water

MDPI

Supplementary material

Potential Risk of Agrochemical Leaching in Areas of Edapho-climatic Suitability for Coffee Cultivation

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Table S1. Soils physicochemical properties.

Soil	Fc (v v^{-1})	ρ (g cm^{-3})	OC (g g^{-1})	δ (v v^{-1})
Argisol[1]	0.2950	1.5875	0.0263	0.5875
Cambisol[2,3]	0.4685	1.4000	0.0296	0.4763
Chernosol[4,5]	0.1540	1.4200	0.0218	0.4800
Spodosol[6]	0.0638	1.7240	0.0098	0.3460
Gleysol[1]	0.3750	1.0300	0.0620	0.5226
Latosol[1]	0.2625	1.2625	0.0194	0.5875
Fluvic Neosol[7]	0.2027	1.3700	0.0088	0.4450
Litholic Neosol[8]	0.2637	1.6900	0.0024	0.3500
Quartzarenic Neosol[1]	0.1838	1.5000	0.0036	0.5188
Red Litosol[1]	0.3250	1.2625	0.0225	0.6375
Haplic Organosol[9]	0.2080	0.2660	0.3738	0.8900

Table S2. Thermal Aptitude ranges for conilon (*Coffea canephora* Pierre ex Froehner) and arabica coffee (*Coffea arabica* L.).

Aptitude	Temperature (ºC)	
	Conilon coffe	arabica coffe
Apt	22 to 26	19 to 22
Restricted	21 to 22	18 to 19 and 22 to 23
Inapt	< 21 and > 26	< 18 and > 23

Table S3. Water aptitude ranges for the cultivation of conilon (*Coffea canephora* Pierre ex Froehner) and arabica coffee (*Coffea arabica* L.).

Aptitude	Water Deficit (mm)	
	Conilon coffee	Arabica coffee
Apt Without Irrigation (AWI)	< 150	< 100
Apt With Occasional Irrigation (AWOCI)	150 to 200	100 to 150
Apt With Complementary Irrigation (AWCI)	200 to 400	150 to 200
Apt With Obligatory Irrigation (AWOBI)	> 400	> 200

Table S4. Physicochemical properties of the active ingredients used in coffee crop.

Pesticides	soil $t_{½}$ (days $^{-1}$)	K_{OC} (mL g^{-1})	k (days $^{-1}$)	K_H (Pa m^3 mol^{-1})
2,4-D[1]	4.4	39.3	0.157533	4.0 x 10^{-6}
Chlorpyrifos[1]	50.0	8,151.0	0.013863	4.78 x10^{-1}
Diuron[1]	75.5	813,0	0.009181	2.00 x 10^{-6}
Glyphosate[1]	15.0	1,424.0	0.046210	2.10 x 10^{-7}
Paraquat[1]	3,000.0	1,000,000.0	0.001899	4.0 x 10^{-9}

Pendimethalin[1]	182.3	17,491.0	0.003802	2.73×10^{-3}
Sulfentrazone[1,2]	541.0	43.0	0.001281	1.878×10^{-4}
Tebuconazole[1,3]	63.0	769.0	0.011002	1.00×10^{-5}
Terbufos[1]	8.0	500.0	0.086643	2.70
Thiamethoxam[1]	50.0	56.2	0.013863	4.70×10^{-10}

Table S5. Adsorption Potential categories for the reduction factor (RF).

Retardation Factor (RF)	Adsorption Potential
1.0	Very low
1.0 to 2.0	Low
2.0 to 3.0	Medium
3.0 to 10.0	High
> 10.0	Very high

Source: Khan and Liang[1] and Rao, Hornsby and Jessup[2].

Table S6. Leaching potential categories for the attenuation factor (AF).

Attenuation Factor (AF)	Leaching potential
0.0	Null
0.0 to 0.0001	Very low
0.0001 to 0.01	Low
0.01 to 0.1	Medium
0.1 to 0.25	High
0.25 to 1.0	Very high

Source: Khan and Liang[1] and Rao, Hornsby and Jessup[2].

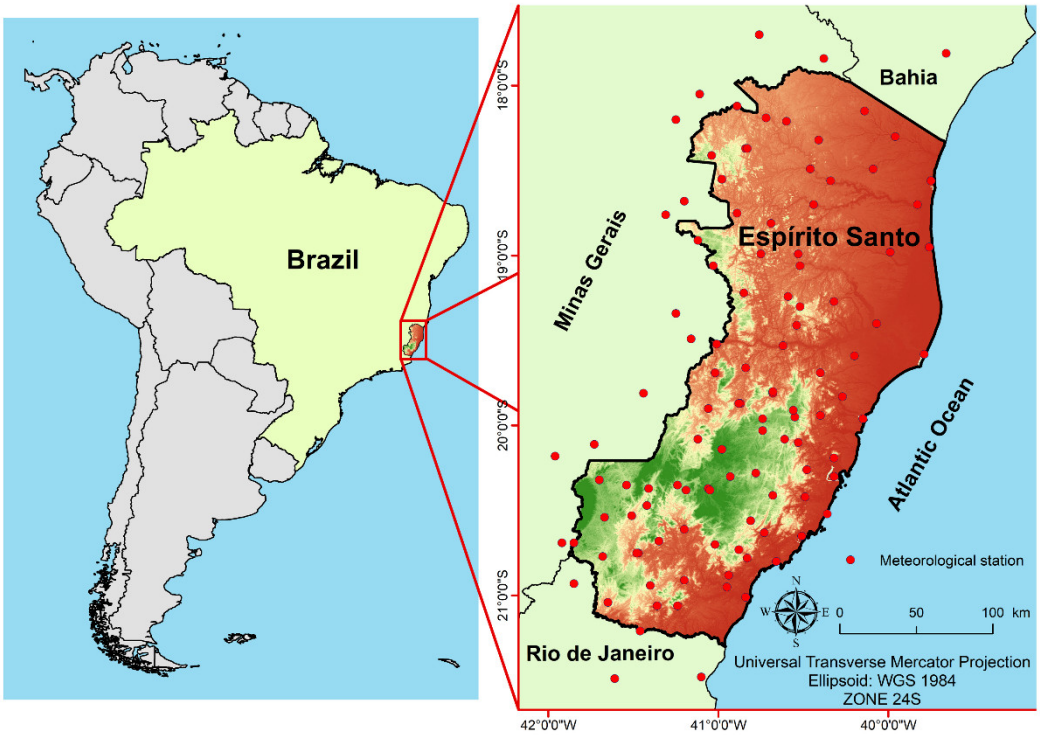


Figure S1

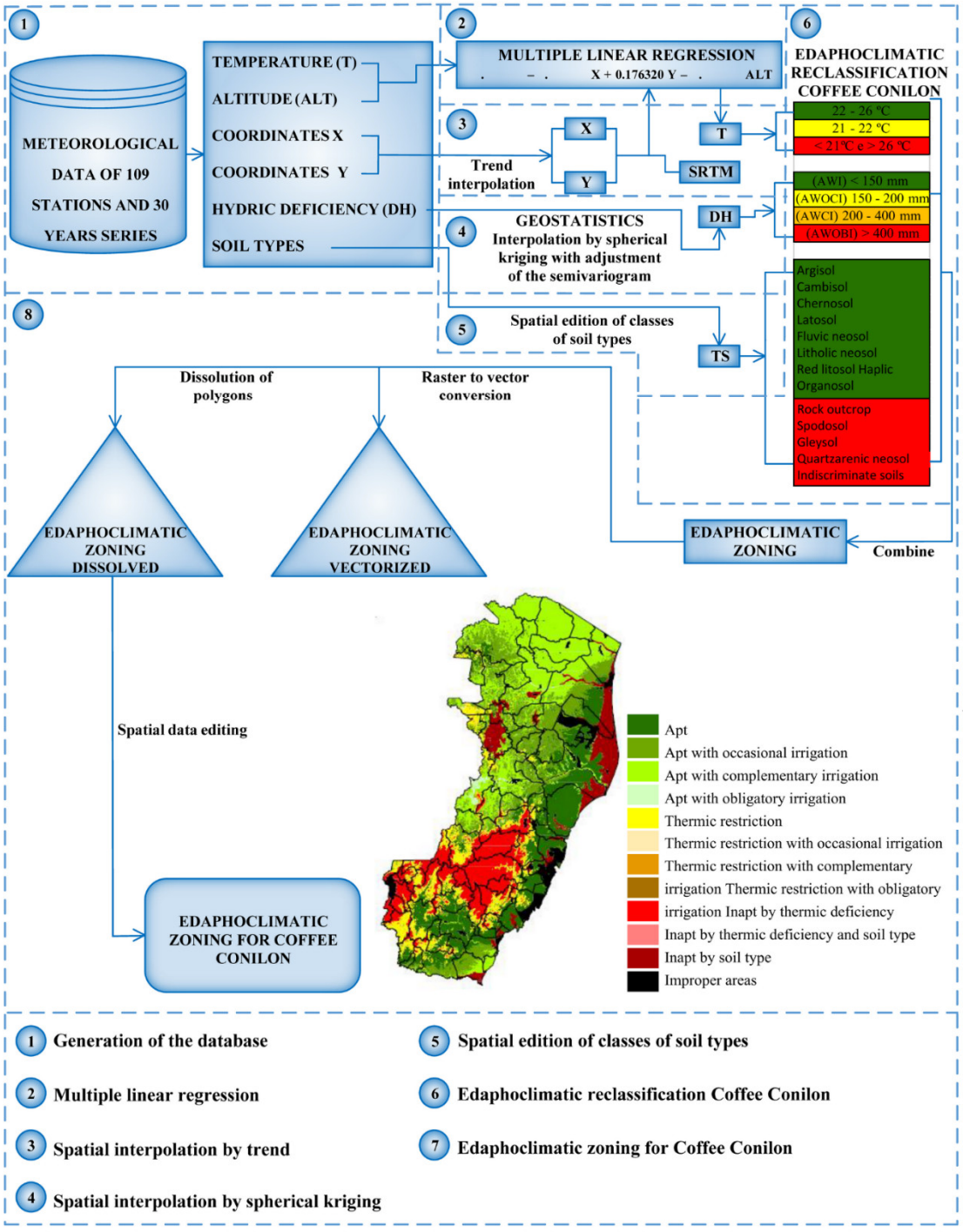
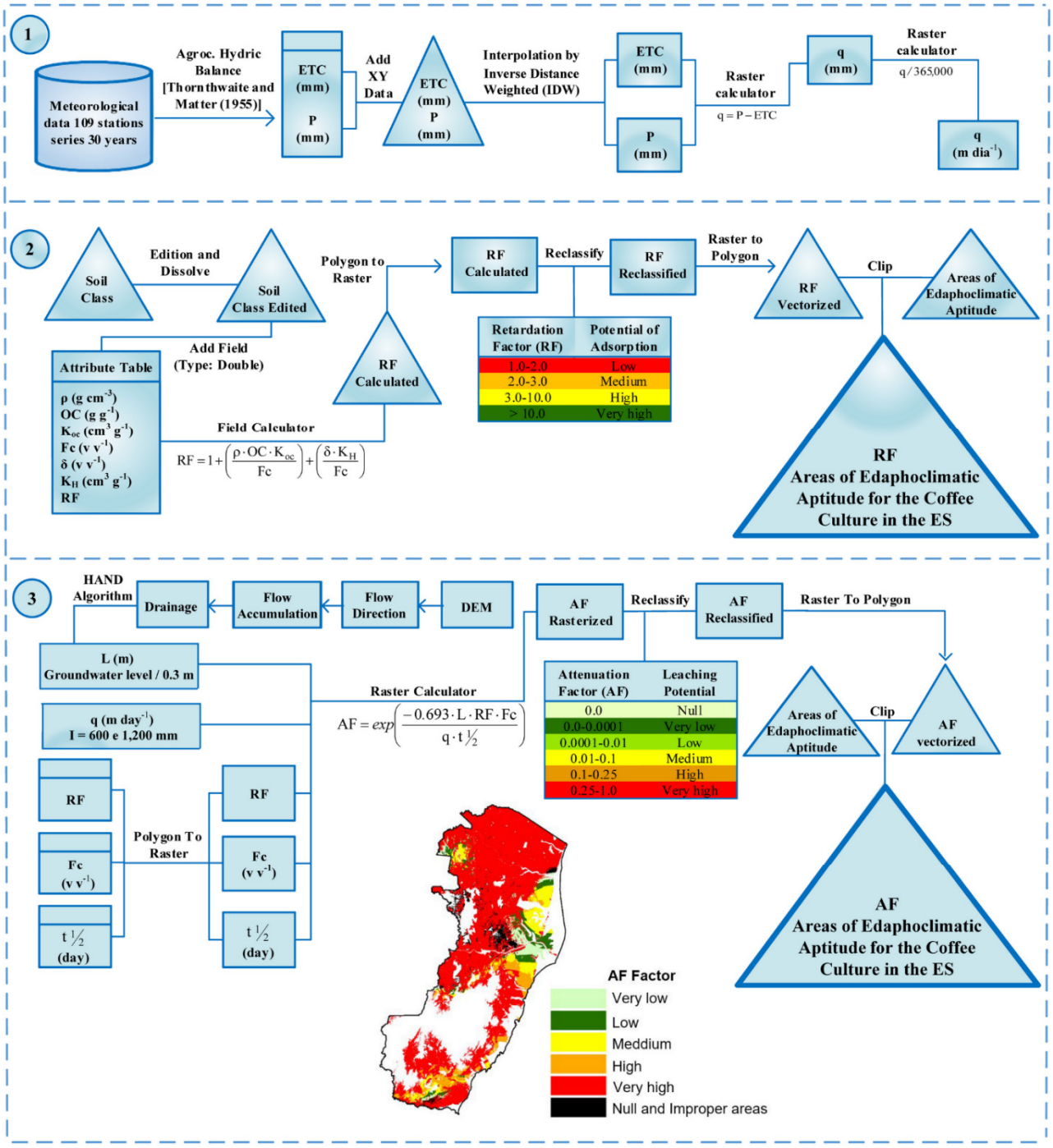

1
METEOROLOGICAL DATA OF 109 STATIONS AND 30 YEARS SERIES
TEMPERATURE (T)
ALTITUDE (ALT)
COORDINATES X
COORDINATES Y
HYDRIC DEFICIENCY (DH)
SOIL TYPES
2
MULTIPLE LINEAR REGRESSION
X + 0.176320 Y – . ALT
3
Trend interpolation
X
Y
T
SRTM
4
GEOSTATISTICS
Interpolation by spherical kriging with adjustment of the semivariogram
DH
5
Spatial edition of classes of soil types
TS
6
EDAPHOCLIMATIC RECLASSIFICATION COFFEE CONILON
22 - 26 ºC
21 - 22 ºC
< 21ºC e > 26 ºC
(AWI) < 150 mm
(AWOCI) 150 - 200 mm
(AWCI) 200 - 400 mm
(AWOBI) > 400 mm
Argisol
Cambisol
Chernosol
Latosol
Fluvic neosol
Litholic neosol
Red litosol Haplic
Organosol
Rock outcrop
Spodosol
Gleysol
Quartzarenic neosol
Indiscriminate soils
8
Dissolution of polygons
Raster to vector conversion
EDAPHOCLIMATIC ZONING DISSOLVED
EDAPHOCLIMATIC ZONING VECTORIZED
EDAPHOCLIMATIC ZONING
Combine
Spatial data editing
EDAPHOCLIMATIC ZONING FOR COFFEE CONILON
Apt
Apt with occasional irrigation
Apt with complementary irrigation
Apt with obligatory irrigation
Thermic restriction
Thermic restriction with occasional irrigation
Thermic restriction with complementary
irrigation Thermic restriction with obligatory
irrigation Inapt by thermic deficiency
Inapt by thermic deficiency and soil type
Inapt by soil type
Improper areas
1 Generation of the database
2 Multiple linear regression
3 Spatial interpolation by trend
4 Spatial interpolation by spherical kriging
5 Spatial edition of classes of soil types
6 Edaphoclimatic reclassification Coffee Conilon
7 Edaphoclimatic zoning for Coffee Conilon

Figure S2



1 Step 1 - Spatial distribution of recharge rate of groundwater.

2 Step 2 - Spatial distribution of the retardation factor in pesticide movement in soil.

3 Step 3 - Spatial distribution of the attenuation factor pesticide in the soil.

Figure S3

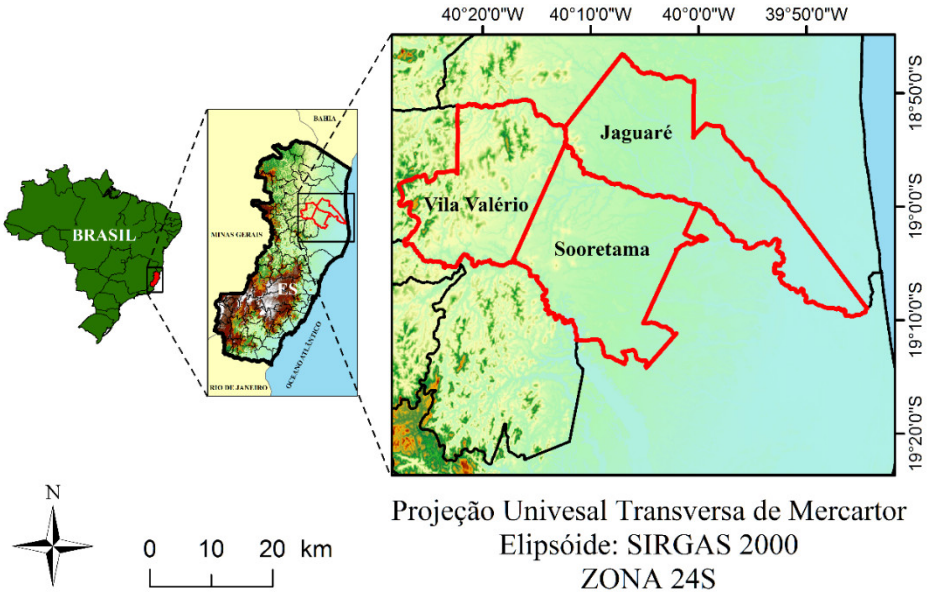


Figure S4

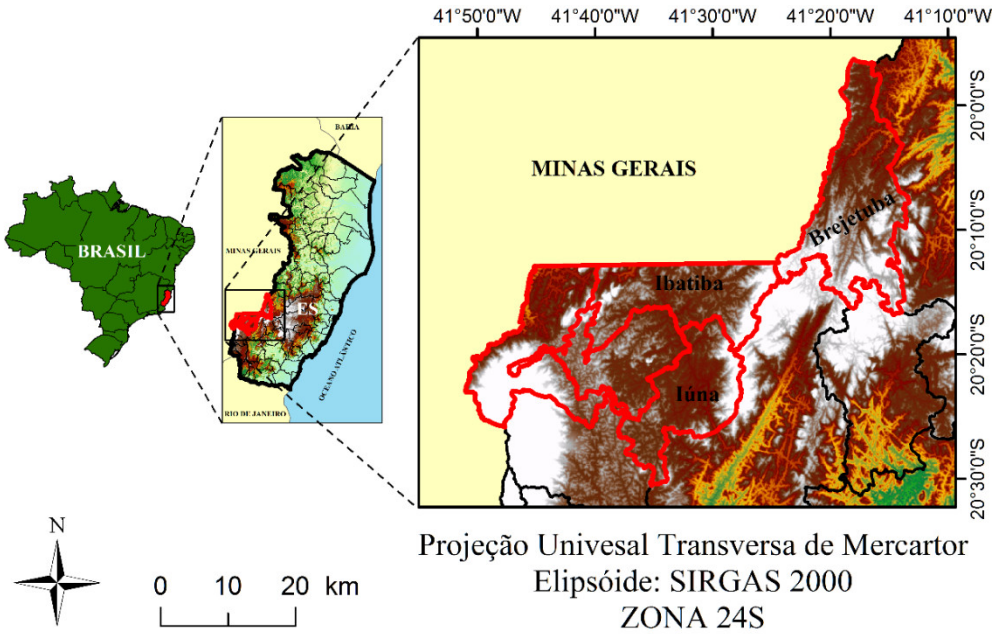


Figure S5

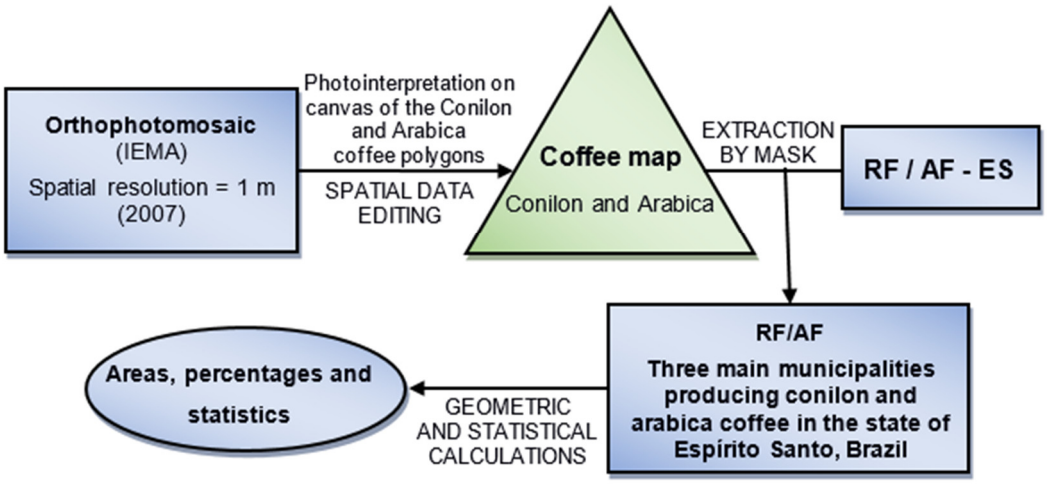


Figure S6

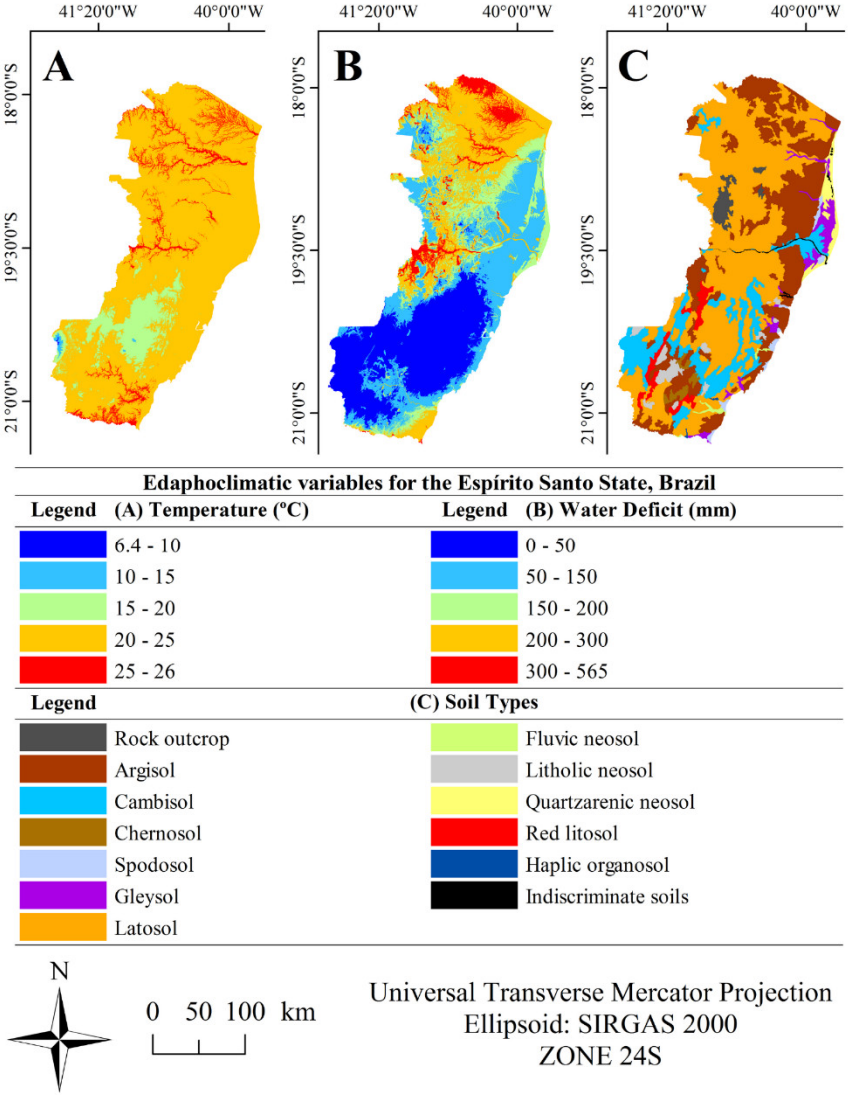
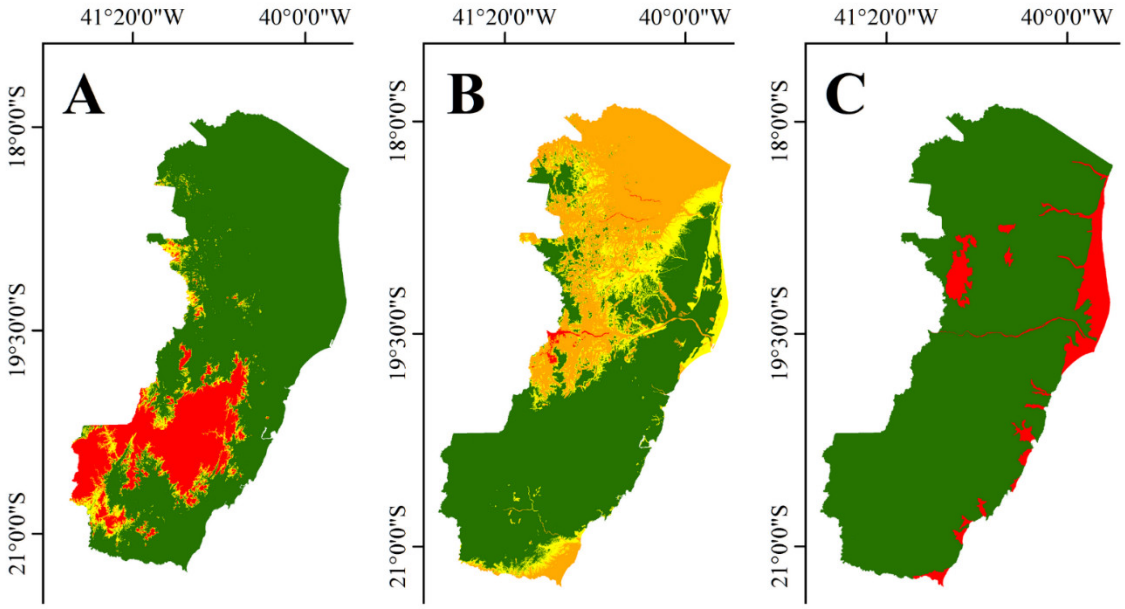


Figure S7



Aptitude Classes for Conilon Coffee

Legend	Classes	(A) Temperature (°C)
	Apt	22 a 26
	Restricted	21 a 22
	Inapt	< 21 e > 26

Legend	Classes	(B) Water Deficit (mm)
	Apt Without Irrigation (AWI)	< 150
	Apt With Occasional Irrigation (AWOCI)	150 a 200
	Apt With Complementary Irrigation (AWCI)	200 a 400
	Apt With Obligatory Irrigation (AWOBI)	> 400

Legend	Classes	(C) Soil Types
	Apt	Argisol, Cambisol, Chernosol, Latosol, Fluvic neosol, Litholic neosol, Red litosol and Haplic organosol
	Inapt	Rock outcrop, Spodosol, Gleysol, Quartzarenic neosol and Indiscriminate soils

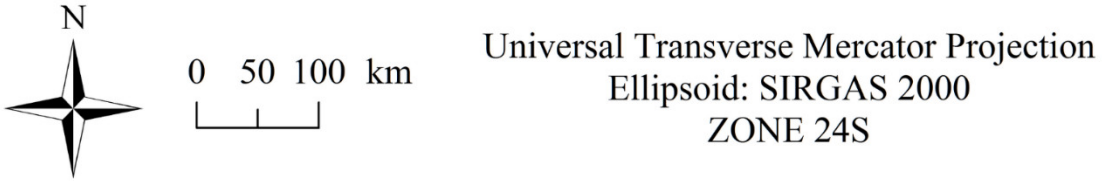
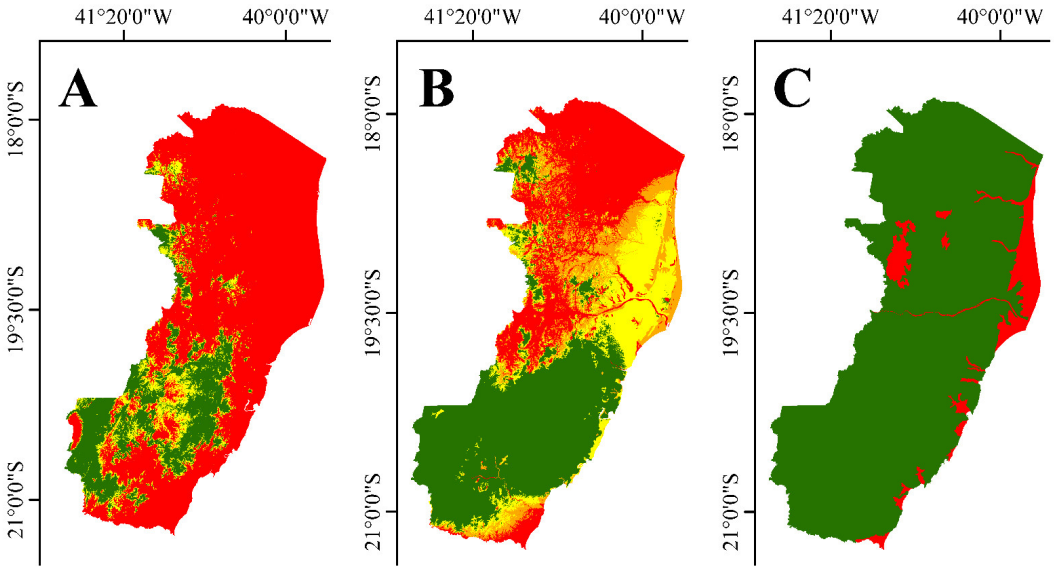
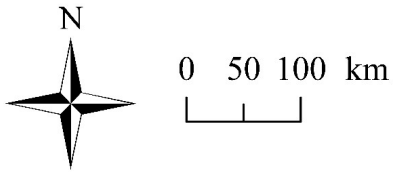


Figure S8

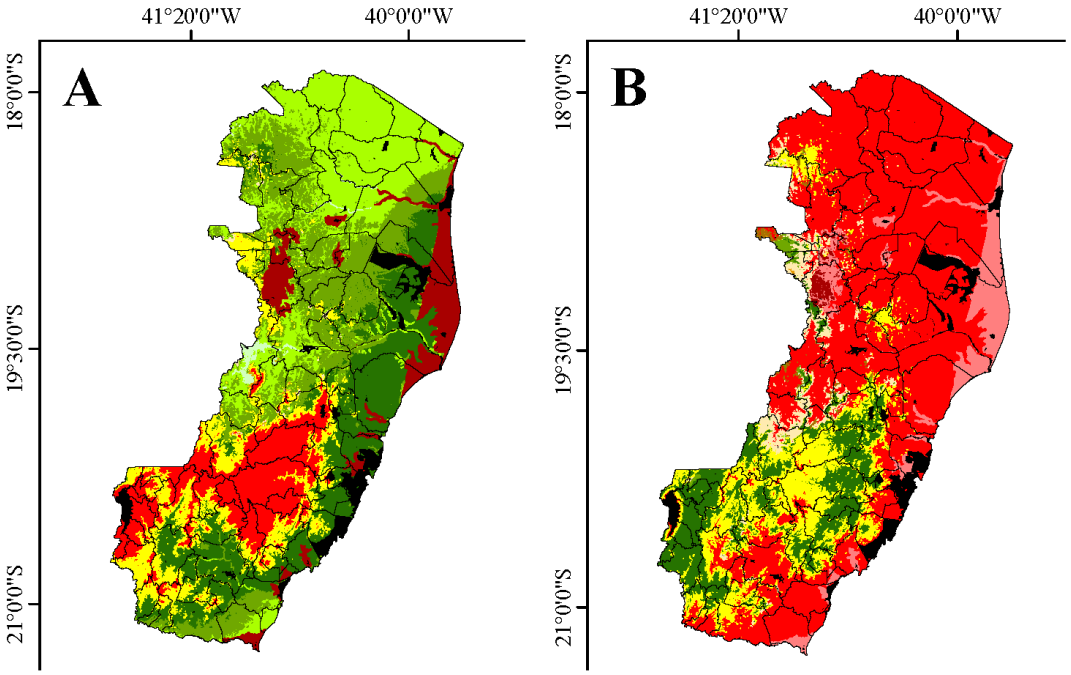


Aptitude Classes for Arabica Coffee		
Legend	**Classes**	**(A) Temperature (°C)**
	Apt	19 a 22
	Restricted	18 a 19 e 22 a 23
	Inapt	< 18 e > 23
Legend	**Classes**	**(B) Water Deficit (mm)**
	Apt Without Irrigation (AWI)	< 100
	Apt With Occasional Irrigation (AWOCI)	100 a 150
	Apt With Complementary Irrigation (AWCI)	150 a 200
	Apt With Obligatory Irrigation (AWOBI)	> 200
Legend	**Classes**	**(C) Soil Types**
	Apt	Argisol, Cambisol, Chernosol, Latosol, Fluvic neosol, Litholic neosol, Red litosol and Haplic organosol
	Inapt	Rock outcrop, Spodosol, Gleysol, Quartzarenic neosol and Indiscriminate soils



Universal Transverse Mercator Projection
Ellipsoid: SIRGAS 2000
ZONE 24S

Figure S9



Legend	Aptitude classes	(A) Conilon Coffee		(B) Arabica Coffee	
		Area (km²)	%	Area (km²)	%
	Apt	12,208.07	26.55	7,630.13	16.59
	Apt with occasional irrigation	4,971.06	10.81	247.43	0.54
	Apt with complementary irrigation	12,809.07	27.85	35.87	0.08
	Apt with obligatory irrigation	152.82	0.33	21.39	0.05
	Thermic restriction	2,795.49	6.08	3,438.97	7.48
	Thermic restriction with occasional irrigation	21.08	0.05	545.90	1.19
	Thermic restriction with complementary irrigation	15.44	0.03	210.12	0.46
	Thermic restriction with obligatory irrigation	-	-	66.95	0.15
	Inapt by thermic deficiency	7,363.03	16.01	28,139.30	61.19
	Inapt by thermic deficiency and soil type	9.90	0.02	2,771.31	6.03
	Inapt by soil type	2,939.55	6.39	178.14	0.39
	Improper areas	2,699.85	5.87	2,699.85	5.87
	Total	**45,985.36**	**100.00**	**45,985.36**	**100.00**

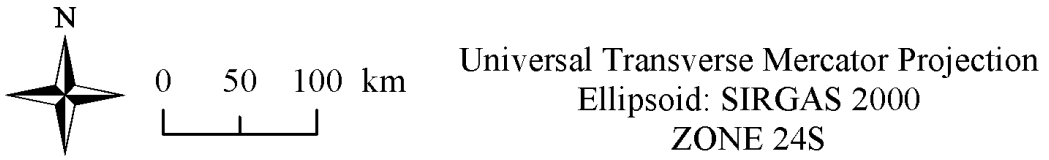


Figure S10

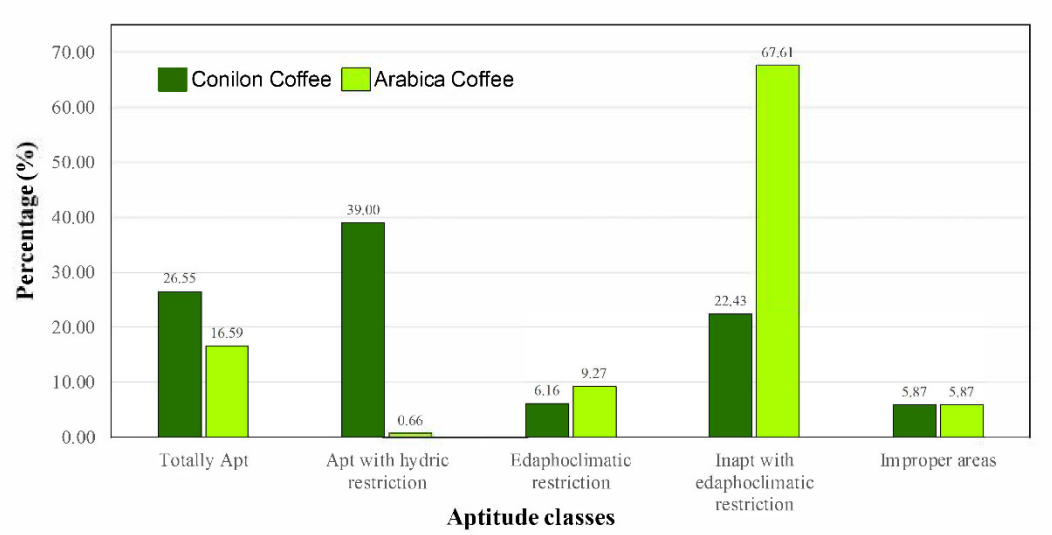
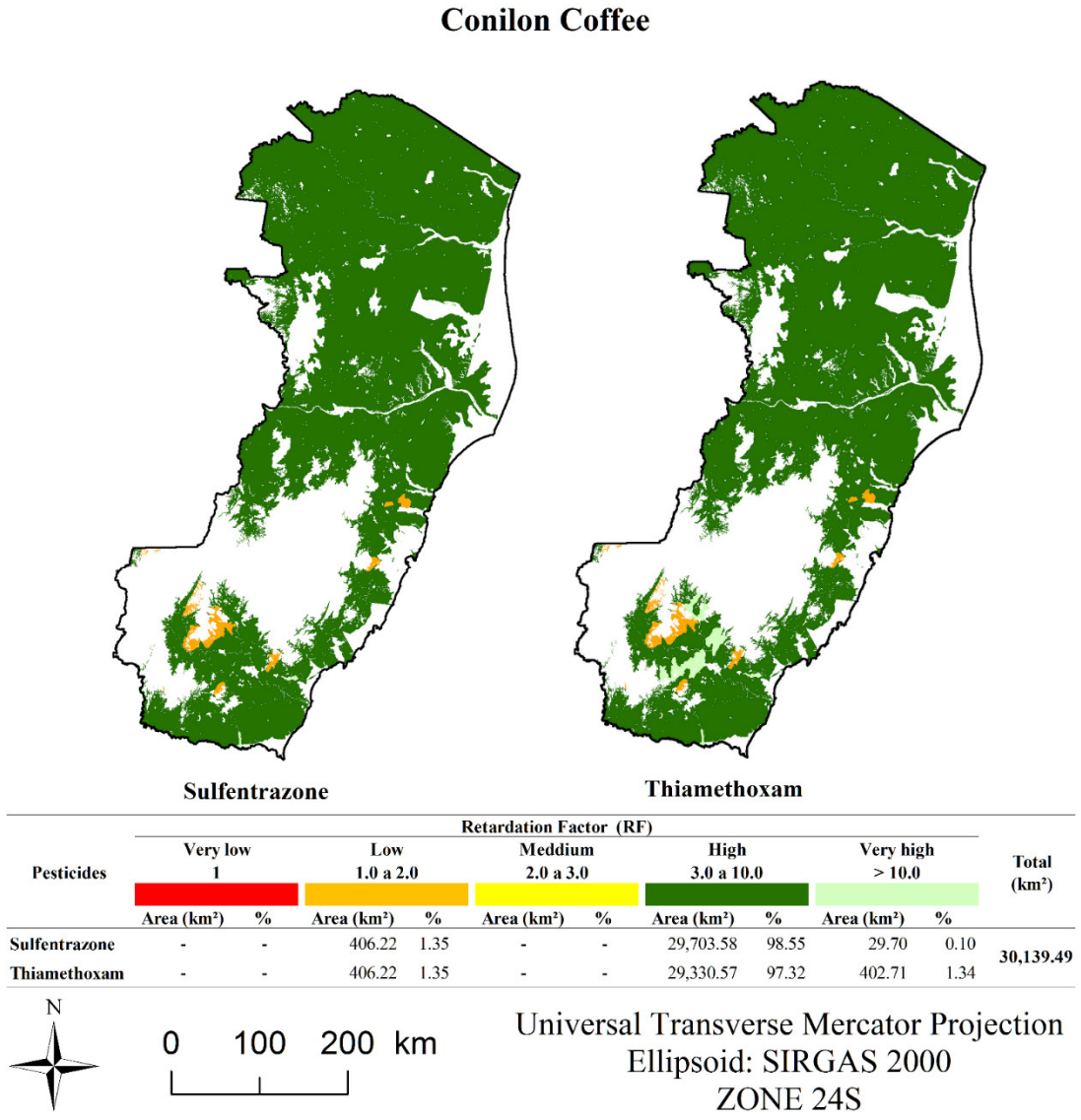


Figure S11



Pesticides	Retardation Factor (RF)										Total (km²)
	Very low 1		Low 1.0 a 2.0		Meddium 2.0 a 3.0		High 3.0 a 10.0		Very high > 10.0		
	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%	Area (km²)	%	
Sulfentrazone	-	-	406.22	1.35	-	-	29,703.58	98.55	29.70	0.10	30,139.49
Thiamethoxam	-	-	406.22	1.35	-	-	29,330.57	97.32	402.71	1.34	

Figure S12

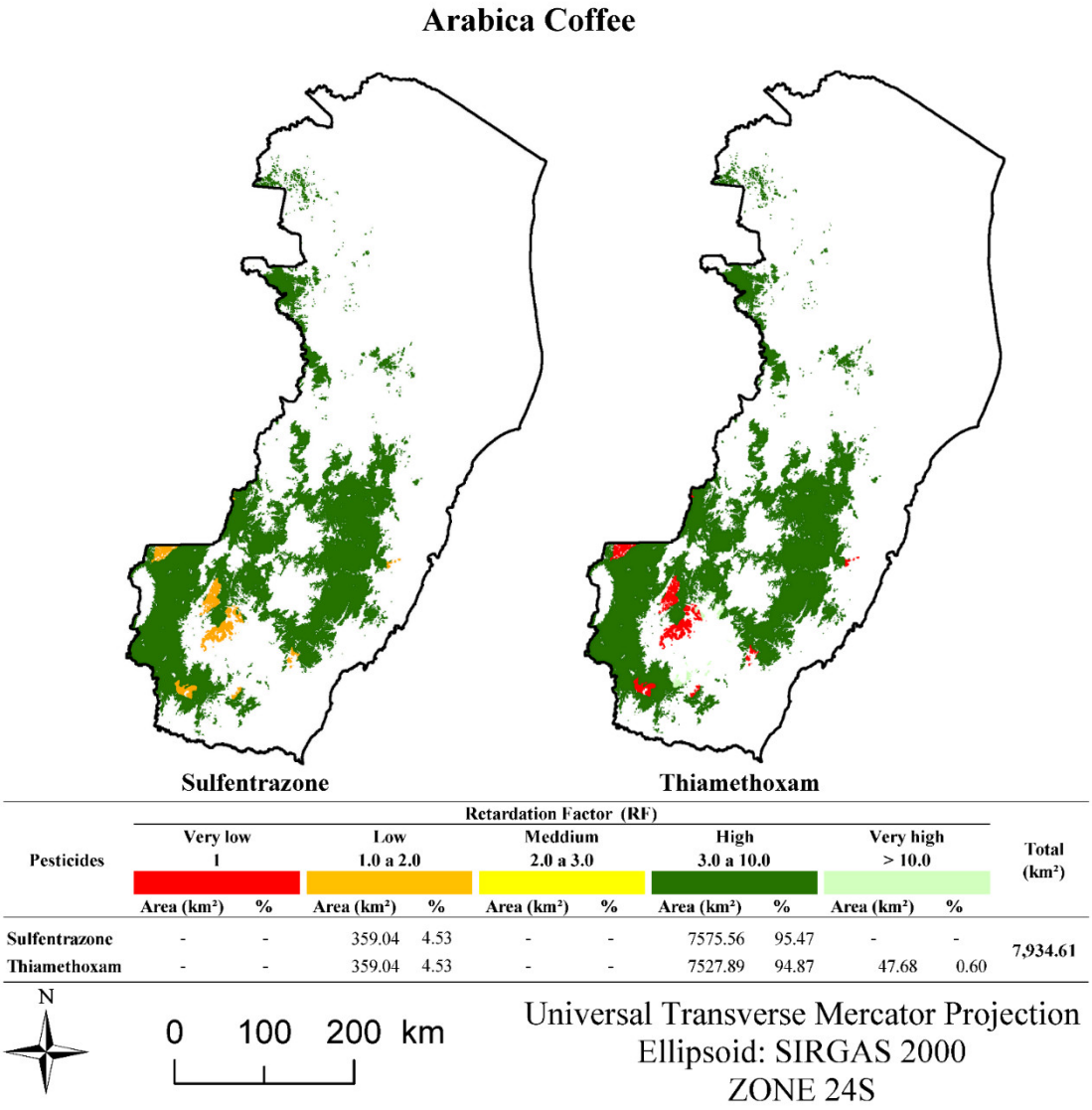

Arabica Coffee
Sulfentrazone
Thiamethoxam
Retardation Factor (RF)
Very low 1
Low 1.0 a 2.0
Meddium 2.0 a 3.0
High 3.0 a 10.0
Very high > 10.0
Pesticides
Total (km²)
Area (km²) % Area (km²) % Area (km²) % Area (km²) % Area (km²) %
Sulfentrazone - - 359.04 4.53 - - 7575.56 95.47 - - 7,934.61
Thiamethoxam - - 359.04 4.53 - - 7527.89 94.87 47.68 0.60
N
0 100 200 km
Universal Transverse Mercator Projection
Ellipsoid: SIRGAS 2000
ZONE 24S

Figure S13

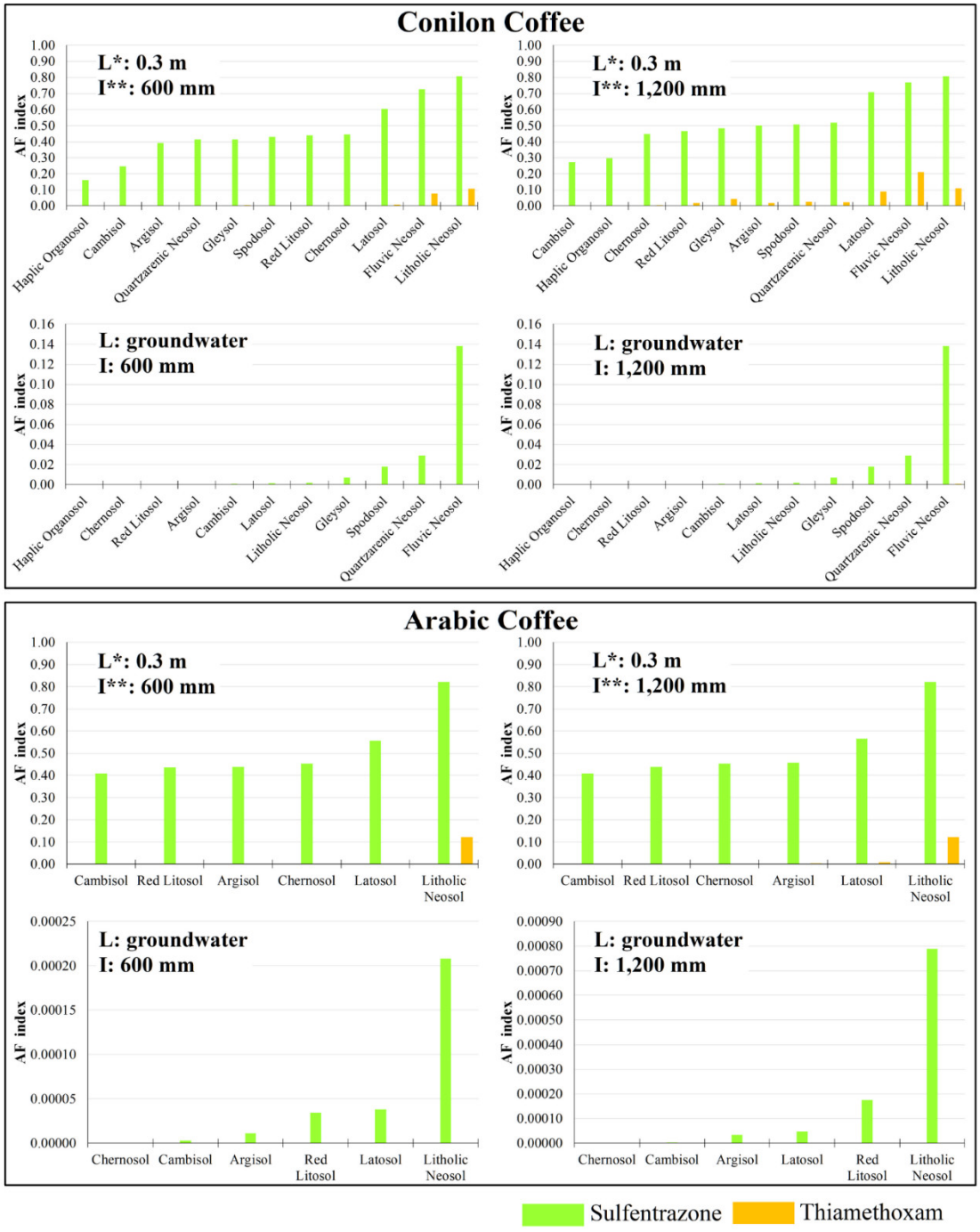

Conilon Coffee
L*: 0.3 m
I**: 600 mm
L*: 0.3 m
I**: 1,200 mm
L: groundwater
I: 600 mm
L: groundwater
I: 1,200 mm
AF index
Haplic Organosol
Cambisol
Argisol
Quartzarenic Neosol
Gleysol
Spodosol
Red Litosol
Chernosol
Latosol
Fluvic Neosol
Litholic Neosol
Arabic Coffee
Sulfentrazone
Thiamethoxam

Figure S14

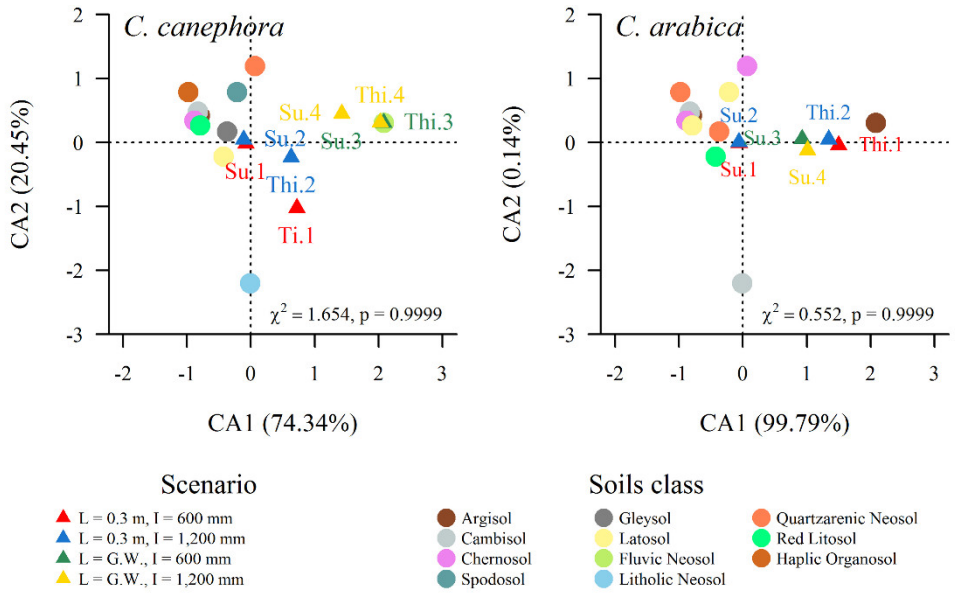

C. canephora
C. arabica
CA2 (20.45%)
CA2 (0.14%)
CA1 (74.34%)
CA1 (99.79%)
Su.4
Thi.4
Thi.3
Su.2
Su.3
Su.1
Thi.2
Ti.1
Thi.1
χ^2 = 1.654, p = 0.9999
χ^2 = 0.552, p = 0.9999
Scenario
L = 0.3 m, I = 600 mm
L = 0.3 m, I = 1,200 mm
L = G.W., I = 600 mm
L = G.W., I = 1,200 mm
Argisol
Cambisol
Chernosol
Spodosol
Soils class
Gleysol
Latosol
Fluvic Neosol
Litholic Neosol
Quartzarenic Neosol
Red Litosol
Haplic Organosol

Figure S15

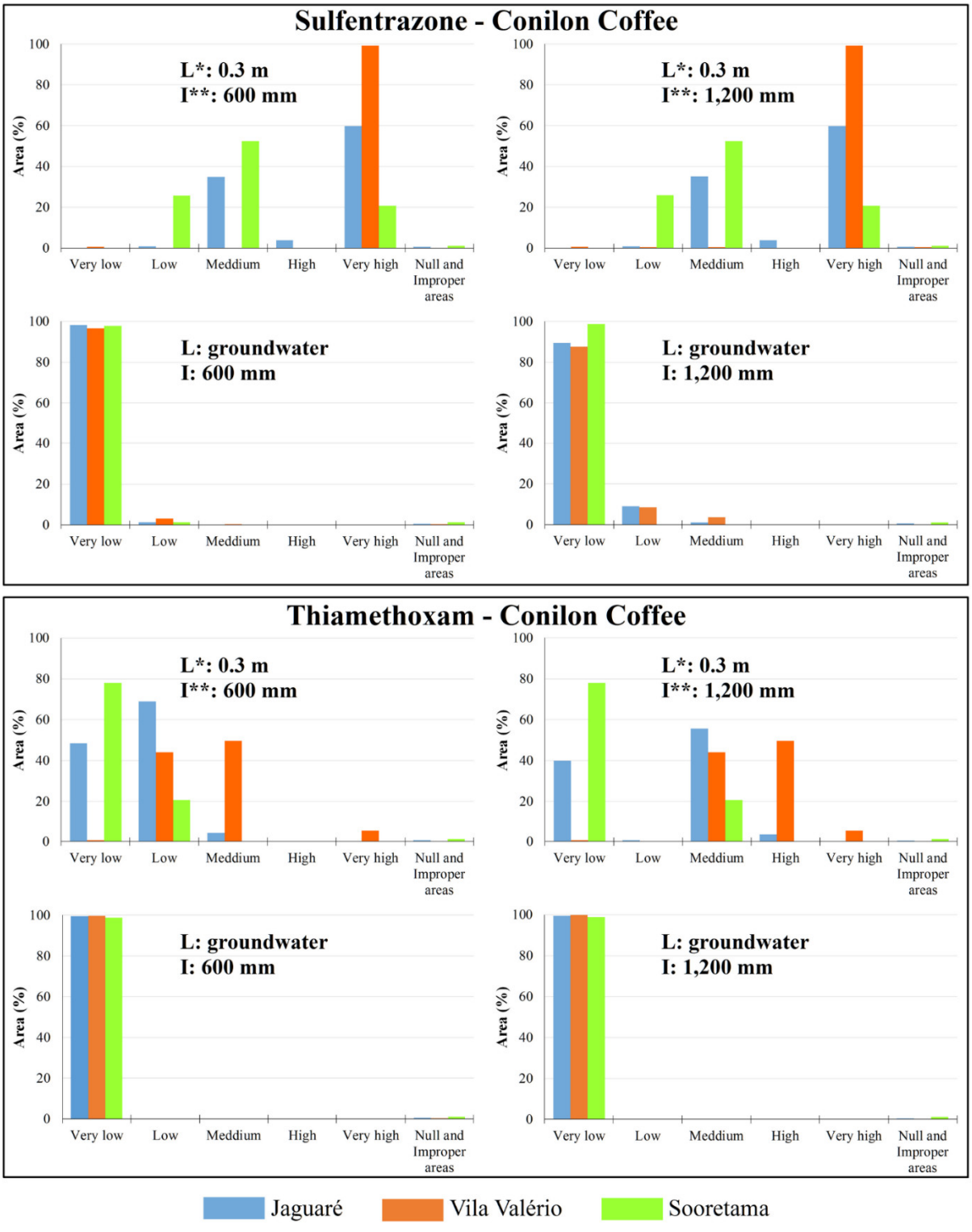

Sulfentrazone - Conilon Coffee
L*: 0.3 m
I**: 600 mm
L*: 0.3 m
I**: 1,200 mm
L: groundwater
I: 600 mm
L: groundwater
I: 1,200 mm
Thiamethoxam - Conilon Coffee
L*: 0.3 m
I**: 600 mm
L*: 0.3 m
I**: 1,200 mm
L: groundwater
I: 600 mm
L: groundwater
I: 1,200 mm
Area (%)
0
20
40
60
80
100
Very low
Low
Meddium
High
Very high
Null and Improper areas
Jaguaré
Vila Valério
Sooretama

Figure S16

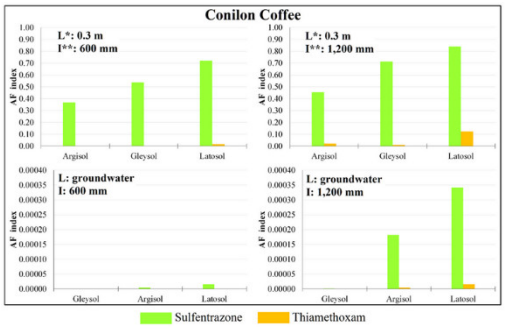


Figure S17

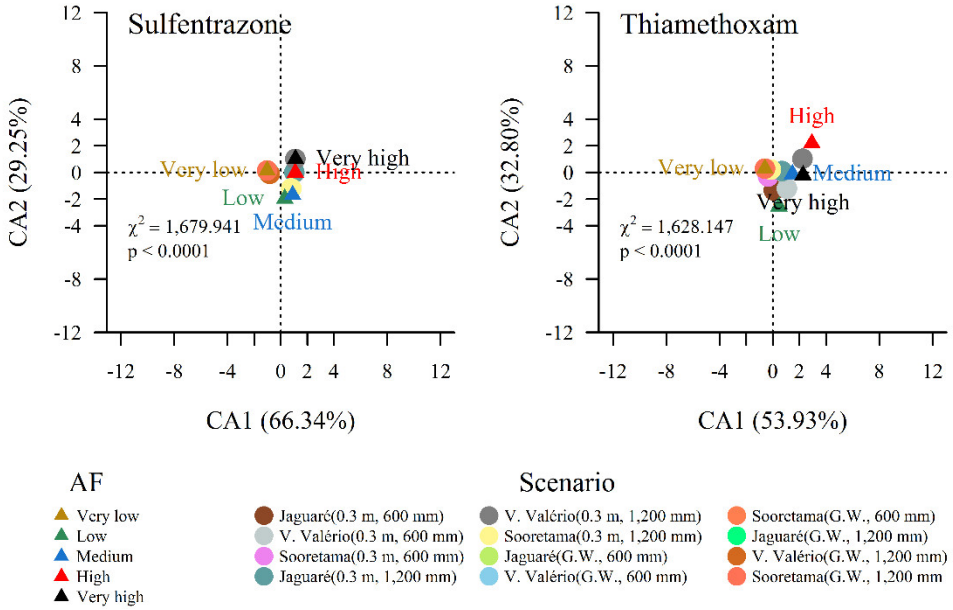


Figure S18

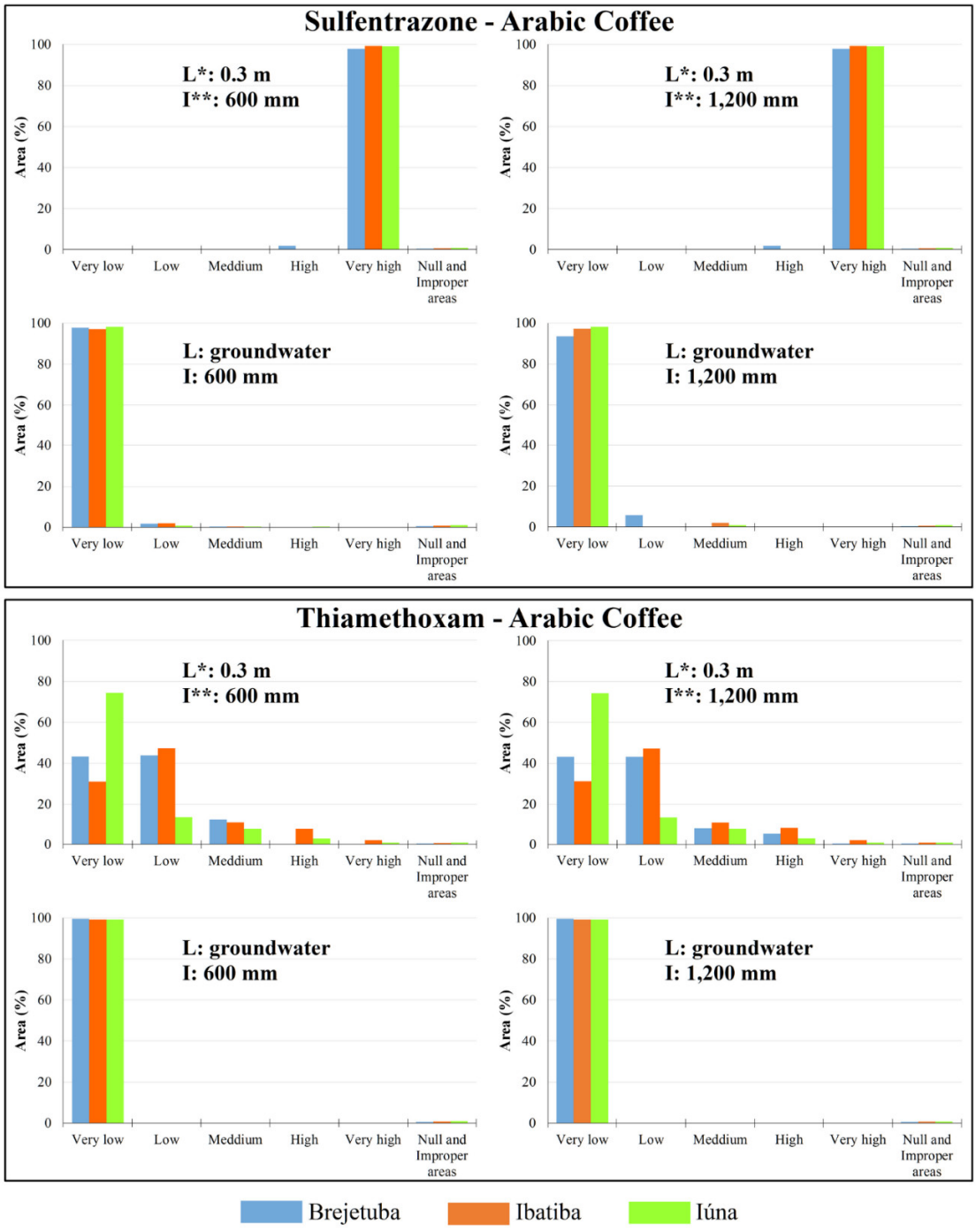


Figure S19

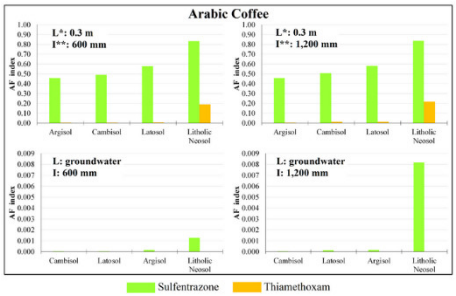


Figure S20

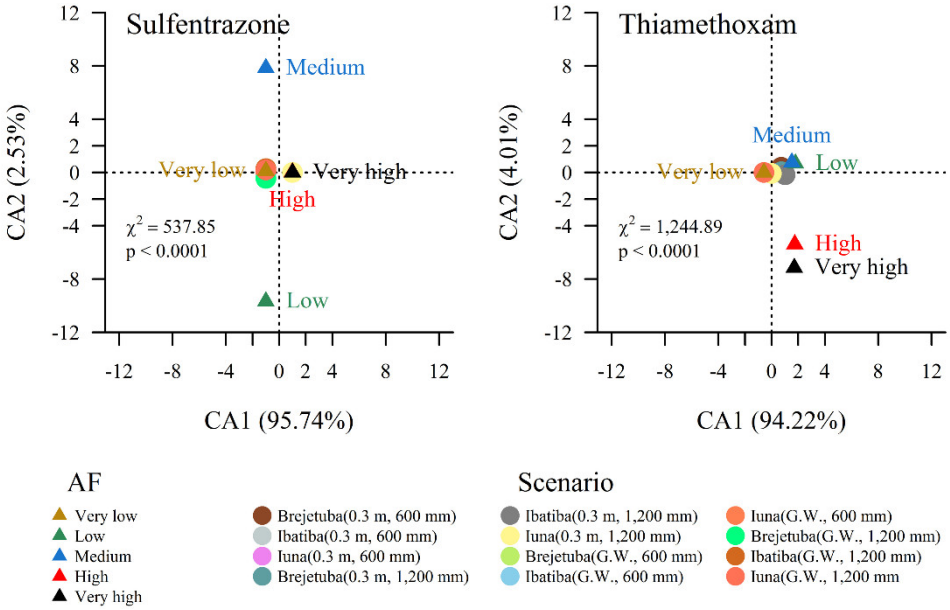


Figure S21.

Supplementary Material References

1. Silva, V.P.R.; Oliveira, S.D.; Santos, C.A.C.; Silva, M.T. Risco climático da cana-de-açúcar cultivada na região nordeste do Brasil. *Rev. Bras. Eng. Agrícola e Ambient*. **2013**, *17*, 180–189. https://doi.org/10.1590/S1415-43662013000200009.
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