



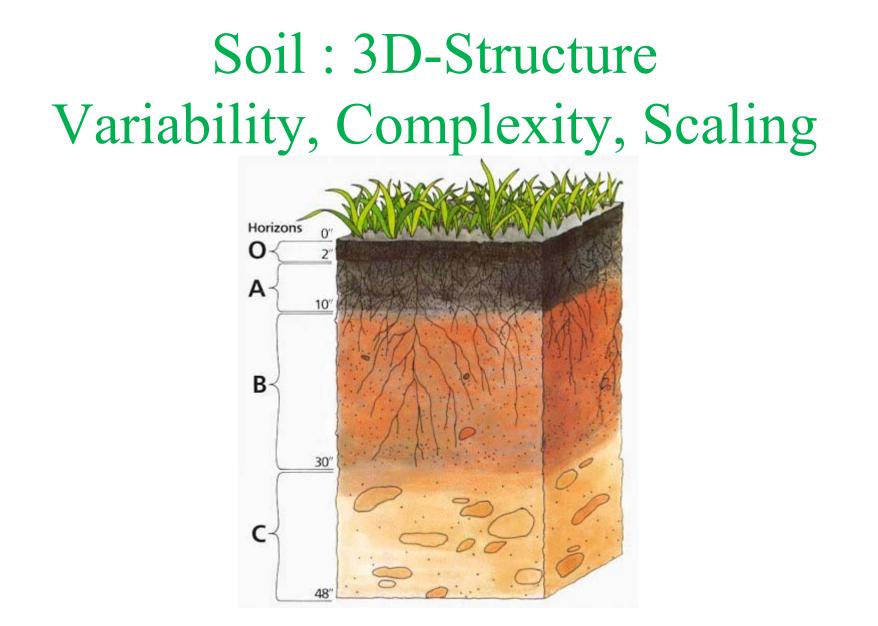
Development and implementation of GIS LIS for waste reuse on soil

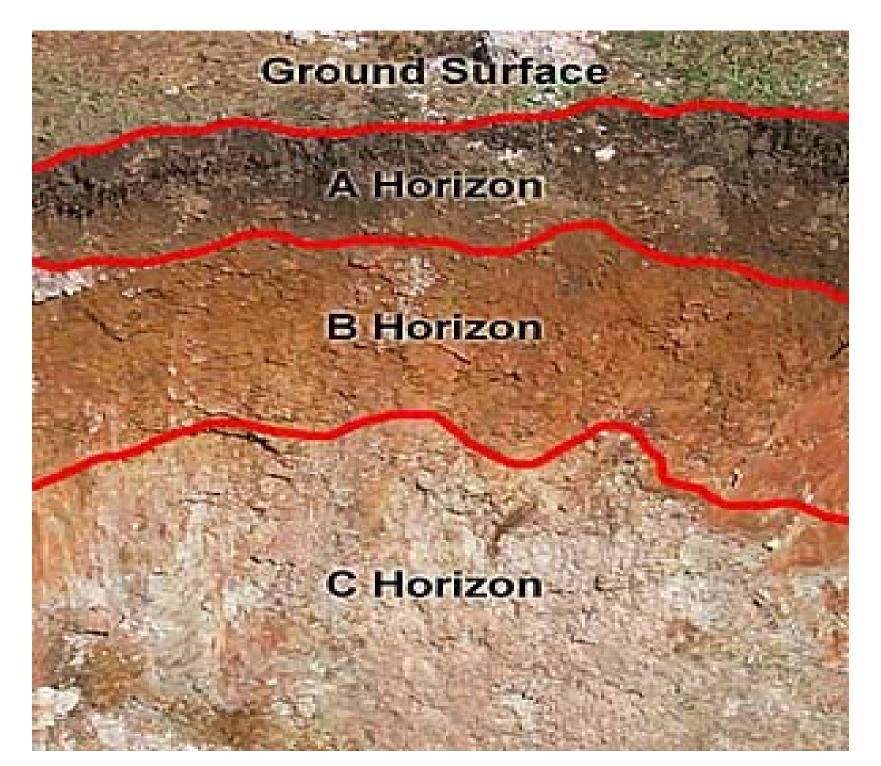
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The Presentation

- Safe Reuse of Wastes on Soil
- Soil/Land:
 - Properties, functions, Threats
- The European Dimension of Threats
- GIS-LIS for land classification:
 - Structure, Uses, Input, Output
- Extrapolation to the EU Med Counties
- Conclusions
- Aknowledgements





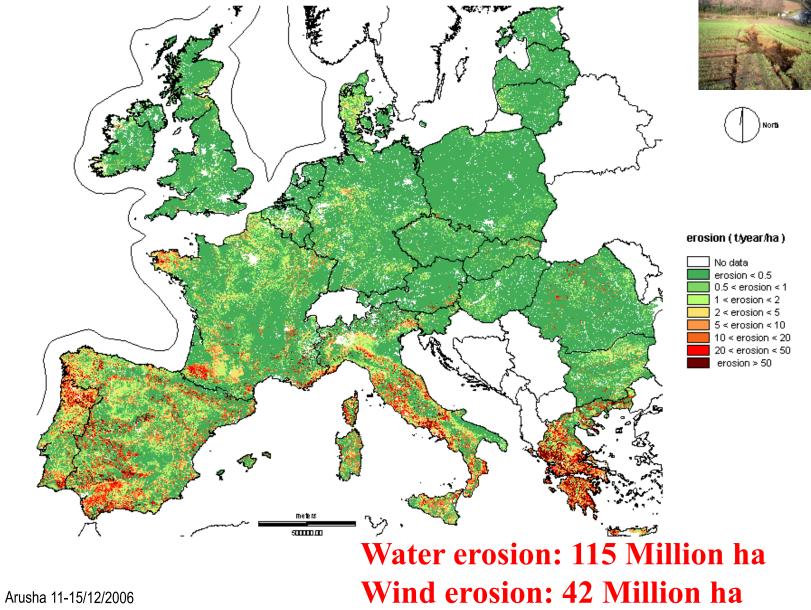
Soil Functions/Processes

- (a) food and other biomass production, including in agriculture and forestry;
- (b) storing, filtering and transforming nutrients, substances and water, as well as replenishing bodies of groundwater;
- (c) basis for life and biodiversity, such as habitats, species and genes; (1g=6.000 sp/genotypes B/F)
- (d) physical and cultural environment for humans and human activities;
- (e) source of raw materials;
- (f) acting as carbon reservoir;
- (g) archive of geological, geomorphological and archaeological heritage.

Threats to European soil

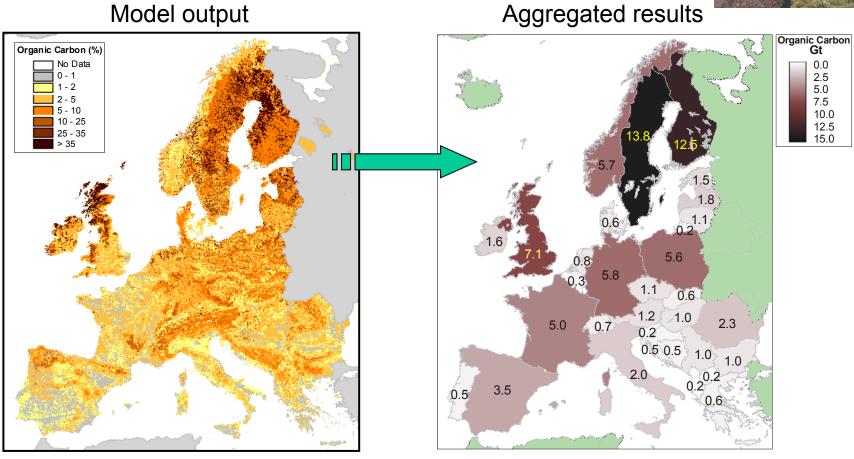
- Erosion
- <u>Decline in organic matter</u>
- <u>Soil contamination</u>
- Soil sealing
- Soil compaction
- <u>Decline in soil biodiversity</u>
- Salinisation
- Floods and landslides

PESERA Soil Erosion Risk Assessment





Topsoil Organic Carbon Content (30cm)



Organic carbon content (%) in the surface horizon (0-30 cm) of soils

National Soil Organic Carbon stocks (0-30cm) in Gt

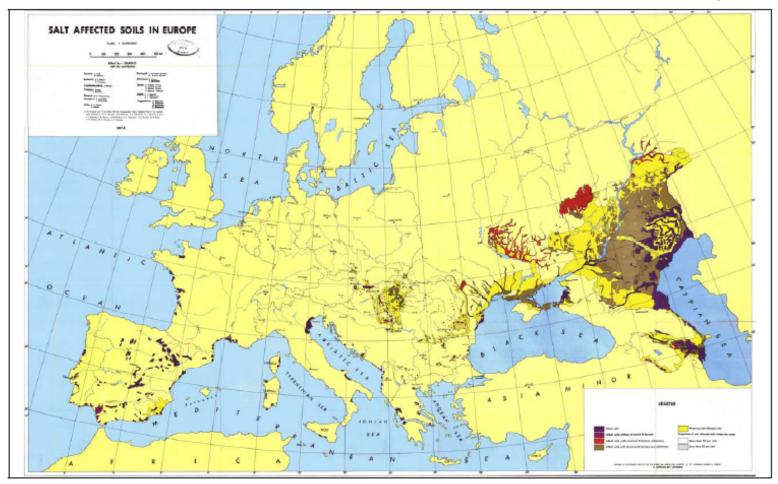
Organic matter decline

Arusha 11-15/12/2006



Soil Salinisation in Europe

Salinisation affects around 3.8 million ha in Europe

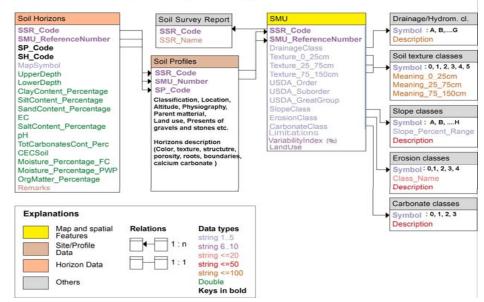


GIS-LIS for Land Classification

- 1. Structure
- 2. Data
- 3. Uses-Output
- 4. Soil Thematic Maps
- 5. Production of Land suitability maps for pistachios wastes application
- 6. Shape file suitable for Cultivation Management Software of Agrostrat

NAGREF-SSIA Greece

(Map scales 1: 20 000, 1: 50 000, 1: 100 000)



Atribute Table with Analyses

Τ		Shape'	BUAM	parage.	XEGSA	VESSA	SDEKMAT	MECANING	CAC03	ER_CAC03	OPIG_OUSAN		P		BA .	CA	885	PE.	CIE	.231		80	UAK	phy.
C		O Point		Aecec	5889993	3917503	KI.	0.	3		2	200	4	4	0	28	3	5	- 2	- 1	26	3	39	72
E		1 Point	MUD.	April 10	500699	3917681	H10	90.	- 4			70	- 21	0	\$	11	3	- 21	1	- 2		- 2	15	8.9
Ľ		2 Fort	94100		5530980	3913775	H100	901-51	10		3	190	75	0	0	. 6	1	11	2	5	7	-3		8.0
I		3 Ford	101.01		592589	3913335		90L-5L	10		2	240	26	0	0	7	0	10	0		24	3	8	8.8
I		4 Point		Mach	592934	2013618		h	0			130	- 6	0	0		1	18		1	32	- 3	8	5.6
		6 Point	H105	Drepart	500160	3912621		a.	0		2	110	Ø	0	0	- 6	2	5	0	- 0	-4	2	0	5.7
1		6 Point		North	593034	3912138		a.	i0		2	165	10	0	0	- 4	1	19	.2	1	71		8	5.1
		7 Point		(level)	580282	2011897		501	0		3	215	. 9	. 0	0			16		. 1		2	9	5.7
		6 Point	#106	Kepsk	593922	3011747	H105	<u>k</u>	15		2	- 96	. 0	0	0		0	- 4	- 0	- 0	- 4	3		7.3
1		9 Point	985027	Minitaje.	595145	3907196		C		10,37	1	145	- 30	1	U	17	2	- 6	15	2	7	3	15	7.3
		0 Forst		Maktp	595267	3906935		C.	16		3	105	5	0	0)	24			- 3	1	- 4	- 4	26	7.4
	1	1 Fold	0109	Keglet .	595300	2906015	K109	CL.		14,75	3	155	88	1	0	10	- 2	7	13	3	5	3	13	7.5
		2 Point		Auger	500627	3917635	811	0.01	0		D	75	2	1	0	12	7	- 6	0	. D	7	3	36	1.5
		3 Point	(#110)	Tapta	595544	3907250		C/GL		14,12	2	155	- 24	1	¢		1	6	16	- 2	24	2	16	7.2
		4 Point		Keyko	595426	2907254		α,		13,62	2	155	1.3	1	0	12	+	- 11	26	- 3	5	2	14	7
I		5 Foirt	H112	Houpé	599012	3908101	H112	a,		13	2	115	- 21	0	0	11	1	6	19	2		. 2	12	72
I		6 Point	(4113	Adulter	590534	3908401	H113	a.		7,12	3	110	20	. 4	0	11	1		10	2		2	13	7.2
	1	7 Foirt	0014	Dettook	\$94993	3907998	90114	α.	6		1	115	6	0	0	- 35	1	8	1		15	- 2	37	7.4
	. 5	8 Poet	34115	Expelify	594636	3907773	HTTS .	α,	19		2	120	62	4		15	-4	7	7	5		2	-21	7.3
		9 Fort		Tepert	594029	3907428		а,		0,75	2	140	15	0	0	13	2	. 7			. 5	. 2	18	7.3
	3	0 Poet	8317	Noord	594408	3906553	R117	3.	15		1	100	12	0	0	16	1	6	5	- T		3	17	7.2
	- 2	1 Post	A218	Hound	594545	3906747	H118	50.	.56	17,5	2	145	5	0	0	13	1	6			-4	3	14	7.2
		2 Point		Hourie	595432	2907870		а,	40	11,25	2	145	20	0	0	7	2	7	26	. 1	-4	- 3	10	7.5
	2	3 Point	H12	Aspor	506490	2017613	H12	51.	- 4		2	125	20	0	0	- 47	-2	12	- 5	3	- 4	- 2	28	7.3
I	- 3	4 Point	H120	Merrogr	596193	3900612	H120	50L-5L	24	0.25	31	90	7	0	0	. 11		5	0	1	3	3	12	7.4
		5 Point		Haver	554850	3904686		α.	26		1	65	.3	0	D	16	- 4	5	1	. 0	- 2	3	20	7.6
	2	6 Foint	98122	Trilpal.	596345	3905264	K122	C.	- 41	16	2	165	15	4	0	18	2	- 6	11		7	2	20	7.3
	- 2	7 Port	8122	drapper .	595263	3905509	R123	a.	36		1	90	0	0	0	11	2	5	7	1	. 2	. 3	13	7.4
	2	6 Foirt	0124	Волил	595018	2905578	H124	50L	31	5	0	50	3	0	0	15	3	6	1	. 0	2	1	17	7.5
	- 2	9 Fort	3125	Linus	595704	3905523	H125	c	45	18	1	65	5	0	0	14	1	-7	2		3	2	15	7.5
		C Point		00000	\$99662	2905194		¢.	47		2	145	17	0	0	75	1	5	-5	1	5	- 2	18	72
	3	t Point	WH27	04400	595537	2904937	H127	c	46	19		115	12	0	0	- 20	. 1	5	9		3	-3	-22	7.1
		2 Point		Npin	595463	3004765	K128	C	1		2	135	20	0	0	7	3	5	3	- 2	2	3	10	7.1
	3	0 Point	H129	Adread	596556	3906273	K129	¢	45	10	3	145	19	0	0	14	1	5	3	1	4	2	16	7.5
Т	3	4 Post	H13.	Michan	506217	3917283	H13	52.	3			90	27	0	0		1	7	+		7		- 21	7.1
		6 Fort	H130	NUT	596723	3906413		ca.	43		2	135	11	0	0	12			3	- 0	4	2	13	7.3



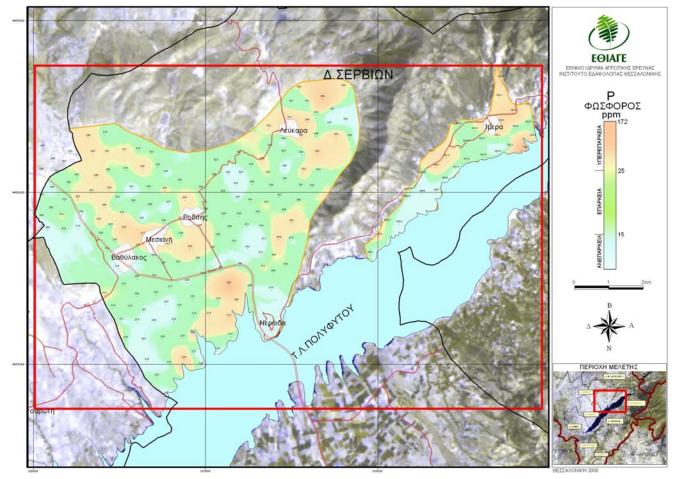
🥥 GS Soil

Attribute Table Mapping Unit Description

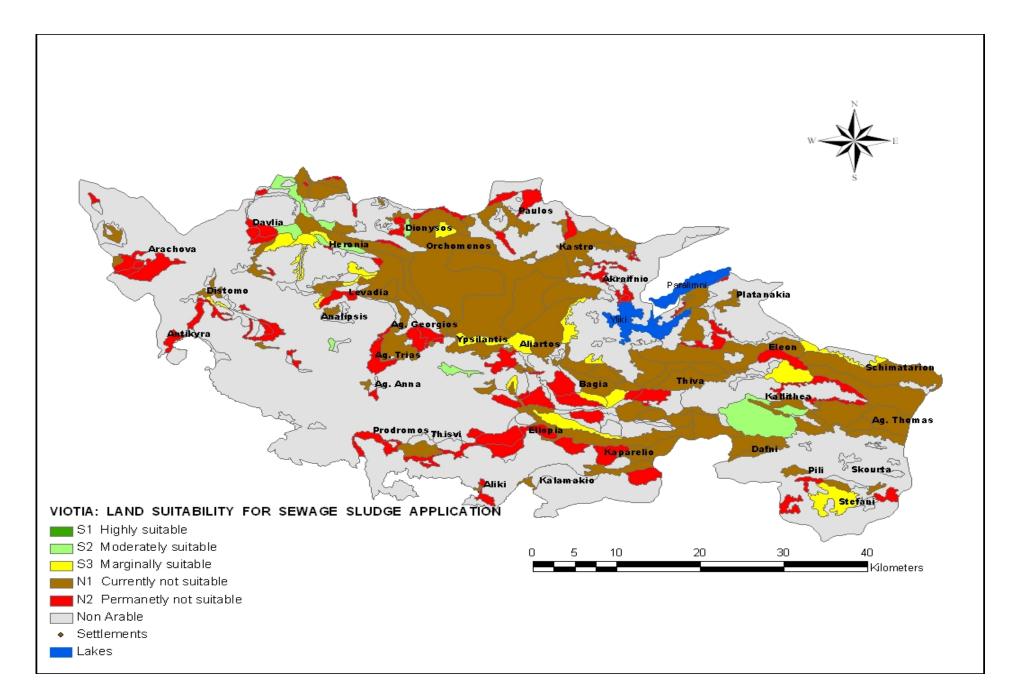
NATE

Т	10	Shape'	STRING	1	2	3	4	- 6	6	7	. 9	10	11	112	13	8003	200008	MELETI	AR_DEJ	KAT	EP
1	0 F	Palygon	2	A.	0	0	4*	10	0	×	D	1	0	lis,d		X	ALCOOR	00052	ABox	Driollis,d	004*
i F	1.0	Polygon	1	A.	3*	0	4*	E	0	×	С	2	0	Ro.d		ж	ATOOB	80052	A80x	C20lls,d	3'04'
1	2)	høygen	3	A	0	0	4*	Æ	0	H	c	1	2	No.d		×	BORO/RA	80062	A80x	C12V9,#	004*
	3.5	Palygon	5	Ð	3*	3*	4*	1	0	×	A	Ð	2	id.		x	ALC:00	80052	Blos	A02ki	313141
	4.5	Polygon	4	A.	2*	3*	4*	E.	0	×	Ð	1	1	Re.d		ж	ALCIO	80052	ABox	Eti18x,d	2*3*4*
1	5.	helygon	8	A	3*	3*	4*	E	0	×	c	2	3	Rg		х	BOROTIA	80062	A	C2386	3*3*4*
	6.5	Palygon	7	A.	0	ů.	4*	6	0	×	C.	- 2	0	80,4		×	All:08	80052	A	C20llic,d	004*
	7.5	Palygon	8	A.	0	0	4*	C.	0	x	D	2	0	Rd,z		ж	ALCIO	80052	ABox	C20Md,x	004*
1	81	helygon	9	A	0	0	4*	E	0	×	D	3	0	89.6		ж	BOROTIA	80062	A80x	0308p,d	004*
1	- 9.9	halygan	10	A.	0	0	4*	Æ	0	×	F	3	0	85,4		×	Afrose 8	80062	A	F308s.4	004*
	10 F	Palygon	11	A.	0	0	2	c	0	×	С	2	3	Ht.d		ж	AITCH08	80052	ABox	C2388,d	005*
	11 8	Polygon	15	A	3*	3*	3*	1	0	×	A	D	0	M		ж	ATCIO	80052	A	AODH	3'3'3'
1	12 8	høygen	14	A.	3*	3*	30	1	0	н	A	Ð	3	14.8		×	BORO/RA	80062	A	A0384.g	3*3*3*
	13 F	Palygon	12	A.	3*	3*	4*	0	0	×	E	2	0	Htt./d		ж	All:00	80052	AEox	0208s,d	313141
	14 8	Polygon	13	A.	0	0	3*	E	0	x	С	2	1	Rc.z.d		ж	ATC/08	80052	ABox	C21llc,x,d	003*
	15.8	hitygon	18	Ð	3	3	4	1	0	×	A.	0	3	łg		×	Afrose	80082	Blox	A039	334
	16 F	Palygon	19	A.	0	0	4*	6	0	*	E .	3	3	kd.		x	ALC:00	80052	AEox	63364	004*
	17 F	Polygon	21	A.	0	0	4*	C	0	x	D	1	3	Rd		ж	ALCIO	80052	ABox	EH 38d	004*
	18.7	helygon	17	A	0	0	4*	e	0	×	C	3	3	R6,5		х	BOROTIA	80062	A80X	C3386,0	004*
1	18.8	Palygon	24	A.	0	0	24	6	0	×	8	0	2	85,4		х.	Alf:06	80062	A	80286,4	003*
	20 F	Palygan	23	A.	0	0	2	C.	0	×	с	3	3	la,d		ж	ALCING	80052	ABox	C33ks,d	005*
	21 8	Polygon	22	A	2*	0	39	e	0	×	B	D	2	Ro , di		х	BOROTIA	80062	A80x	802ks,d	2*03*
	22 8	høygen	28	A.	3*	0	4*	E	0	×	Ċ.	- 2	- 0	85,63		×	Afrose	60062	A	C2084,40	3'04'
	23 F	Palygon	25	A.	3*	0	4*	0	0	×	A.	D	3	Rd .		ж	ATC/00	80052	ABox	A036d	3104*
	24 8	Polygon		A.	0	0	4*	E	0	×	С	2	3	Ro,d.g		ж	ATCIO	80082	A800	C238b;6.p	004*
	25.9	helygen	28	A.	4	3	82)	0	н	¢	2	3	88,63		×	Afrose	60062	A	C2384,6,8	4397
	26 F	Palygon	20	A.	0	0	4*	0	0	26	0	3	3	in #		ж	All:00	80052	ABox	000ks,t	004*
	27 8	Polygon	19	A.	0	0	4*	E	0	x	D	3	3	H.		ж	ATOIOB	80052	ABox	D33M	004*
1	28.9	helygen	88	A	4	3	4	1	0	×	8	1	1	Po gr		x	BORO/RA	80062	A	8118.0	434
	29 F	Palygon	67	C.	4	3*	4	1	0	26	8	1	2	is g		x	Alf:09	80062	Cbox	012kr,g	43*4
	30 F	Palygon	50	A.	14	0	2*	E	0	x	A.	D	3	Rdp		ж	ATCIO	80052	ABox	A038d.t	1*02*
	31.1	helygon		B	3*	2*	3*	E	4	×	A	0	3	R,d		ж	Afr:06	80082	8Eft	A038,d	3*2*3*
	32 6	halygon	58	A.	14	ů.	4*	6	0	×	8	1	3	84		×	Alf/309	60062	A	En 38d	1'04'
	30 F	Palygon	57	A.	0	0	24	c	0	×	С	2	3	Rd .		ж	AITCHOR	80052	ABox	C238d	0024

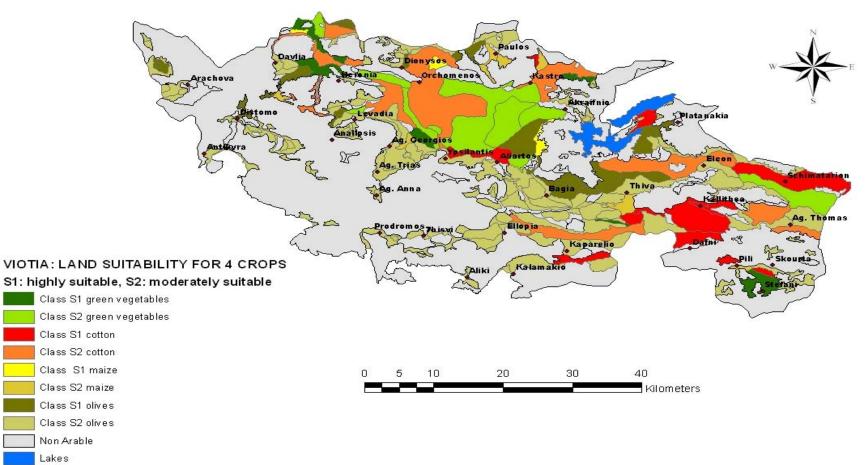
P-Olsen in the soils of the Municipality of W.Serbion.



Land Suitability map for sewage sludge application

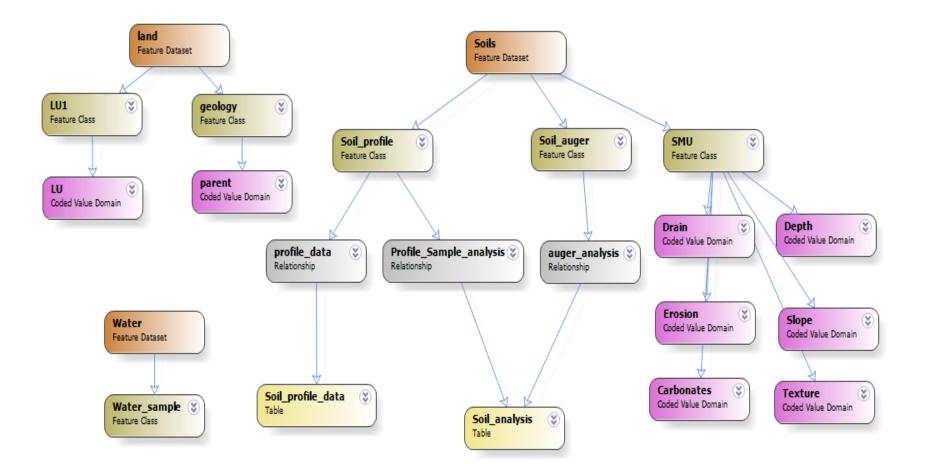


Land planning for maximum income

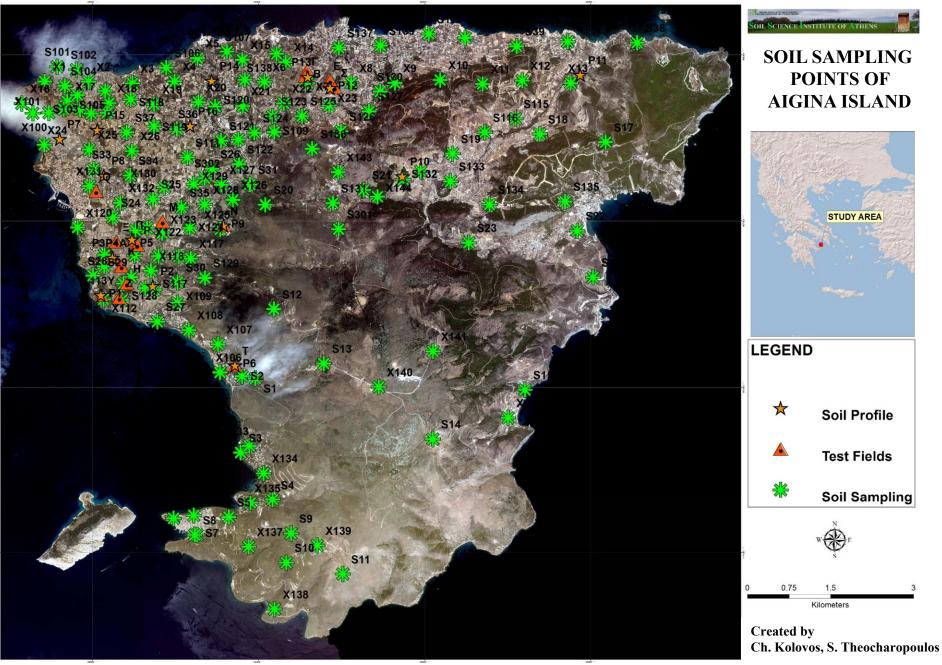


Settlements

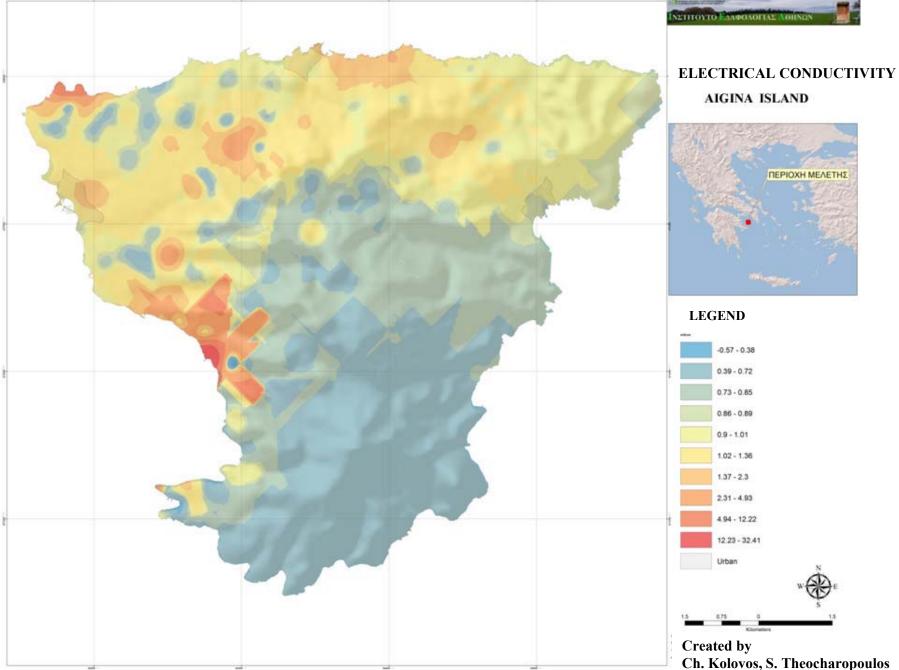
GIS-LIS developed for Aegina soils (Kolovos, 2014)



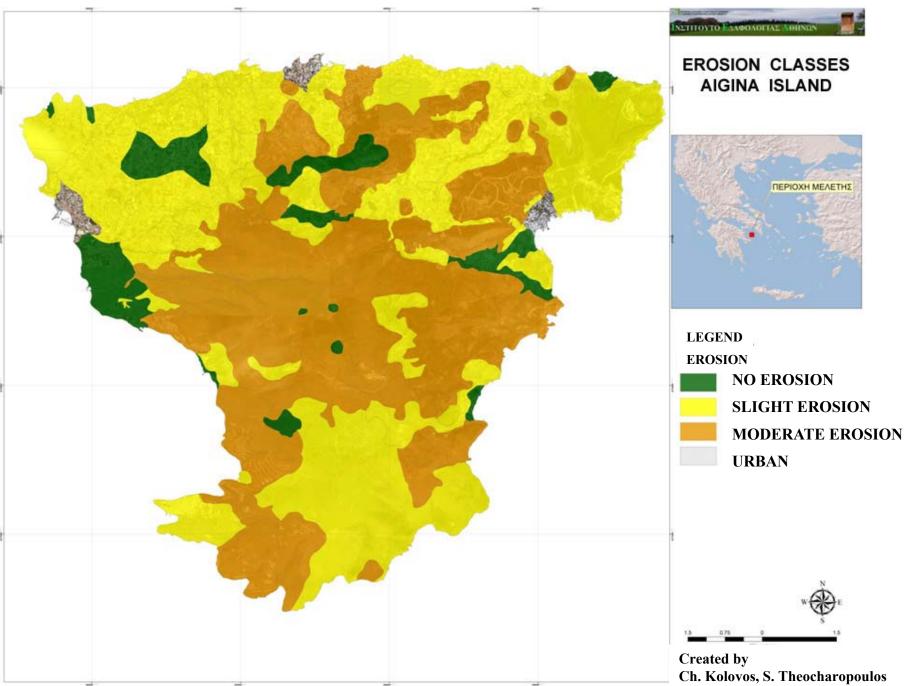
SOIL SAMPLING POINTS OF AIGINA ISLAND



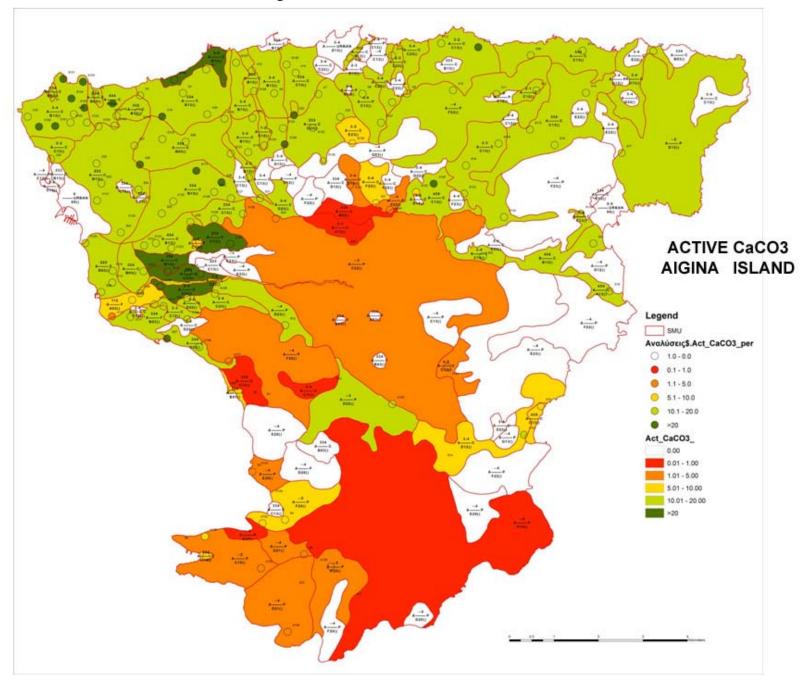
ELECTRICAL CONDUCTIVITY MAP OF AIGINA ISLAND



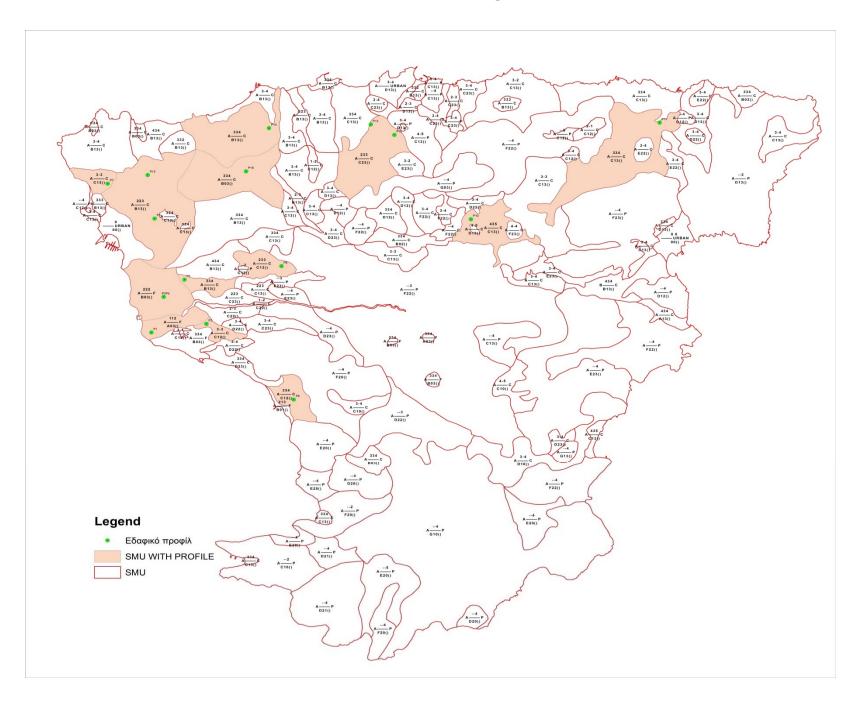
SOIL EROSION MAP OF AIGINA ISLAND



ACTIVE CaCO₃ MAP OF AIGINA ISLAND



SOIL MAP OF Aegina Island



GIS-LIS Extrapolation to EU Med areas

- Classification System (Land suitability)
- Guidance to find the required proper Soil Data:
 - 1. Download from existing GIS-LIS
 - 2. Evaluation
 - 3. Harmonization/Interoperability/INSPIRE
 - 4. Produce New data/Collect additional updated soil data
 - 5. Pedo-transfer functions/Multivariate techniques/geostatistical techniques
- Soil and Water monitoring/Evaluation
- Guidance from the Agrostrat Team

GIS-LIS Extrapolation to EU Med areas is Supported

- Groundwater vulnerability Assessment
- Life Cycle Analysis
- Offers a Holistic approach for agricultural waste management
- Tool for improvement of sustainability in sensitive and prone to desertification agricultural areas
- Soil and Water monitoring scheme NEEDED

 Table 4. Land Suitability Classes (FAO, 1976)

Suitability	Description
Classes	
S1 Highly Suitable	Land having no significant limitations to sustained application for given land use or only minor limitations. Nil to minor negative economic, environmental, health and/or social outcomes.
S2 Moderately Suitable	Land having limitations which in aggregate are moderately severe fo sustained application of a given land use. Appreciably inferior to S land. Potential negative economic, environmental, health and/or socia outcomes if not adequately managed.
S3 Marginally suitable	Land having limitations which in aggregate are severe for sustained application of a given use. Moderate to high risk of negative economic environmental, health and/or social outcomes if not adequately managed.
N1 Not Suitable	Land having limitations, which may be insurmountable. Limitation are so severe as to preclude successful sustained use of the land. Very high risk o negative economic, environmental and/or social outcomes if no managed.
N2 Not Suitable	Land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner. Almost certain risk of significant negative economic, environmental and/or social outcomes

FLOODED SOILS/Ground Water Gley



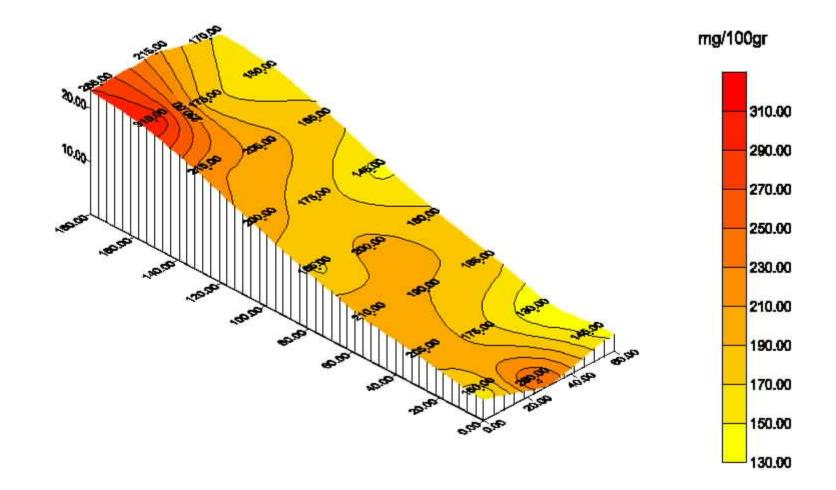
FLOODED SOIL/Surface water Gley

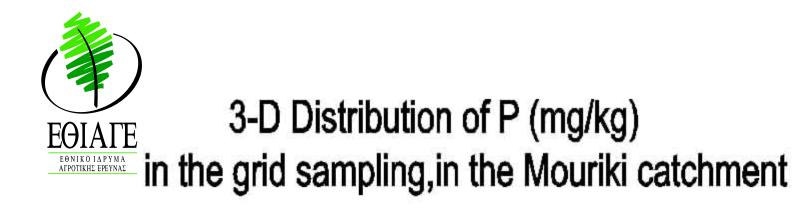


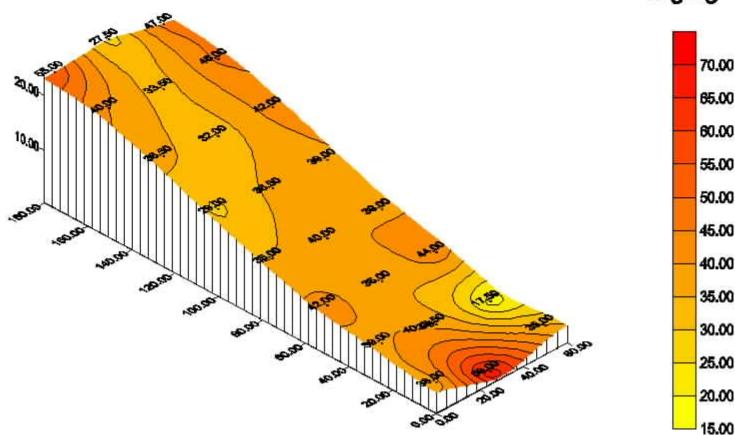
Vertic Soils/Cracked Soils



3-D Distribution of N (mg/100gr) in the grid sampling, in the Mouriki catchment







mg/kg

Shallow soils







Property/parameter		Su	iitability Cl	asses	
	S1	S2	S3	N1	N2
Drainage	A	B,C	D	Е	F.G
Slope, %	A	В	С	D	Е
Depth	6, 5	4	3	2	1
Erosion	0	1	2	3	4
On-site wastewater management	A	В	С	D	D
Salinity, dS/m	< 2	2-4	4-8	>8	
Infiltration rate, cm/h	2-8	0.1-2.0	< 0.1		
		8-16	16-50		
CEC, meq/100g	>15	8-15	<8		
ESP, %	0-6	6-10	10-15	15-25	>25
Total Nitrogen, %	<0.1	0.1-0.3	>0.3		
N-NO ₃ , mg/kg	<10	10-20	20-30	>30	
P-Olsen, mg/kg	<10	10-28	28-40	40-59	>59
Exchangeable K, cmol(+)/kg	< 0.26	0.26-1.2	1.2-2.0	>2.0	>2.0
DTPA Cu, mg/kg	<3	3.0-10	10-20	>20	
DTPA Zn, mg/kg	<2.9	2.9-8.1	8.1-13	> 13	
Polyphenols, mg/kg	<50			>50	

Table 12. Parameters for land evaluation for pistachio wastewater disposal

(Doula et al., 2015)

Property/parameter		Su	itability Cl	lasses	
	S1	S2	S3	N1	N2
Drainage	A, B	С	D, E	F	G
Slope, %	A, B	С	D	Е	Е
Depth	6, 5, 4	3	2	1	1
Erosion	0, 1	2	3	4	4
Salinity, dS/m	< 2	2-4	4-8	>8	
Infiltration rate, cm/h	2-8	0.1-2.0	< 0.1		
		8-16	16-50		
CEC, meq/100g	>15	8-15	<8		
ESP, %	0-6	6-10	10-15	15-25	>25
Total Nitrogen, %	<0.1	0.1-0.3	>0.3		
N-NO ₃ , mg/kg	<10	10-20	20-30	>30	
P-Olsen, mg/kg	<10	10-28	28-40	40-59	>59
Exchangeable K, cmol(+)/kg	< 0.26	0.26-1.2	1.2-2.0	>2.0	>2.0
DTPA Cu, mg/kg	<3	3.0-10	10-20	>20	
DTPA Zn, mg/kg	<2.9	2.9-8.1	8.1-13	> 13	
Polyphenols, mg/kg	<50			>50	

 Table 13. Parameters for land evaluation for pistachio solid waste/sludge disposal

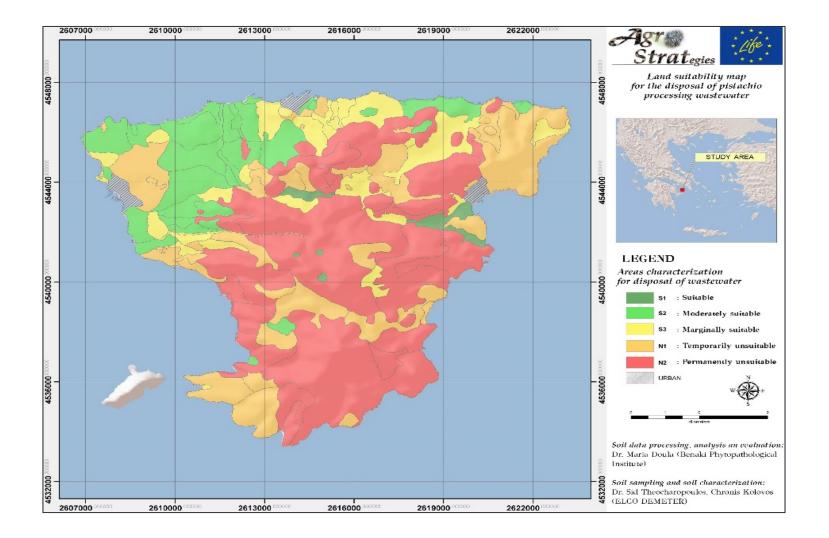
(Doula et al., 2015)

Property/parameter		S	Suitability Cl	asses	
	S1	S2	S3	N1	N2
Drainage	Х				
Slope, %		Х			
Depth	Х				
Erosion	Х				
Salinity, dS/m		Х			
Infiltration rate, cm/h	Х				
CEC, meq/100g	Х				
ESP, %		Х			
Categorization According to		Х			
physical properties					
Total Nitrogen, %	Х				
N-NO ₃ , mg/kg	Х				
P-Olsen, mg/kg	Х				
Exchangeable K, cmol(+)/kg					Х
DTPA Cu, mg/kg			Х		
DTPA Zn, mg/kg			Х		
Polyphenols, mg/kg		Х			
Although the suitability class of t	the area, cons	sidering phy	sical properti	es, CEC and	ESP is S2,
however, the concentration of	exchangeabl	e K of the ar	ea is extreme	ly high, there	efore the
disposal or reuse of the wastes m	ust not be all	owed. There	efore the area	is re-categor	ized as N2.

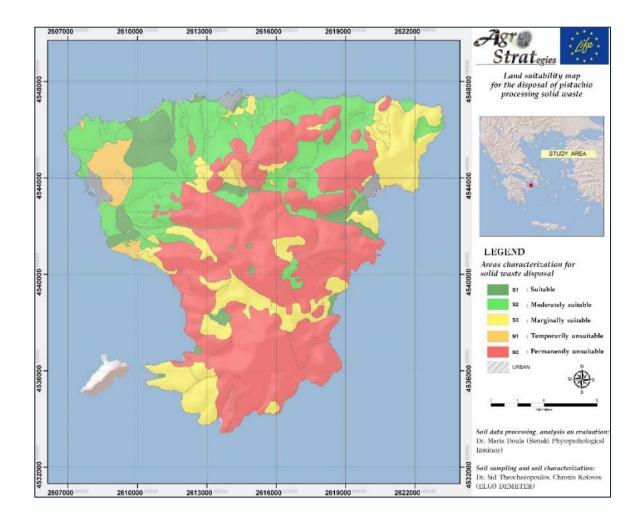
 Table 14. An example for categorization of a map unit for which one soil indicator belong N2 class.

(Doula et al., 2015)

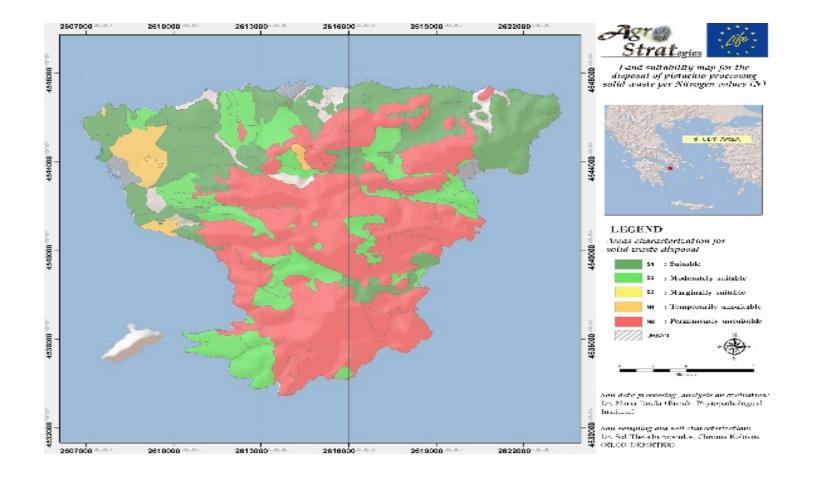
Land Suitability for pistachio waste water (Doula et al., 2015)



Land Suitability for pistachio solid wastes (Doula et al., 2015)



Land Suitability Map according to N content (Doula et al., 2016)



Conclusions/1

- Extrapolation of the GIS-LIS classification for Pistachios liquid and solid wastes to EU Med Countries:
 - The system described is web available
 - Existed Soil Data must be used :
 - Lucas Soil Data Base
 - ESDAC Raster Soil Data
 - ESDAC Vector Soil Data
 - National-Regional Soil Dbases/www.GSSOIL.eu
 - Existing soil data need:
 - Evaluation
 - Harmonization/ineroperability
 - Updating/new data/seasonal variability
 - Pedotransfer functions/multivariate /geostatistical techniques
 - Guidance from the Agrostrat Team
 - Evaluation by local experts

Conclusions/2

- GIS-LIS is supported by (TUC):
 - Groundwater vulnerability Assessment
 - Life Cycle Analysis
- Offers a Holistic approach for agricultural waste management
- Powerfull tool for :
 - Improvement of sustainability in sensitive and prone to desertification agricultural areas
- MONITORING SOIL and WATER

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