from Nexus Thinking to Nexus Doing

REXUS

A novel tool implementation to estimate the Land Use Sustainability for crops production under different climate changes scenarios

Joan Miquel Galve[1], *Jesús Garrido-Rubio[1], José González-Piqueras[1], Anna Osann[2], Alfonso Calera[1],Maria Llanos López[2], Esteban Henao[2], David Sánchez[1], Jesús Puchades[1], Antonio Jesús Molina[1],Christina Papadaskalopoulou[3], Marina Antoniadou[3], and Dimitris Tassopoulos[3].*

*1IDR-UCLM, Campus Universitario s/n, 02071 Albacete, Spain (**joanmiquel.galve@uclm.es**)*

2Agrisat Iberia S.L., Parque Científico y Tecnológico, Edificio Emprendedores, Paseo de la Innovación nº 1, 02006 Albacete, Spain

3DRAXIS Environmental S.A., 54-56 Themistokli Sofouli str., 54655 Thessaloniki, Greece

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003632.

Nexus

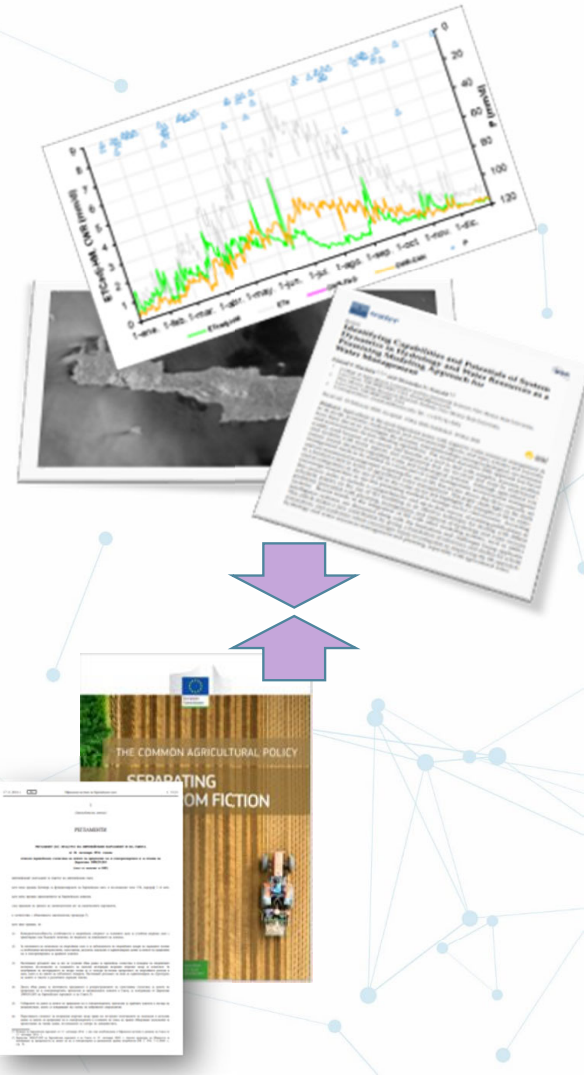
Understanding and managing the complex interactions between **water, energy, food and environment.**

As demand grows, there is **increasing competition for resources** between **water, energy, agriculture, fisheries, livestock, forestry, mining, transport and other sectors** with unpredictable impacts for livelihoods and the environment (FAO 2011).

Large-scale water infrastructure projects, may have synergetic impacts, producing hydropower and providing water storage for irrigation and urban uses.

Increase in prices of energy (including bioenergy and renewable energy) affects food production and employment in industrial sectors.

The Rexus Project aims to **close the gap between science and policy,** moving from Nexus thinking to Nexus doing. It brings together the scientific tools and the integrated vision necessary to analyze real-world conditions, including frictions and climate risks



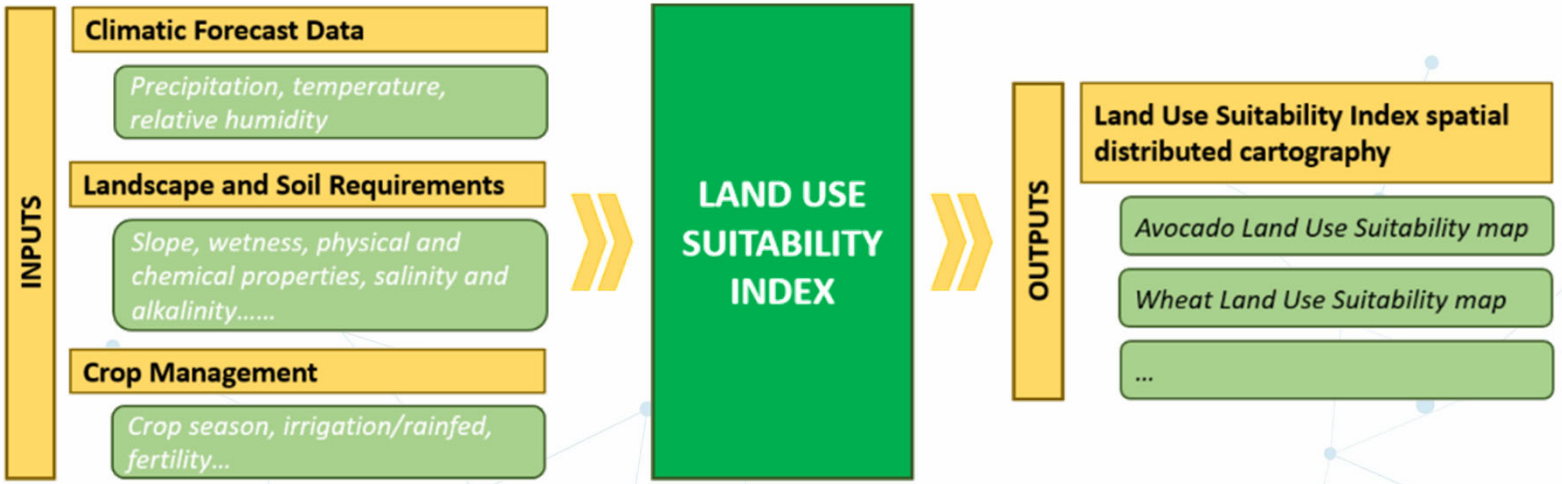
Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

Land-use suitability mapping tool

Given a set of maps and their corresponding thresholds, we obtain a result in classifying areas suitable for a particular crop. The approach involves standardizing the suitability maps, assigning relative importance weights to the suitability maps, and then combining the weights and the standardized suitability maps to obtain a suitability score.

FAO suitability classes	Characterization	Performance/Score Sys et al., (1991)
S1	Highly suitable	100-85
S2	Average suitable	85-60
S3	Marginal suitable	60-40
N1	Temporary unsuitable	40-25
N2	Permanently unsuitable	< 25



Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

Crop Card (Sys, et al., 1993).

WHEAT (*Triticum aestivum*)		CLIMATIC REQUIREMENTS						
		Class, degree of limitation and rating scale						
Climatic characteristics		VAR	S1			S2	S3	N1	N2
			100	95	85	60	40	25	0
Moisture	Precipitation of growing cycle (mm)		700 700	450 1000	350 1250	250 1500	200 1750	- -	< 200 > 1750
	Monthly rainfall vegetative storage (mm)		65 65	45 90	20 120	12 > 120	8 -	- -	< 8 -
	Monthly rainfall flowering stage (mm)		75 75	60 90	30 120	15 > 120	10 -	- -	< 10 -
	Monthly rainfall of ripening stage (mm)		60 60	50 70	30 100	10 120	< 10 > 120	- -	- -
Temperature	Mean Temperature of the growing cycle (°C)		18 18	20 15	23 12	25 10	30 8	- -	> 30 < 8
	Mean temperature of the vegetative cycle (°C)		10 10	8 12	6 18	4 24	2 28	- -	< 2 > 28
	Mean temperature of the flowering stage (°C)		18 18	14 22	12 26	10 32	8 36	- -	< 8 > 36
	Mean temperature of ripening stage (°C)		20 20	16 24	14 30	12 36	10 42	- -	< 10 > 42
Thermal amplitude	Average daily min temperature of the coldest month combined with average daily max temperature of coldest month (°C)		< 8 if < 21	-	> 8 if < 21	8-19 if > 21	> 21	-	-

WHEAT (*Triticum aestivum*)		LANDSCAPE AND SOIL REQUIREMENTS							
		Class, degree of limitation and rating scale							
Land characteristics		VAR	S1			S2	S3	N1	N2
			100	95	85	60	40	25	0
Topography	Slope (%)	(1)	0	1	2	4	6	-	> 6
		(2)	0	2	4	8	16	-	> 16
		(3)	0	4	8	16	30	-	> 30
Wetness	Flooding		F0		F1	F1/F2	F2	-	F3+
	Drainage	(4)	good	good	moderate	imperfect	poor and aeric	poor but drainable	poor > not drainable
		(5)	imperfect	imperfect	moderate	good	poor and aeric	poor but drainable	poor > not drainable
Physical soil characteristics	Texture / structure		C<60s, SiC, Co, Si, SiL, CL	C<60s, SiC, Co, Si, SiL, CL	C>60v, SC, C>60s L	C>60v, SCL	SL, LfS	-	Cm, SiCmLcS, fS, cS
	Coarse fragm (vol%)		0	3	15	35	55	-	> 55
	Soil depth (cm)		> 90	90	50	20	10	-	< 10
	$CaCo_3$ (%)		3	20	30	40	60	-	> 60
	Gypsum (%)		0	3	5	10	20	-	> 20
Soil fertility characteristics	Apparent CEC (cmol(+)/kg clay)		> 24	24	16	< 16(-)	< 16(+)	-	-
	Base saturation (%)		> 80	80	50	35	< 35	-	-
	Sum of basic cations (cmol(+)/kg soil)		> 8.0	8.0	5.0	3.5	2.0	< 2.0	-
	pH H_2O		7.0	6.5	6.0	5.6	5.2	< 5.2	-
			7.0	7.5	8.2	8.3	8.5	-	> 8.5
	Organic carbon (%)		> 1.5	1.5	0.8	< 0.8	-	-	-
		(6)	> 2.5	2.5	1.5	1.0	< 1.0	-	-
		(7)	> 1.5	1.5	1.0	0.5	< 0.5	-	-
		(8)	> 0.6	0.6	0.4	< 0.4	-	-	-
Salinity and alkalinity	Electrical conductivity - ECe (dS/m)		0	1	3	5	6	10	> 10
	Exchangeable sodium percentage - ESP (%)		0	15	20	35	45	-	> 45

Expert questionnaire to determine the weighting of parameters

REXUS

Exercise

V8- 26/09/2022

Part I: Variables

LANDSCAPE AND SOIL REQUIREMENTS

Wetness

	Absolute importance				Equal importance				Absolute importance	
Flooding	☐	☐	☐	☐	☐	☐	☐	☐	☒	Drainage

Physical soil characteristics

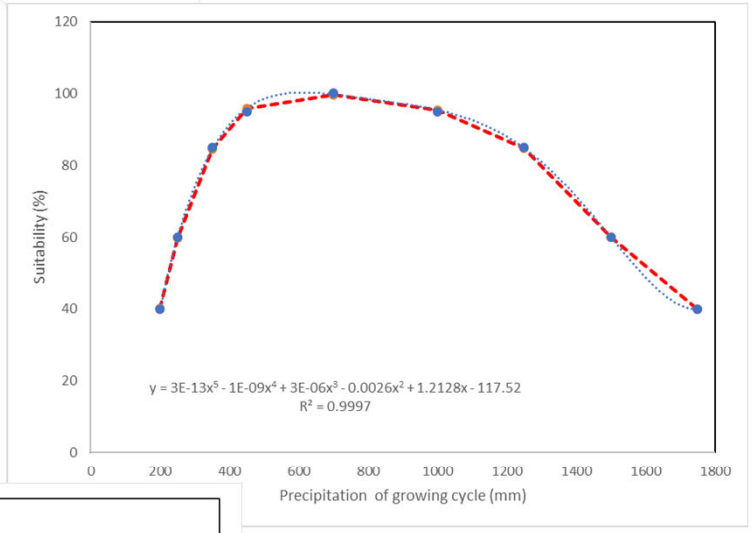
	Absolute importance				Equal importance				Absolute importance	
Texture / Structure	☐	☐	☐	☐	☒	☐	☐	☐	☐	Coarse fragments
Texture / Structure	☐	☐	☒	☐	☐	☐	☐	☐	☐	Soil depth
Texture / Structure	☐	☒	☐	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Texture / Structure	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
Coarse fragments	☐	☐	☐	☐	☐	☐	☒	☐	☐	Soil depth
Coarse fragments	☐	☐	☒	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Coarse fragments	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
Soil depth	☐	☐	☒	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Soil depth	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
CaCo3 (%)	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)

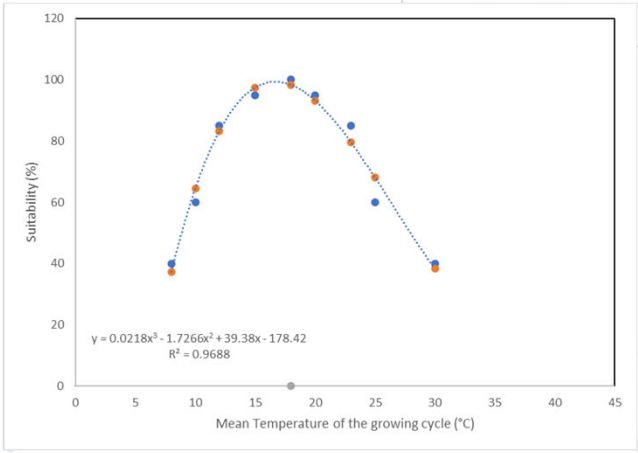
Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

Climátic Forecast Data

WHEAT (*Triticum aestivum*)			CLIMATIC REQUIREMENTS						
			Class, degree of limitation and rating scale						
Climatic characteristics		VAR	S1			S2	S3	N1	N2
			100	95	85	60	40	25	0
Moisture	Precipitation of growing cycle (mm)		700 700	450 1000	350 1250	250 1500	200 1750	- -	< 200 > 1750
	Monthly rainfall vegetative storage (mm)		65 65	45 90	20 120	12 > 120	8 -	- -	< 8 -
	Monthly rainfall flowering stage (mm)		75 75	60 90	30 120	15 > 120	10 -	- -	< 10 -
	Monthly rainfall of ripening stage (mm)		60 60	50 70	30 100	10 120	< 10 > 120	- -	- -
Temperature	Mean Temperature of the growing cycle (°C)		18 18	20 15	23 12	25 10	30 8	- -	> 30 < 8
	Mean temperature of the vegetative cycle (°C)		10 10	8 12	6 18	4 24	2 28	- -	< 2 > 28
	Mean temperature of the flowering stage (°C)		18 18	14 22	12 26	10 32	8 36	- -	< 8 > 36
	Mean temperature of ripening stage (°C)		20 20	16 24	14 30	12 36	10 42	- -	< 10 > 42
Thermal amplitude	Average daily min temperature of the coldest month combined with average daily max temperature of coldest month (°C)		< 8 if < 21	-	> 8 if < 21	8-19 if > 21	> 21	-	-





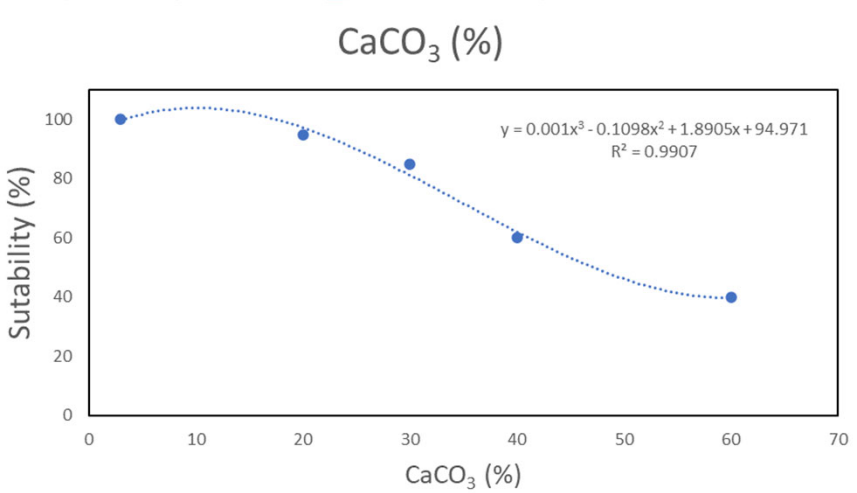
A spatial database (13 km of spatial resolution) with the climatic forecast data that includes precipitation, temperature or relative humidity (among others) in the desired time period(2031-2090). Including a reference period from 1986-2005.

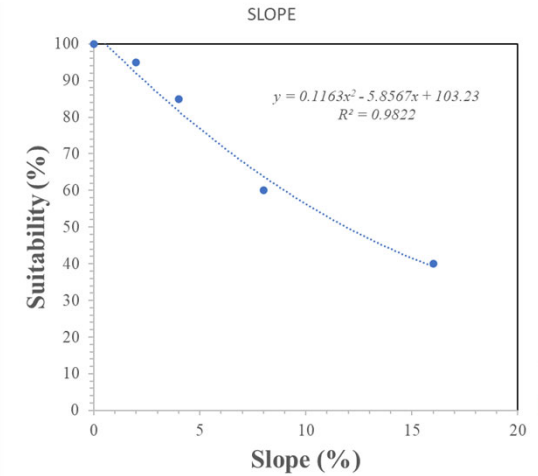
Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

Soil Data

WHEAT (*Triticum aestivum*)		LANDSCAPE AND SOIL REQUIREMENTS						
		Class, degree of limitation and rating scale						
Land characteristics		VAR	S1			S2	S3	N1	N2
			100	95	85	60	40	25	0
Topography	Slope (%)	(1)	0	1	2	4	6	-	> 6
		(2)	0	2	4	8	16	-	> 16
		(3)	0	4	8	16	30	-	> 30
Wetness	Flooding		F0		F1	F1/F2	F2	-	F3+
	Drainage	(4)	good	good	moderate	imperfect	poor and aeric	poor but drainable	poor > not drainable
		(5)	imperfect	imperfect	moderate	good	poor and aeric	poor but drainable	poor > not drainable
Physical soil characteristics	Texture / structure		C<60s, SiC, Co, Si, SiL, CL	C<60s, SiC, Co, Si, SiL, CL	C>60v, SC, C>60s L	C>60v, SCL	SL, LfS	-	Cm, SiCmLcS, fS, cS
	Coarse fragm (vol%)		0	3	15	35	55	-	> 55
	Soil depth (cm)		> 90	90	50	20	10	-	< 10
	$CaCo_3$ (%)		3	20	30	40	60	-	> 60
	Gypsum (%)		0	3	5	10	20	-	> 20
Soil fertility characteristics	Apparent CEC (cmol(+)/kg clay)		> 24	24	16	< 16(-)	< 16(+)	-	-
	Base saturation (%)		> 80	80	50	35	< 35	-	-
	Sum of basic cations (cmol(+)/kg soil)		> 8.0	8.0	5.0	3.5	2.0	< 2.0	-
	pH H_2O		7.0	6.5	6.0	5.6	5.2	< 5.2	-
			7.0	7.5	8.2	8.3	8.5	-	> 8.5
	Organic carbon (%)		> 1.5	1.5	0.8	< 0.8	-	-	-
		(6)	> 2.5	2.5	1.5	1.0	< 1.0	-	-
		(7)	> 1.5	1.5	1.0	0.5	< 0.5	-	-
		(8)	> 0.6	0.6	0.4	< 0.4	-	-	-
Salinity and alkalinity	Electrical conductivity - ECe (dS/m)		0	1	3	5	6	10	> 10
	Exchangeable sodium percentage - ESP (%)		0	15	20	35	45	-	> 45





JRC, Shuttle Radar Topographic Mission data (SRTM)
https://srtm.csi.cgiar.org/download/

A spatial database with the physical and chemical soil characteristics data that includes the topography, wetness, physical and fertility soil characteristics, salinity and alkalinity among others.

Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

Weights

REXUS

Exercise

VB- 26/07/2022

Part I: Variables

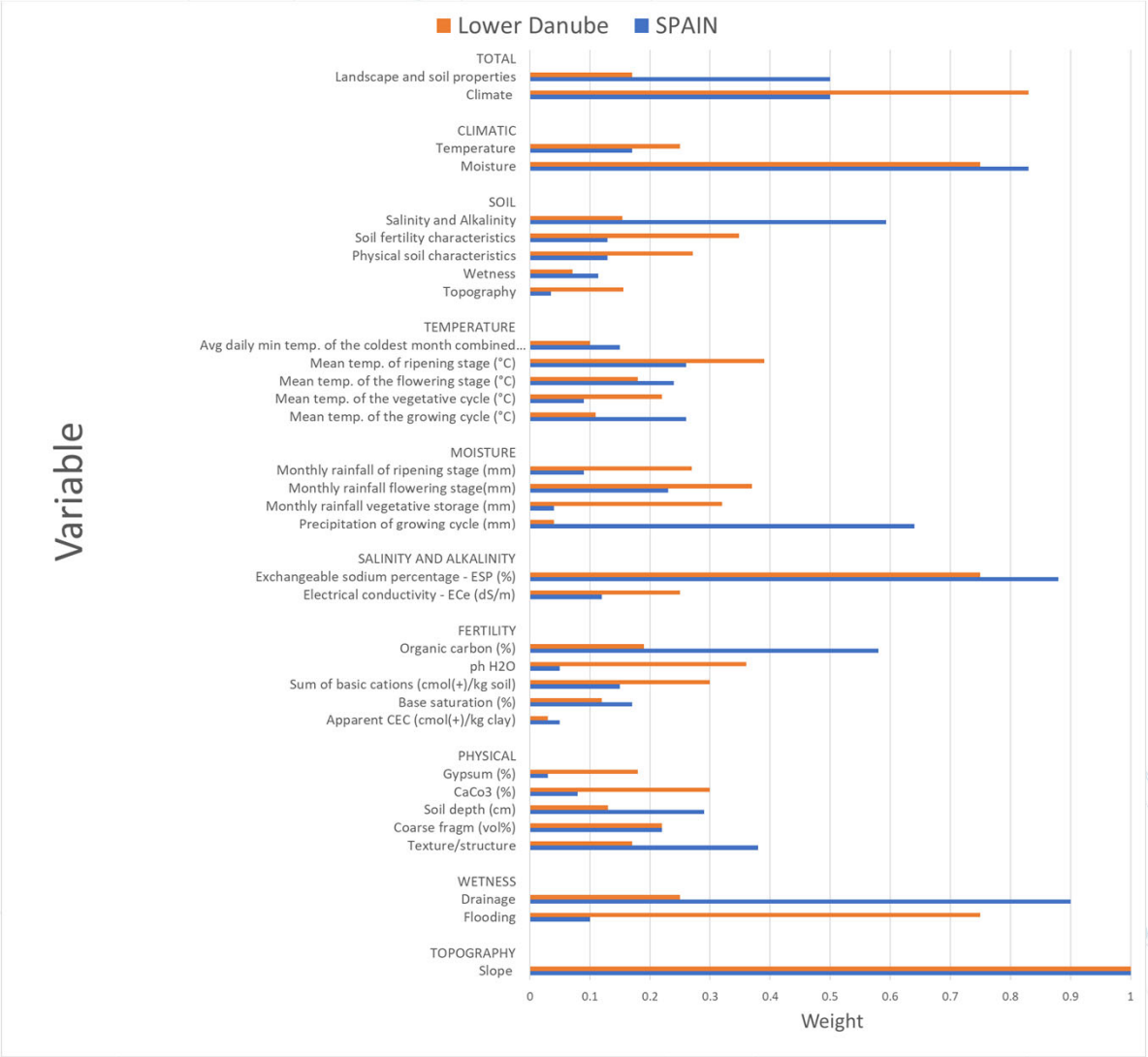
LANDSCAPE AND SOIL REQUIREMENTS

Wetness

	Absolute importance				Equal importance				Absolute importance	
Flooding	☐	☐	☐	☐	☐	☐	☐	☐	☒	Drainage

Physical soil characteristics

	Absolute importance				Equal importance				Absolute importance	
Texture / Structure	☐	☐	☐	☐	☒	☐	☐	☐	☐	Coarse fragments
Texture / Structure	☐	☐	☒	☐	☐	☐	☐	☐	☐	Soil depth
Texture / Structure	☐	☒	☐	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Texture / Structure	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
Coarse fragments	☐	☐	☐	☐	☐	☐	☒	☐	☐	Soil depth
Coarse fragments	☐	☐	☒	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Coarse fragments	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
Soil depth	☐	☐	☒	☐	☐	☐	☐	☐	☐	CaCo3 (%)
Soil depth	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)
CaCo3 (%)	☐	☒	☐	☐	☐	☐	☐	☐	☐	Gypsum (%)



Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

LUS index classification

- ✓ CALCULATION OF LUS FOR EACH INPUT PARAMETER GROUP: The calculation will use a linear equation considering the weighting factors determined previously:

where:
w = weight
x = var1, var2, var3... is the input parame

$$y_1 = \sum_{j=1}^{n} w_j \times x_{ij}$$

- ✓ DETERMINATION OF WEIGHTING FACTORS FOR EACH INPUT PARAMETER GROUP: For each input parameter group, a weighting factor will be determined using the same procedure. This step results in a weighting factor (0-1) for each input parameter group

- ✓ CALCULATION OF TOTAL LSU: The calculation will use same linear equation considering the weighting factors of the parameters group.

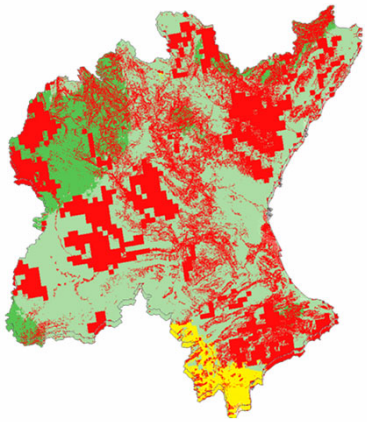
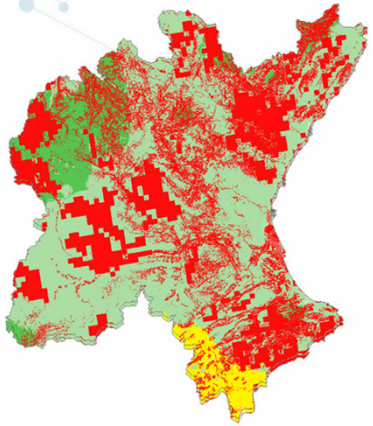
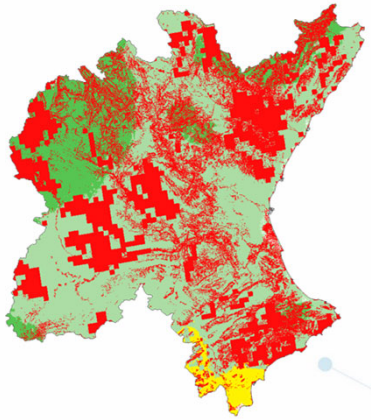
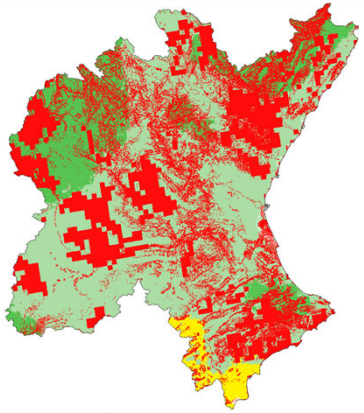
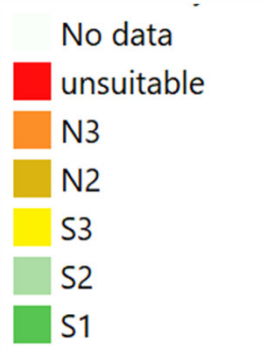
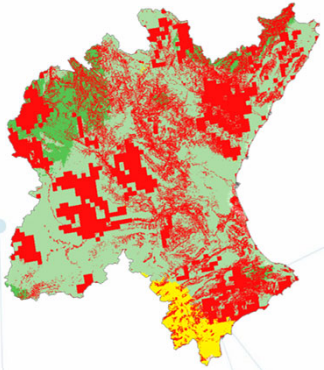
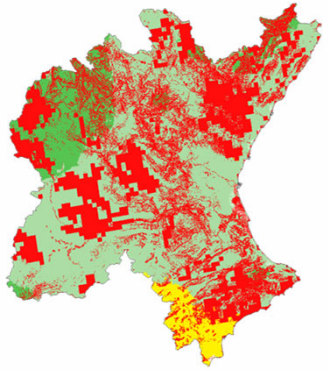
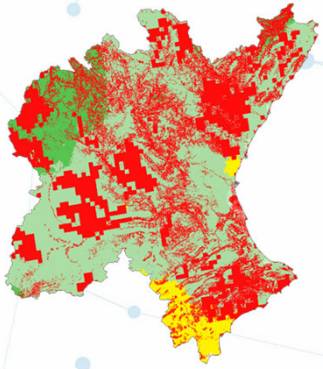
- ✓ GROUPING INTO SUITABILITY CLASSES:

FAO suitability classes	Characterization	Performance/Score Sys et al., (1991)
S1	Highly suitable	100-85
S2	Average suitable	85-60
S3	Marginal suitable	60-40
N1	Temporary unsuitable	40-25
N2	Permanently unsuitable	< 25

Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

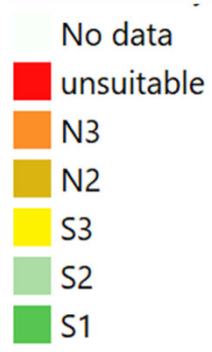
WHEAT LUS Jucar River Basin

REFERENCE	2030-2050	2050-2070	2070-2090	RCP
				4.5
				8.5

Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

WHEAT LUS Lower Danube River Basin

REFERENCE	2030-2050	2050-2070	2070-2090	RCP
				4.5
				8.5

Funded by the European Union

DRAXIS agriSat Iberia S.L. UCLM Universidad de Castilla-La Mancha Teledetección y SIG Instituto de Desarrollo Regional Universidad Castilla-La Mancha REXUS

DRAXIS

agriSat Iberia, S.L.

UCLM Universidad de Castilla-La Mancha
CAMPUS DE EXCELENCIA INTERNACIONAL

Teledetección y SIG
Instituto de Desarrollo Regional
Universidad Castilla-La Mancha

from Nexus Thinking to Nexus Doing

REXUS

Thank you!

Joan Miquel Galve Romero (UCLM) joanmiquel.galve@uclm.es

@rexusproject | Rexus Project | info@rexusproject.eu | www.rexusproject.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003632.