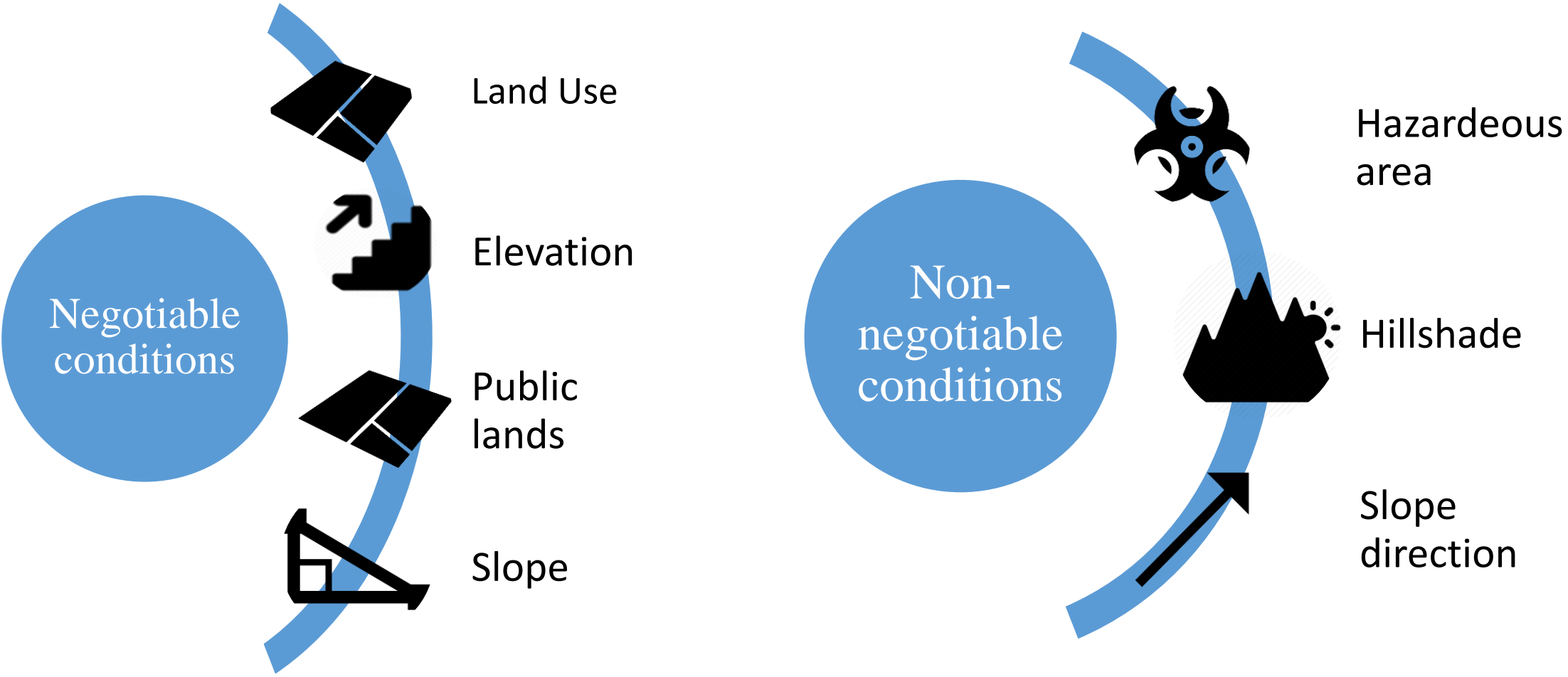2   Classification for NDVI result.

Vegetation Density in Hermel

Low Vegetation

High Vegetation

| 0 | 4,000 | 8,000 | 16,000 Meters |

N

17

Results

The decision of selecting Solar Farms depends on two kinds of conditions :

Negotiable conditions

- Land Use
- Elevation
- Public lands
- Slope

Non-negotiable conditions

- Hazardeous area
- Hillshade
- Slope direction

Negotiable Conditions
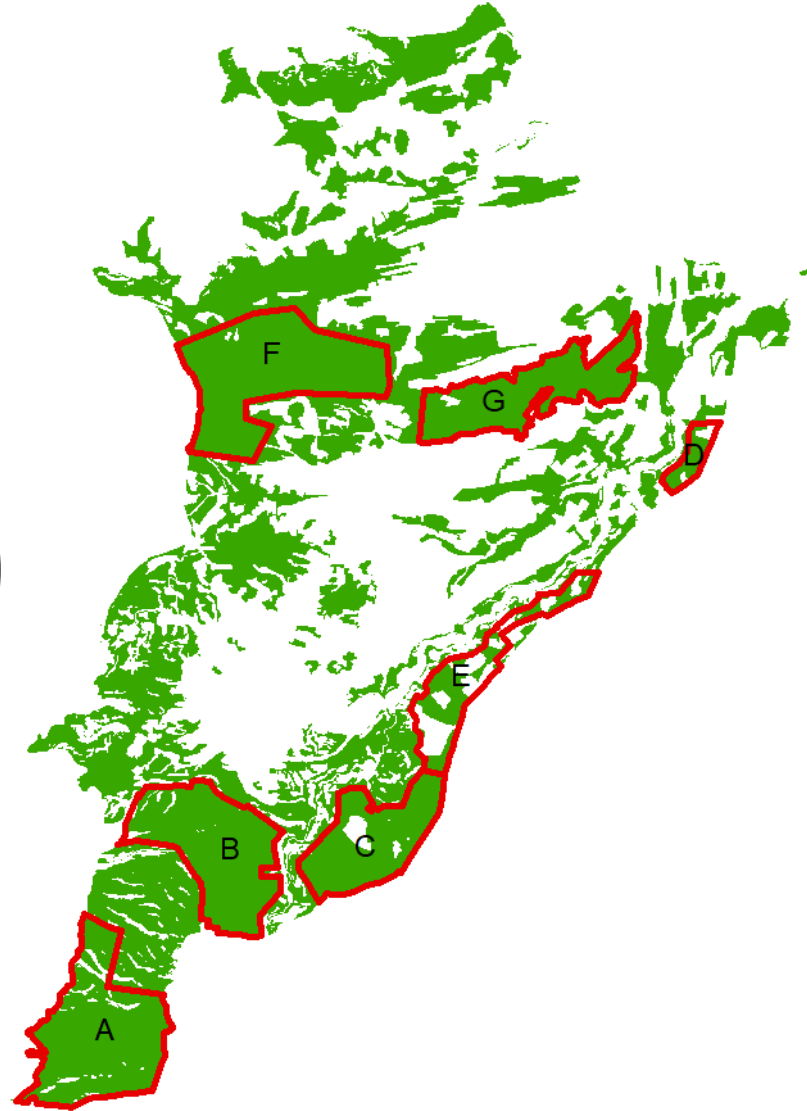
Intersection Area

Site Identification

Solar Sites

0   3,750   7,500   15,000 Meters

N

22

Area for each Site

Unit in Square-kilometer

Solar Sites

0   3,750   7,500   15,000 Meters

N
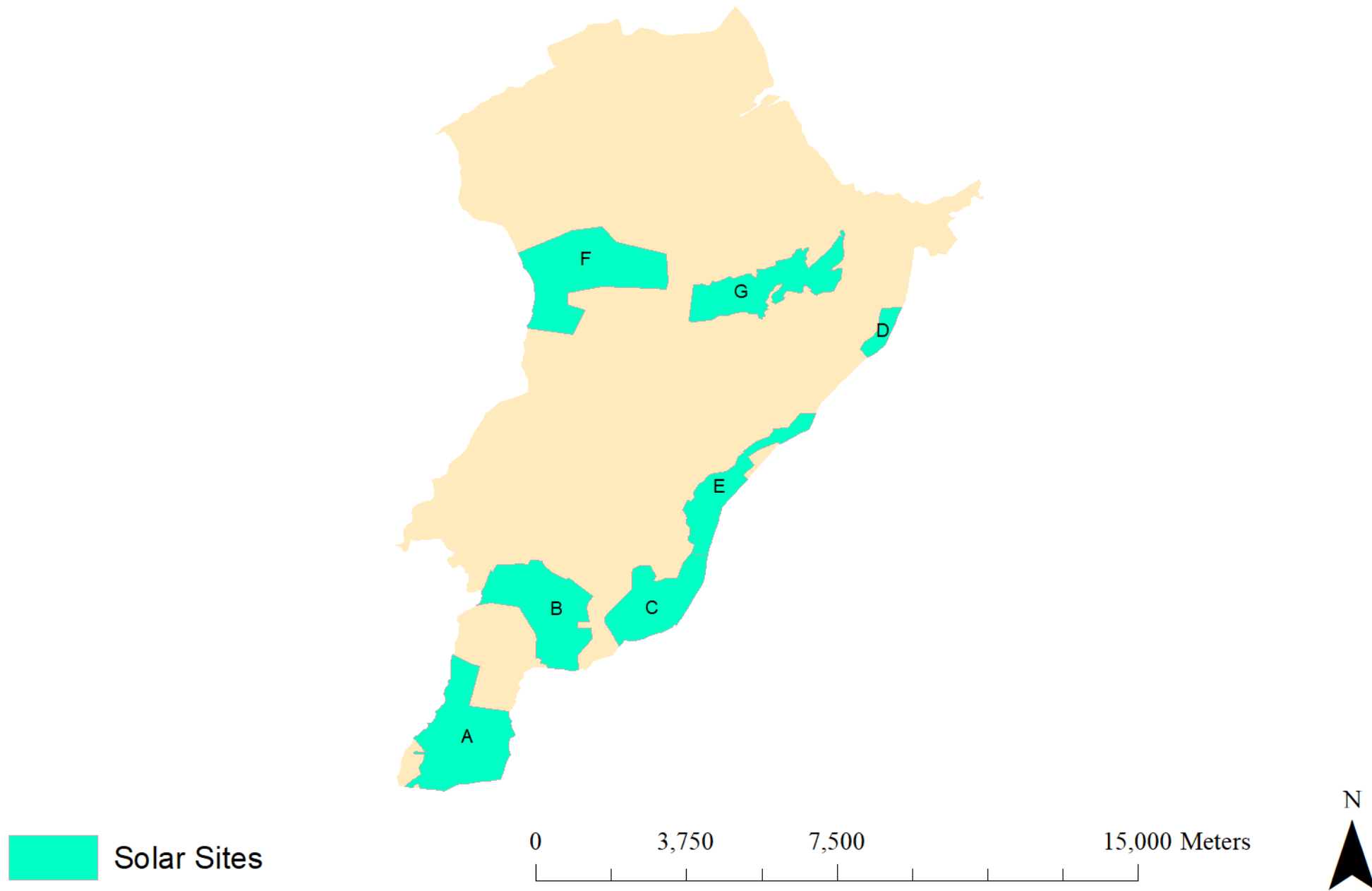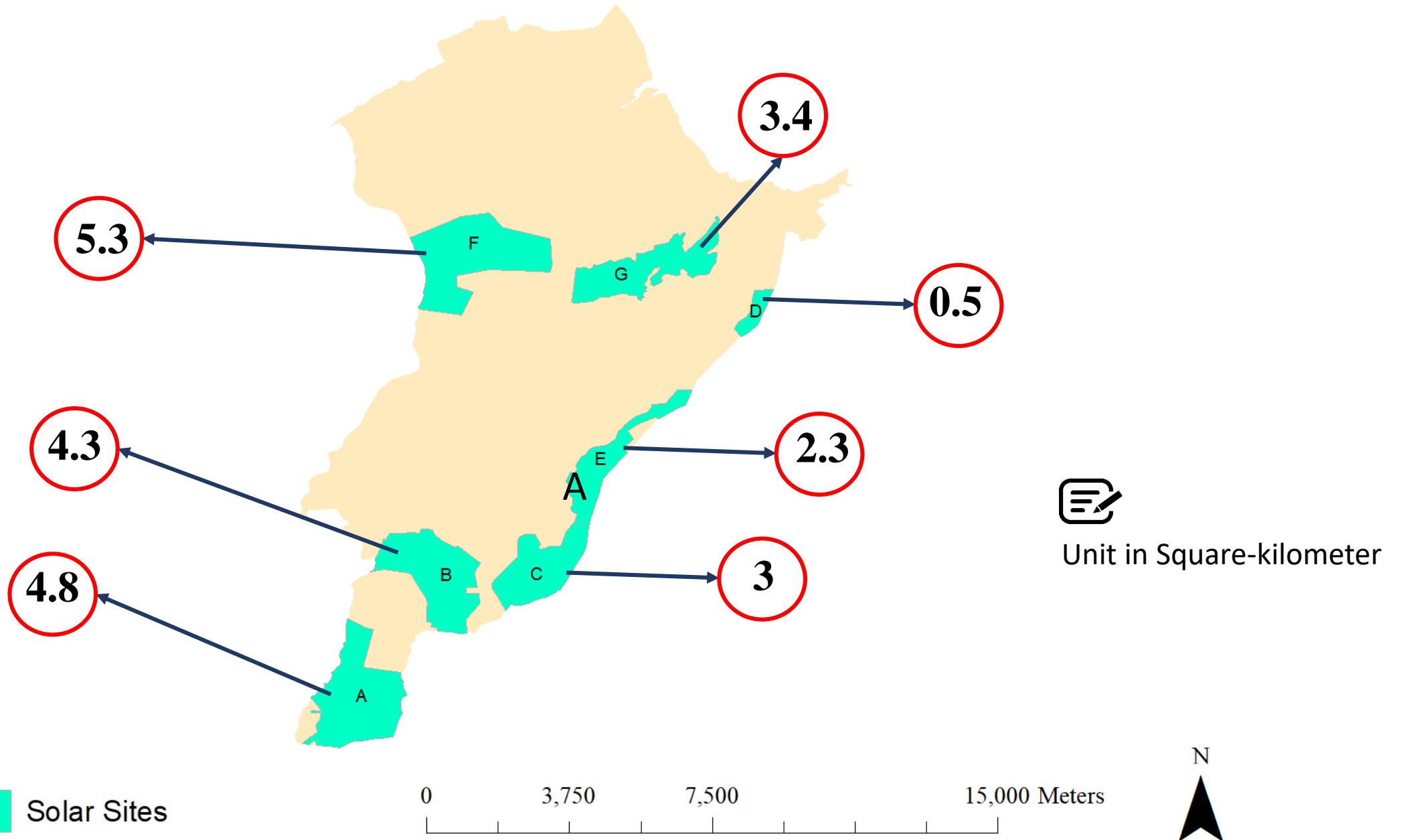
Elevation Analysis for each Site

Average = **605 (+ or -) 21 m**
Max = **648 m**
Min = **567 m**

Average = **769 (+ or -) 49 m**
Max = **862 m**
Min = **670 m**

Average = **600 (+ or -) 0.4 m**
Max = **602 m**
Min = **599 m**

Average = **764 (+ or -) 55 m**
Max = **916 m**
Min = **663 m**

Average = **665 (+ or -) 25 m**
Max = **726 m**
Min = **601 m**

Average = **816 (+ or -) 53 m**
Max = **928 m**
Min = **697 m**

Average = **722 (+ or -) 22 m**
Max = **779 m**
Min = **659 m**

Solar Site

Elevation (m)

340 - 600

600 - 800

800 - 1100

1100 - 1300

0   3,750   7,500   15,000 Meters

N

24

Slope Analysis for each Site

Average = **3.7 (+ or -) 1.5 degree**
Max = **16 degree**
Min = **0.04 degree**

Average = **6.7 (+ or -) 3.4 degree**
Max = **26.5 degree**
Min = **0.18 degree**

Average = **8.4 (+ or -) 3.7 degree**
Max = **22.6 degree**
Min = **0.1 degree**

Average = **1.3 (+ or -) 0.6 degree**
Max = **3.7 degree**
Min = **0 degree**

Average = **0.4 (+ or -) 0.5 degree**
Max = **8.7 degree**
Min = **0 degree**

Average = **4 (+ or -) 3 degree**
Max = **21 degree**
Min = **0 degree**

Average = **4.8 (+ or -) 3.5 degree**
Max = **23 degree**
Min = **0.01 degree**

Solar Site

Slope (degree)

- 0 - 5.7
- 5.7 - 11.3
- 11.3 - 16.6
- 16.6 - 21.8
- 21.8 - 26.5
- 26.5 - 86

0   3,750   7,500   15,000 Meters

N

Public Lands Percentage in each Site

Legend:
- Solar Site
- Private Land
- Public Land

0.13 %
1 %
0 %
71 %
68 %
73 %
95 %

0   3,750   7,500   15,000 Meters

N

26
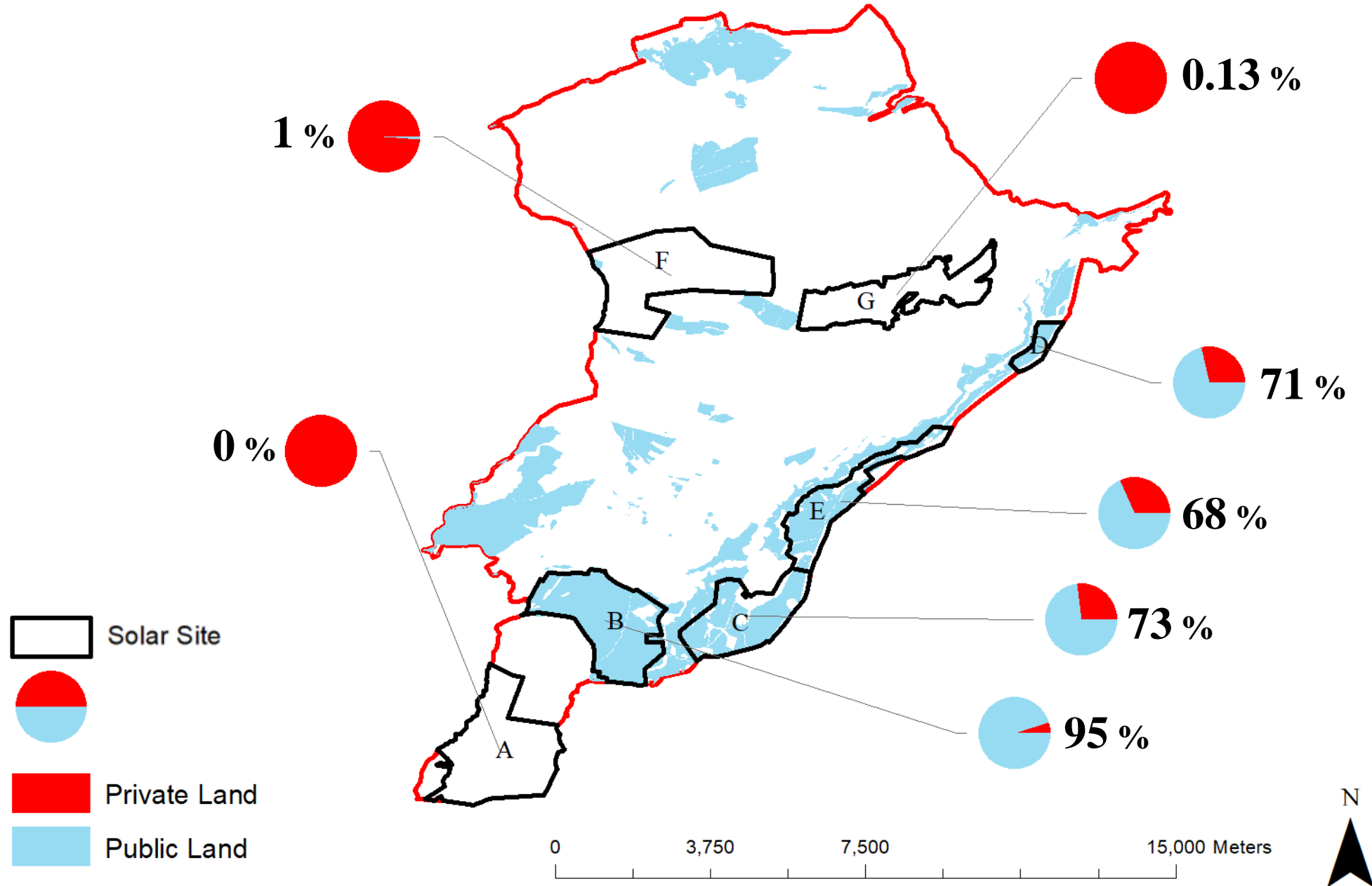
Agriculture Percentage with respect to each Site

Agriculture = 1.2 %

Agriculture = 0.5 %

Agriculture = 18.7 %

Agriculture =3.64 %

Agriculture = 42 %

Agriculture = 6.7 %

Agriculture = 3.1 %

Legend:
- Natural Lands
- Olives
- Field Crop
- Fruit trees and Vineyards

N

0   3,750   7,500   15,000 Meters
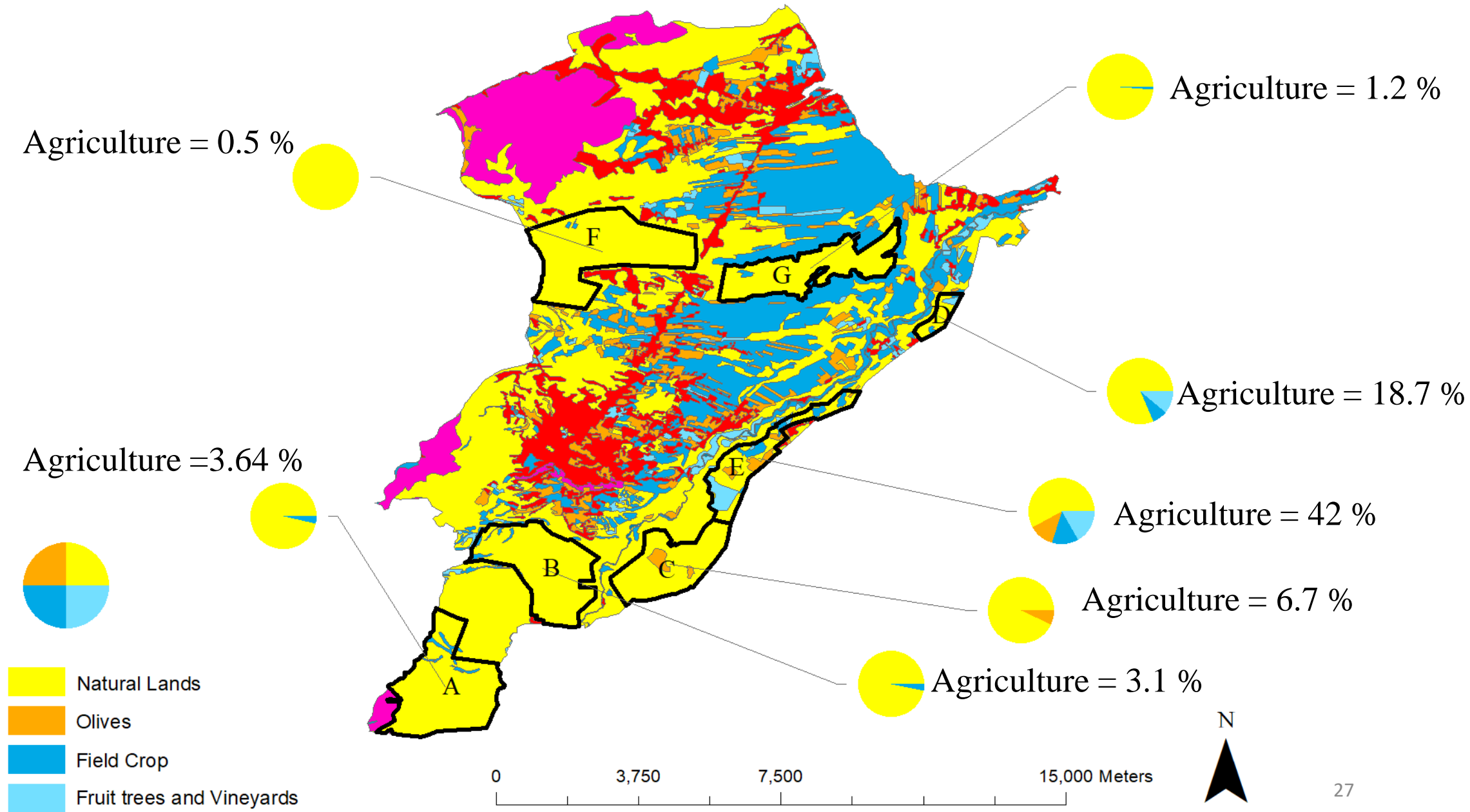
Agriculture Percentage with respect to Hermel

Agriculture = 0.15 %

Agriculture = 0.1 %

Agriculture = 1.9 %

Agriculture = 0.7 %

Agriculture = 16.7 %

Agriculture = 2.4 %

Agriculture = 0.5 %

Natural Lands

Olives

Field Crop

Fruit trees and Vineyards

N

0   3,750   7,500   15,000 Meters
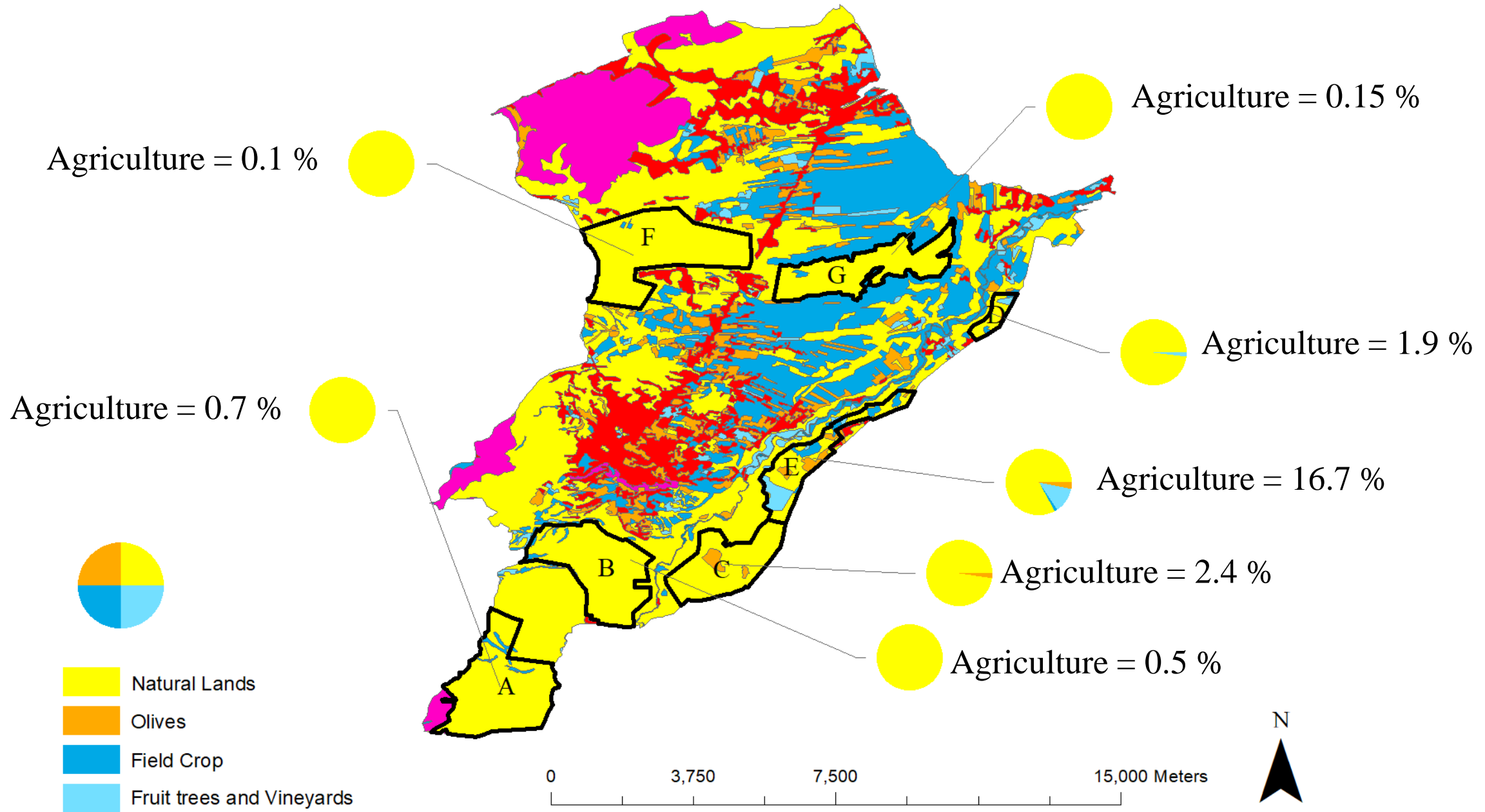
Non-negotiable Conditions

HillShade in each Site

Solar Site

HillShade

High Shade

Moderat Shade

Low Shade

No Shade

0   3,750   7,500   15,000 Meters

N
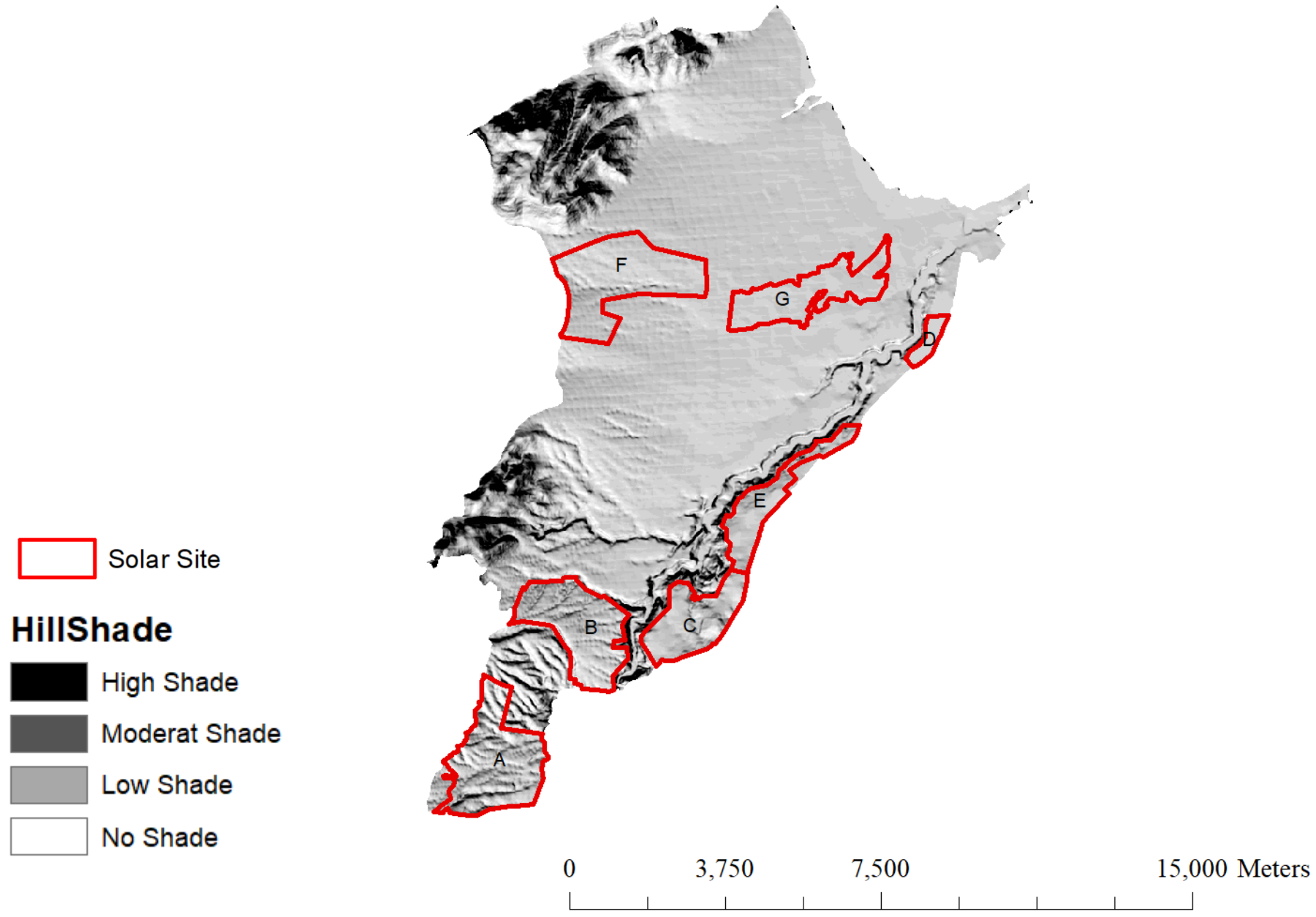
Slope Diraction in each Site
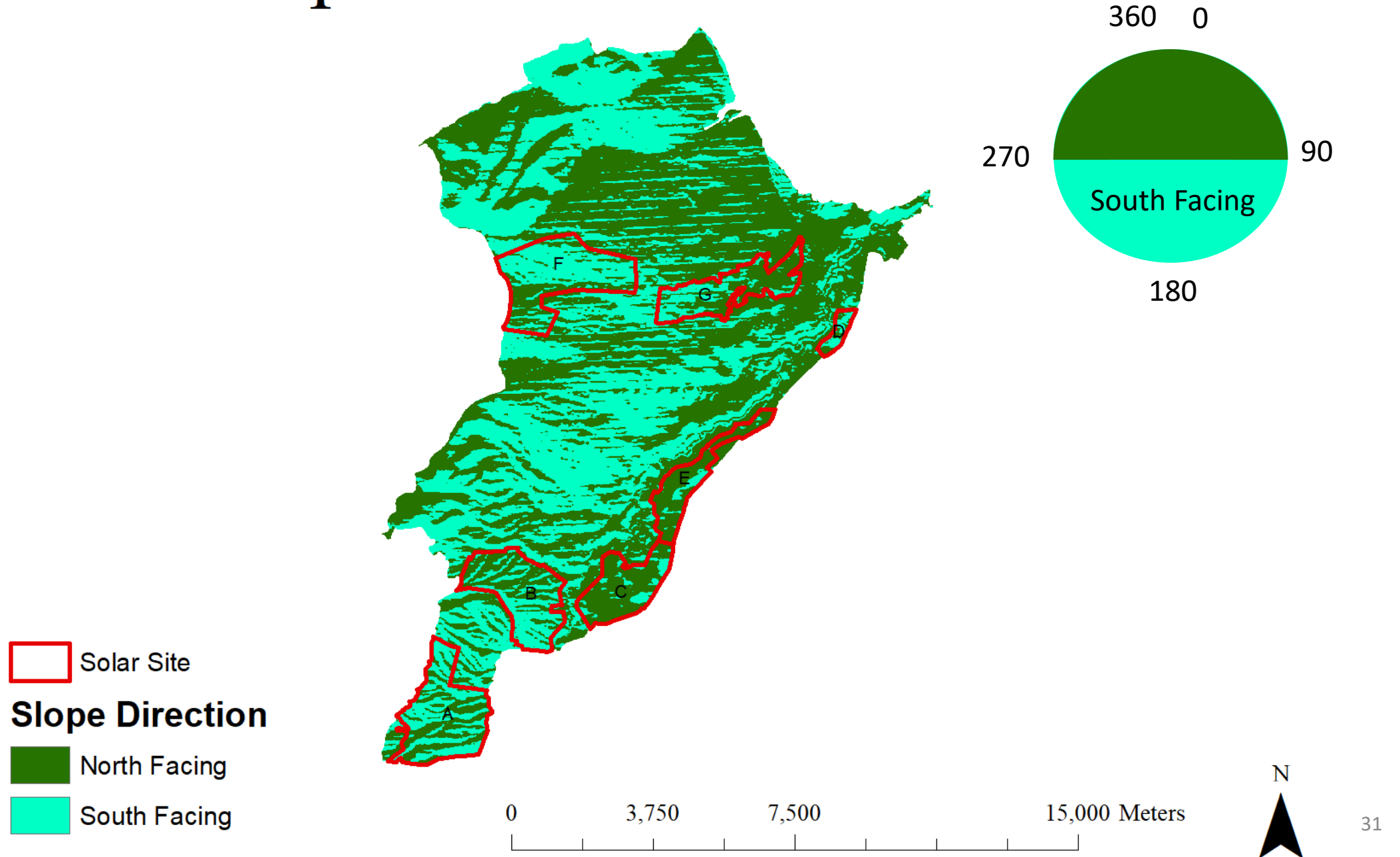
Hazardeous Area in each Site
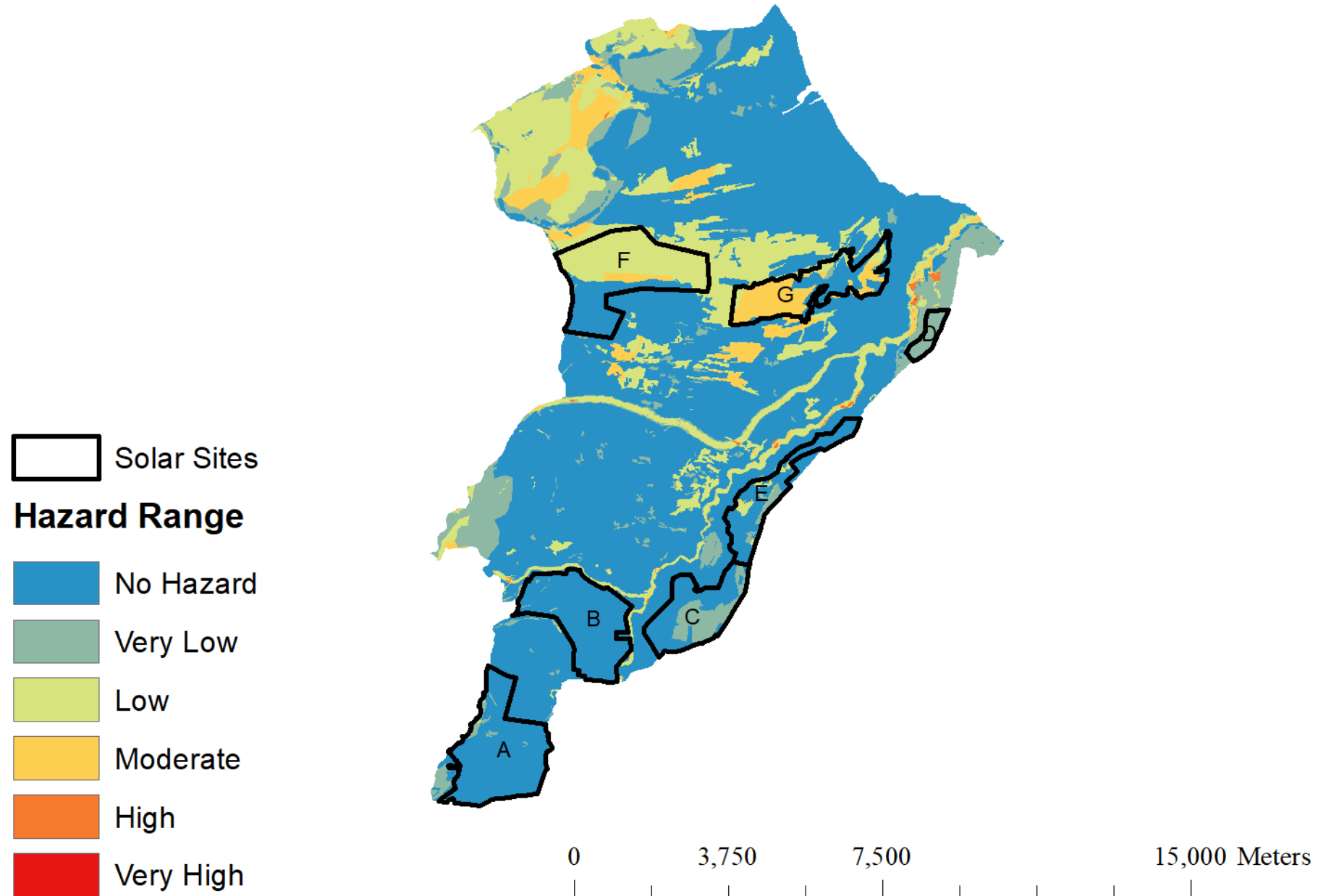
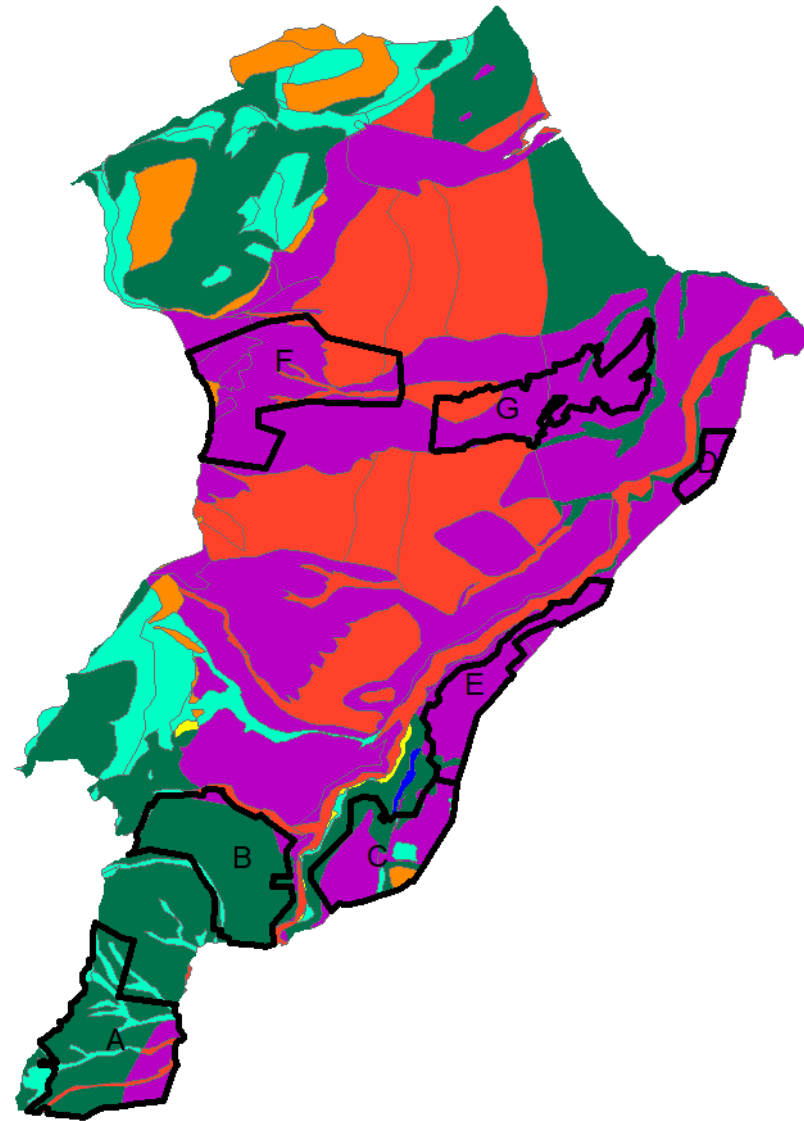# Note

Soil Type in each Site

Solar Sites

Soil Type
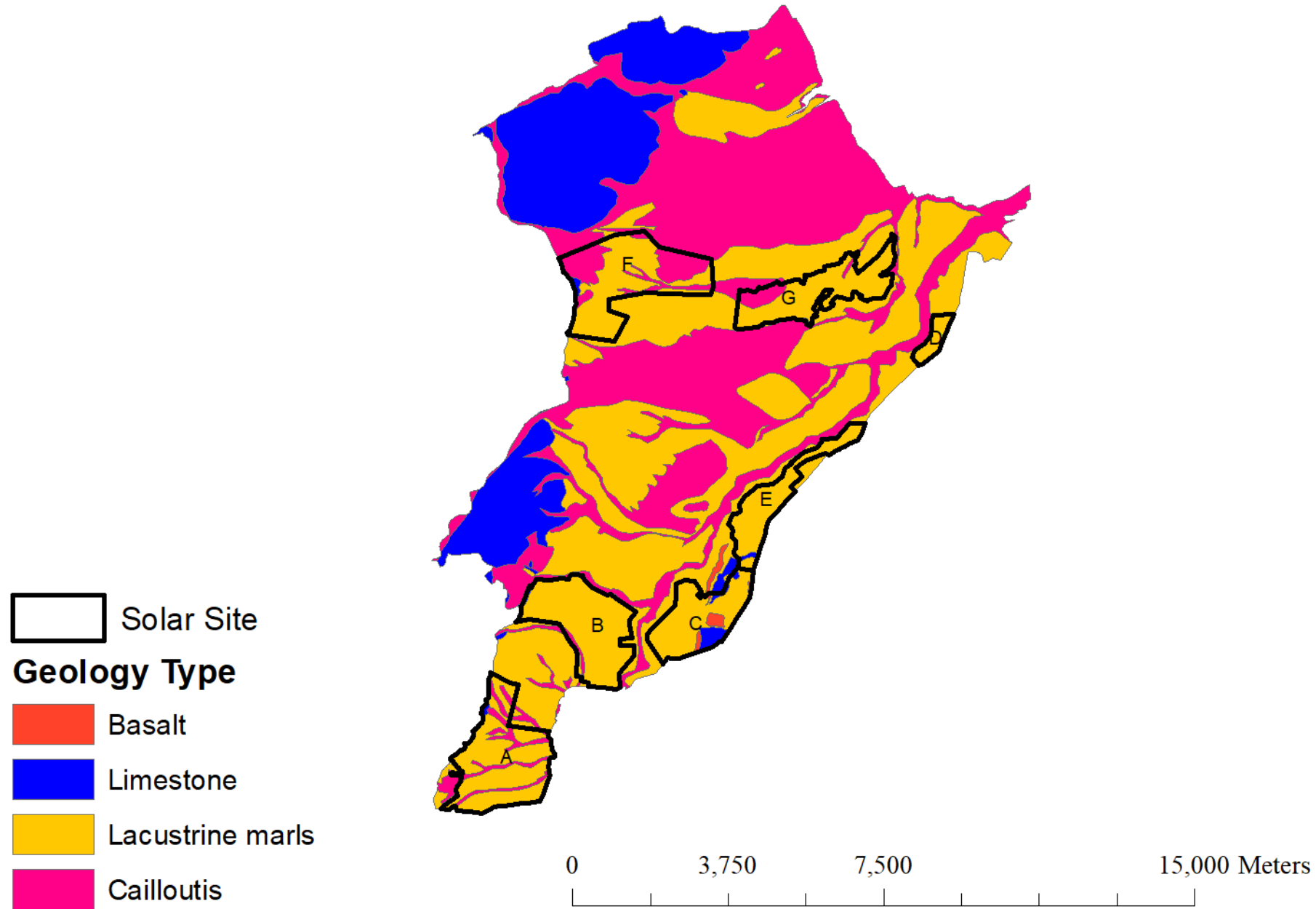
- Andosols
- Anthrosols
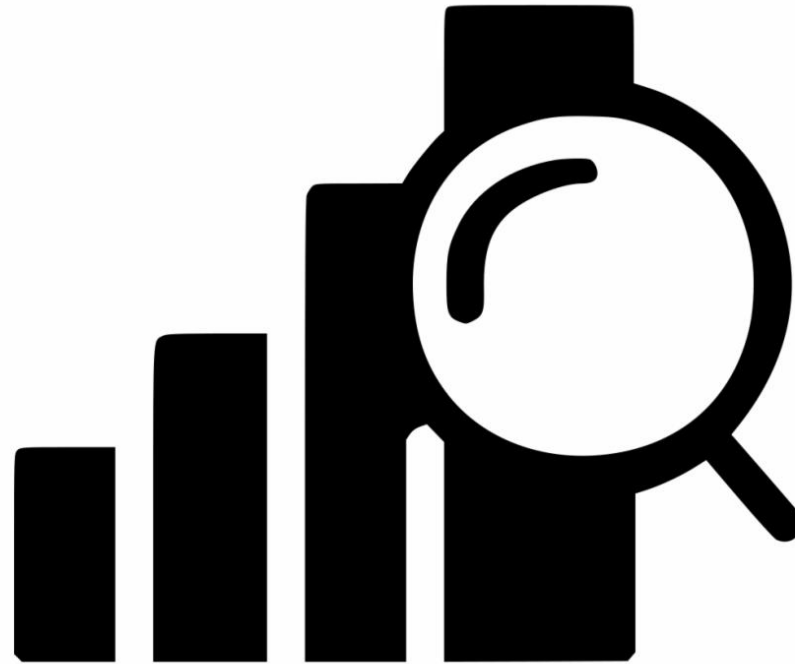- Calcisols
- Fluvisols
- Leptosols
- Luvisols
- Regosols

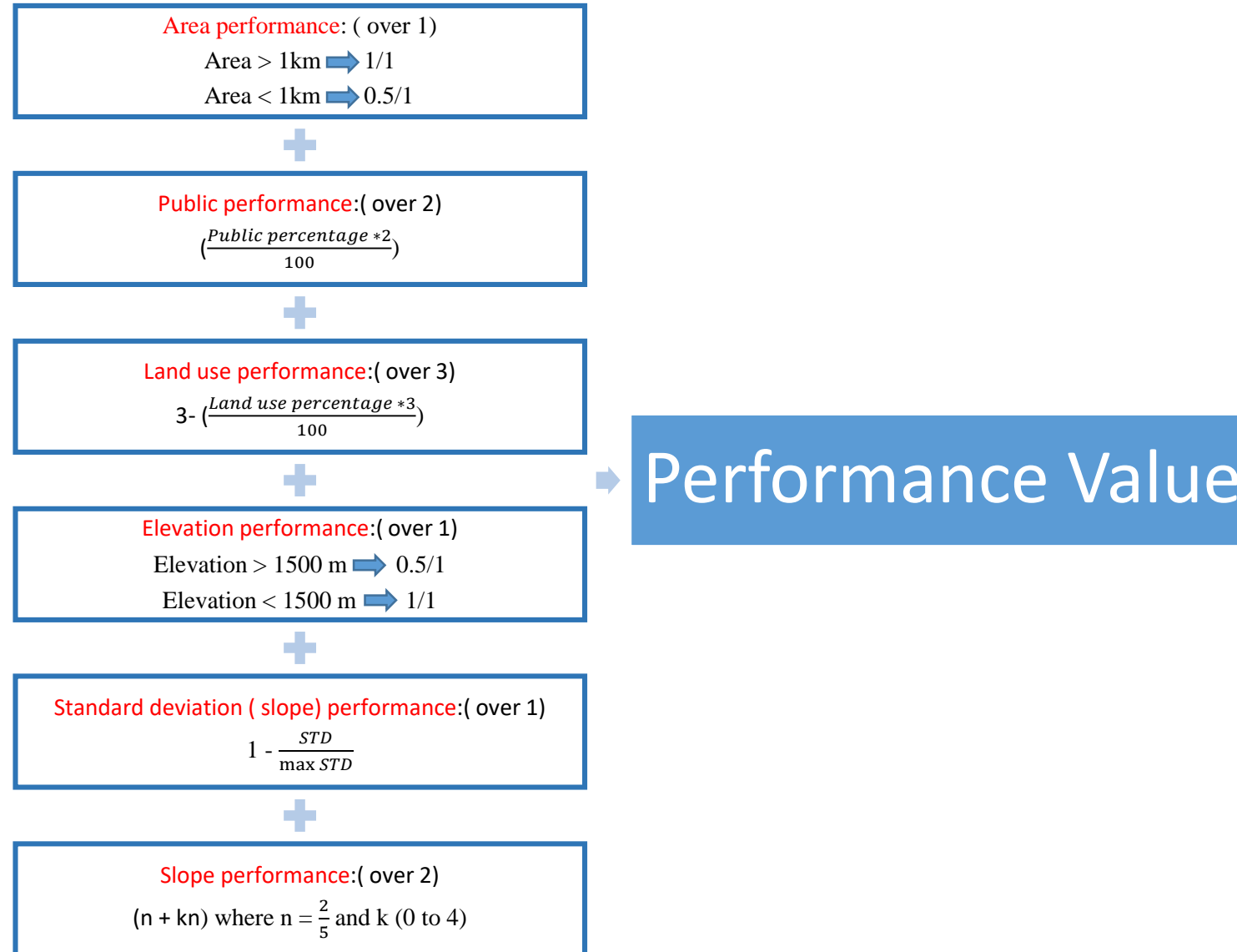0   3,750   7,500   15,000 Meters
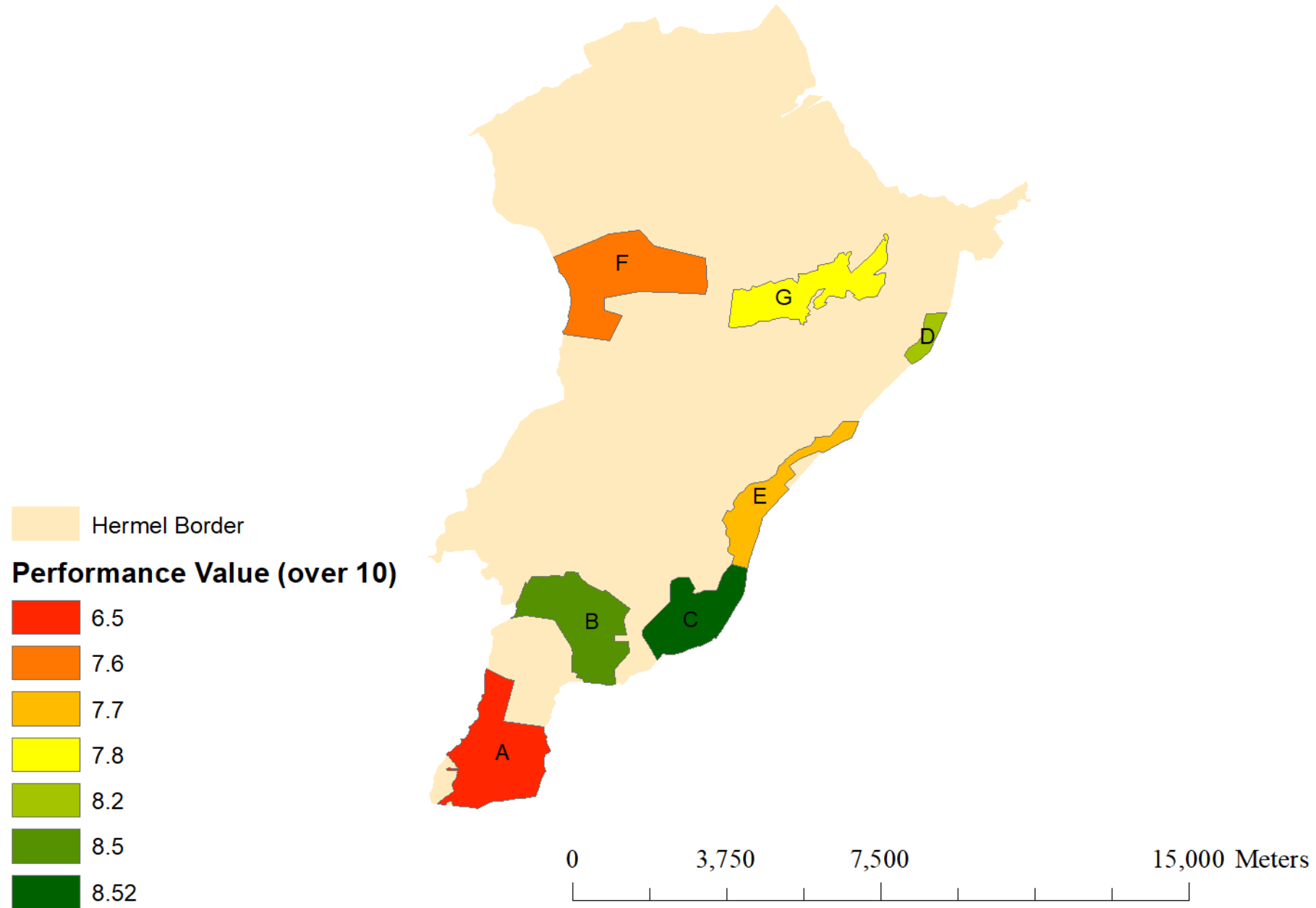
N

34

Geological Type in each Site

Solar Site

Geology Type

- Basalt
- Limestone
- Lacustrine marls
- Cailloutis

0   3,750   7,500   15,000 Meters

N

35

Analysis of Resultant Sites

Unique Process for calculating Performance value:

Area performance: (over 1)

Area > 1km ➡ 1/1

Area < 1km ➡ 0.5/1

➕

Public performance:(over 2)

$(\dfrac{Public\ percentage *2}{100})$

➕

Land use performance:(over 3)

$3-(\dfrac{Land\ use\ percentage *3}{100})$

➡ **Performance Value**

➕

Elevation performance:(over 1)

Elevation > 1500 m ➡ 0.5/1

Elevation < 1500 m ➡ 1/1

➕

Standard deviation (slope) performance:(over 1)

$1 - \dfrac{STD}{max\ STD}$

➕

Slope performance:(over 2)

$(n + kn)$ where $n = \dfrac{2}{5}$ and k (0 to 4)

Performance Evaluation

Hermel Border

Performance Value (over 10)

- 6.5
- 7.6
- 7.7
- 7.8
- 8.2
- 8.5
- 8.52

0   3,750   7,500   15,000 Meters

N

38

Calculation of MW value in Site A in Terabase Tool

Calculation of MW value in Site B in Terabase Tool

terabase.energy

V 3.0

Hello Jaafarserh ▼

Hermel_B

Simulations 1	Drone 0

Add Simulation

Jaafarserh_2019-09-05_01
Result: ✅ 1   ☆ ⬇ 🗑

Inputs	Layout
Racking:	Ground Fix Tilt,...
Module Manufacturer:	SunPower
Module Type:	Mono-Perc
Module SKU:	SPR-P19-405-COM
Module Rating:	405 W
Inverter Manufacturer:	Generic inverter
Inverter Model 1:	
Inverter Model 2:	
Weather File ID:	615870
Ground Albedo:	0.16
Losses:	Standard
Financial/EPC Cost Profile:	Custom
EPC Cost Roadmap Date:	2019-09-30
Project Lifespan:	25
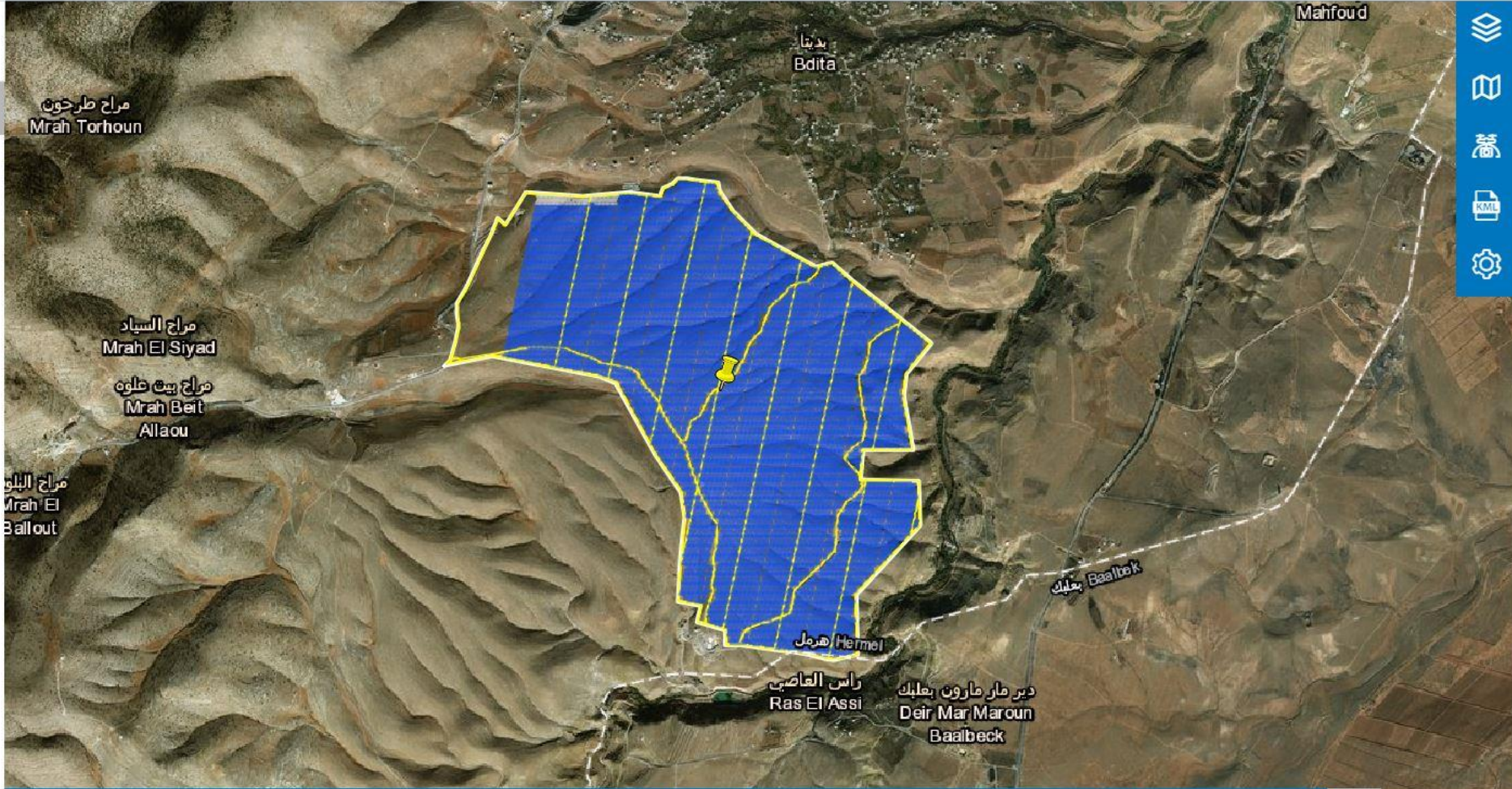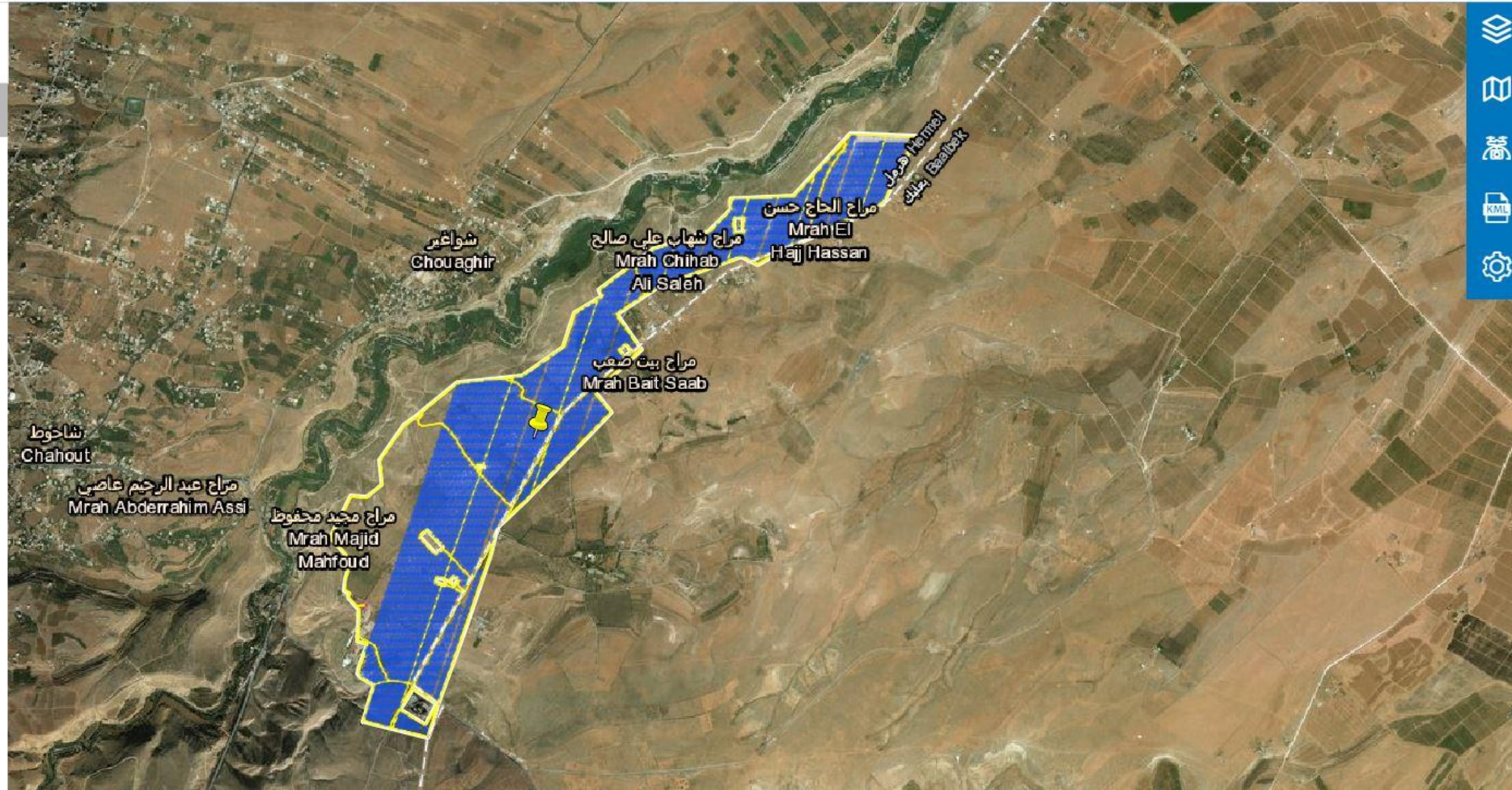
	GCR	DC/AC	DC(MW)	AC(MW)	Yield(kWh/kWp)	Clipping Loss(%)	Epc Cost($/W)	IRR(%)	LCOE($/kWh)	Land USE(%)	POA/GHI	R2 Shad
☆	0.45	1.10	300.31	273.00	1547.15	0.00%	-	-	-	80.6%	-	-

Calculation of MW value in Site C in Terabase Tool

Calculation of MW value in Site D in Terabase Tool

Calculation of MW value in Site E in Terabase Tool

Calculation of MW value in Site F in Terabase Tool

Calculation of MW value in Site G in Terabase Tool

terabase.energy

Hello Jaafarserh

Hermel_G

Simulations 1 | Drone 0

Add Simulation

Jaafarserh_2019-09-05_01
Result: ✅ 1

Inputs	Layout
Racking:	Single Axis Tra...
Module Manufacturer:	SunPower
Module Type:	Mono-Perc
Module SKU:	SPR-P19-405-COM
Module Rating:	405 W
Inverter Manufacturer:	Generic inverter
Inverter Model 1:	
Inverter Model 2:	
Weather File ID:	615870
Ground Albedo:	0.2
Losses:	Standard
Financial/EPC Cost Profile:	Custom
EPC Cost Roadamap Date:	2019-09-30
Project Lifespan:	25
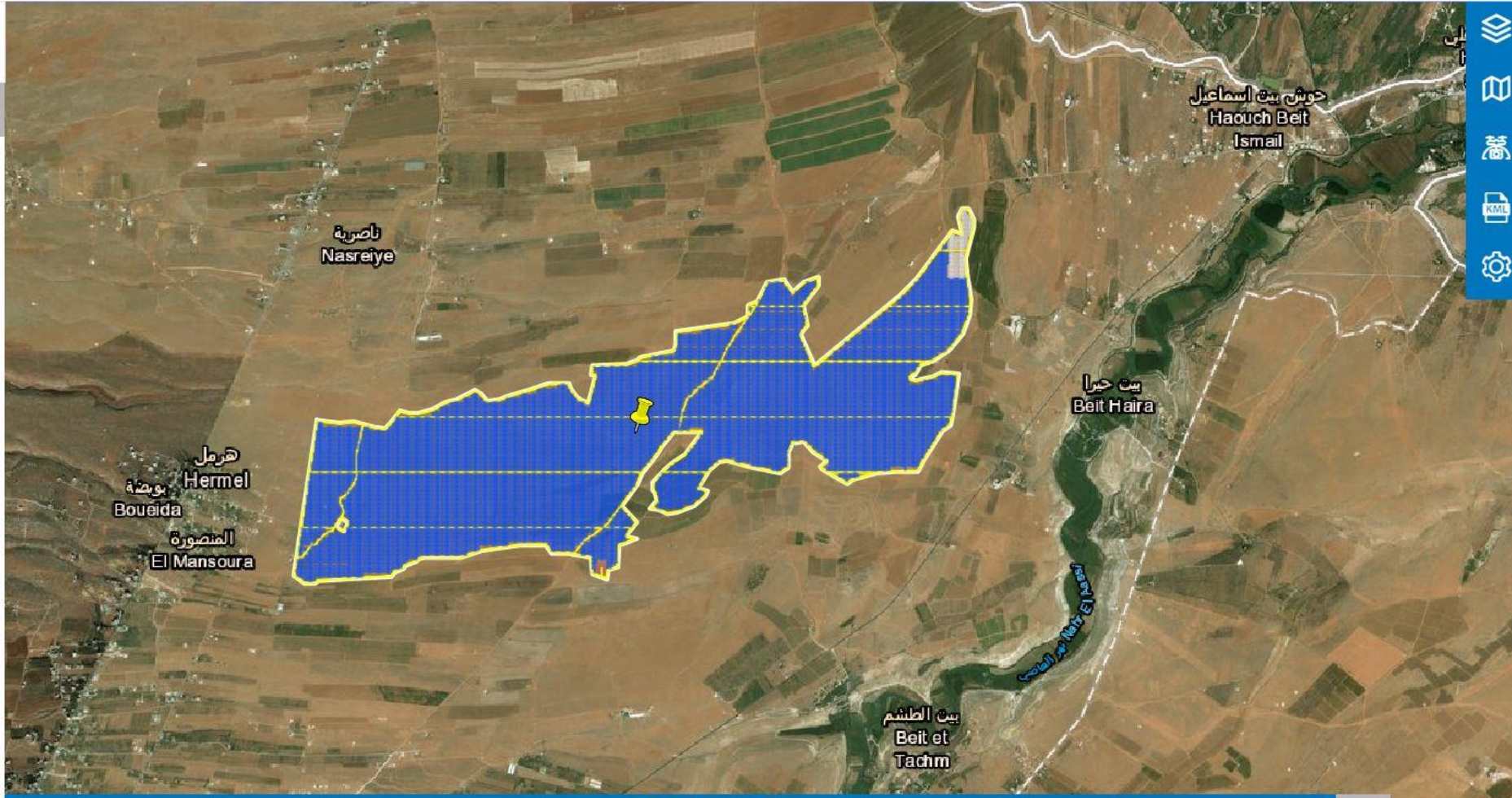
	GCR	DC/AC	DC(MW)	AC(MW)	Yield(kWh/kWp)	Clipping Loss(%)	Epc Cost($/W)	IRR(%)	LCOE($/kWh)	Land USE(%)	POA/GHI	R2 Shad
☆	0.45	1.10	260.70	237.00	2227.89	-0.06%	-	-	-	86.2%	-	-

Production Value in DC MW for each Solar Site

$\sum$ Total DC (MW) = **1725.39MW**

260.7 MW

415.79 MW

29.71 MW

300.31 MW

128.71 MW

217.81 MW

372.9 MW
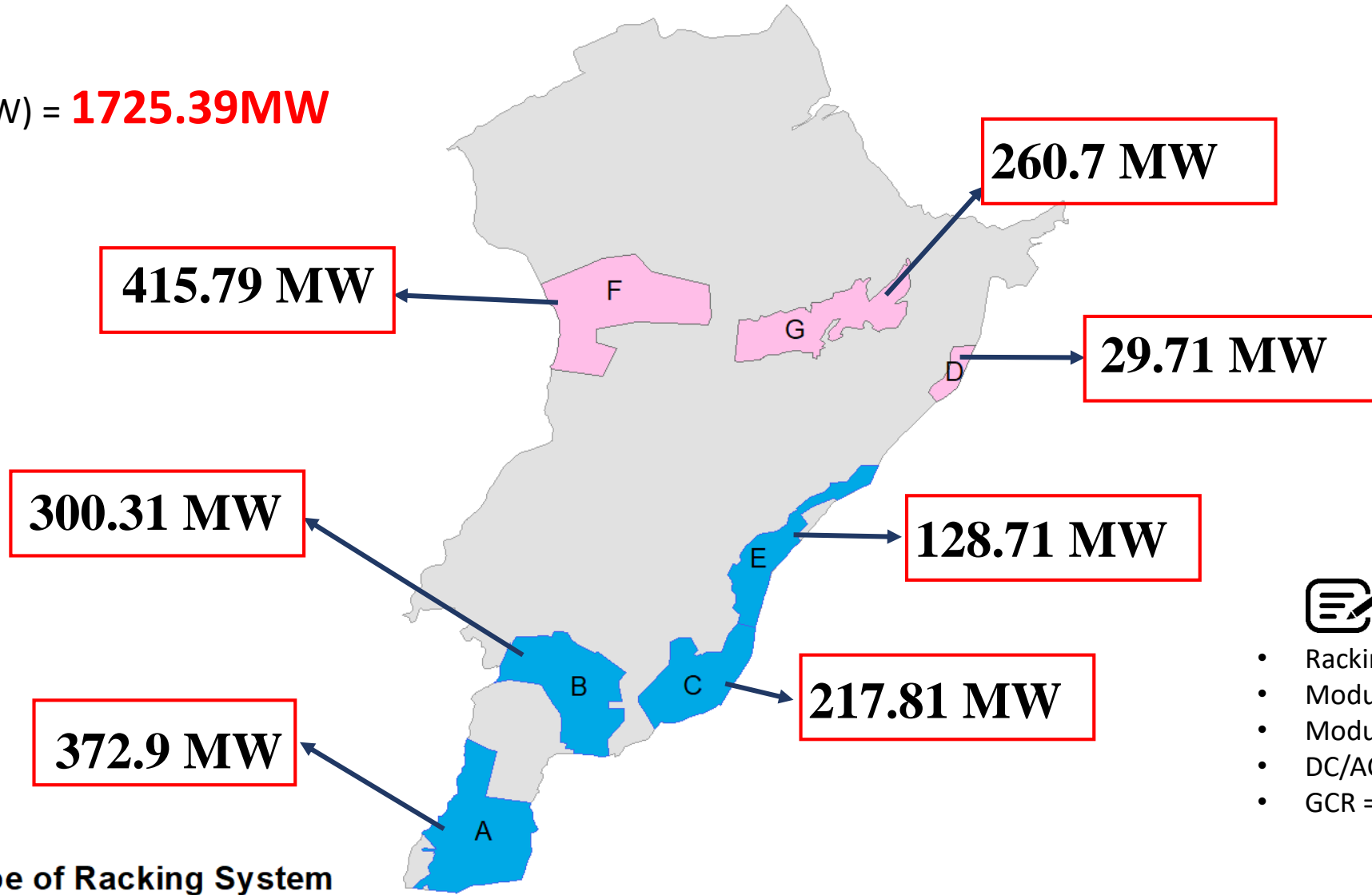
- Racking : Tracker and Ground Fixed
- Module Rate : 405 Wp
- Module Type : Shingled Mono Perc
- DC/AC = 1.1
- GCR = 0.45

Type of Racking System

Ground Fixed

Tracker

0   3,750   7,500   15,000 Meters

N