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ON THE SUSTAINABLE MANAGEMENT OF SEWAGE SLUDGE DISPOSAL IN APULIA

Lotito, A. M.^{1,2}, Blonda, M.², Fratino, U.¹

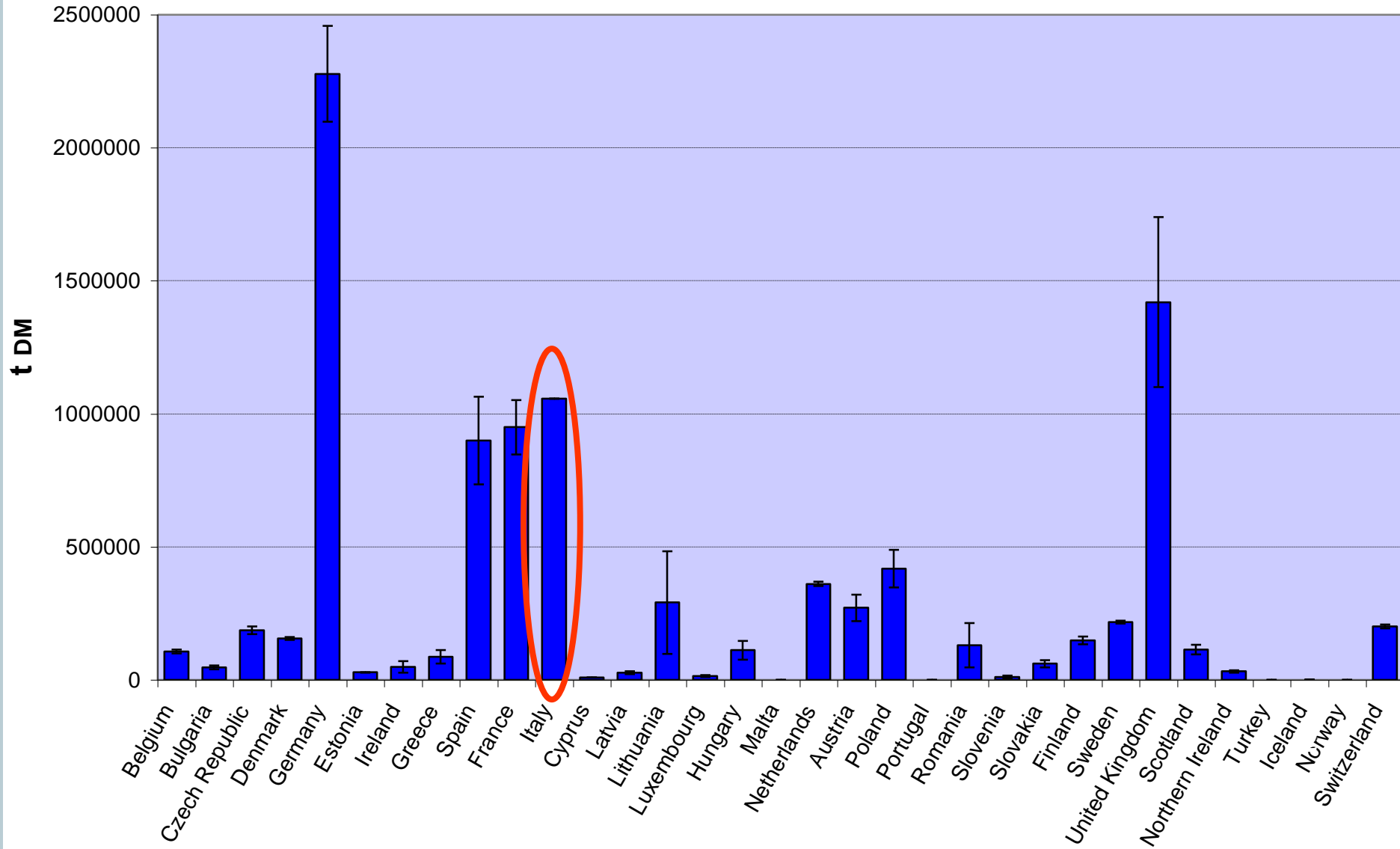
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**Wastewater and Biosolids Treatment and Reuse:
Bridging Modeling and Experimental Studies**

Otranto, 13th June 2014

EU: 10 million tons DM of sewage sludge per year



SEWAGE SLUDGE DISPOSAL

- sludge agricultural use (direct or as compost)
- landfilling
- incineration
- thermal treatments
- land reclamation
- incorporation in building materials



SEWAGE SLUDGE DISPOSAL

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- incineration
- thermal treatments
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SEWAGE SLUDGE

SLUDGE



organic
matter

nutrients
(N, P)

micro & macro
nutrients

pathogens

organic
contaminants

heavy metals
(Cd, Pb, Ni, Hg, Zn)

SLUDGE AGRICULTURAL REUSE

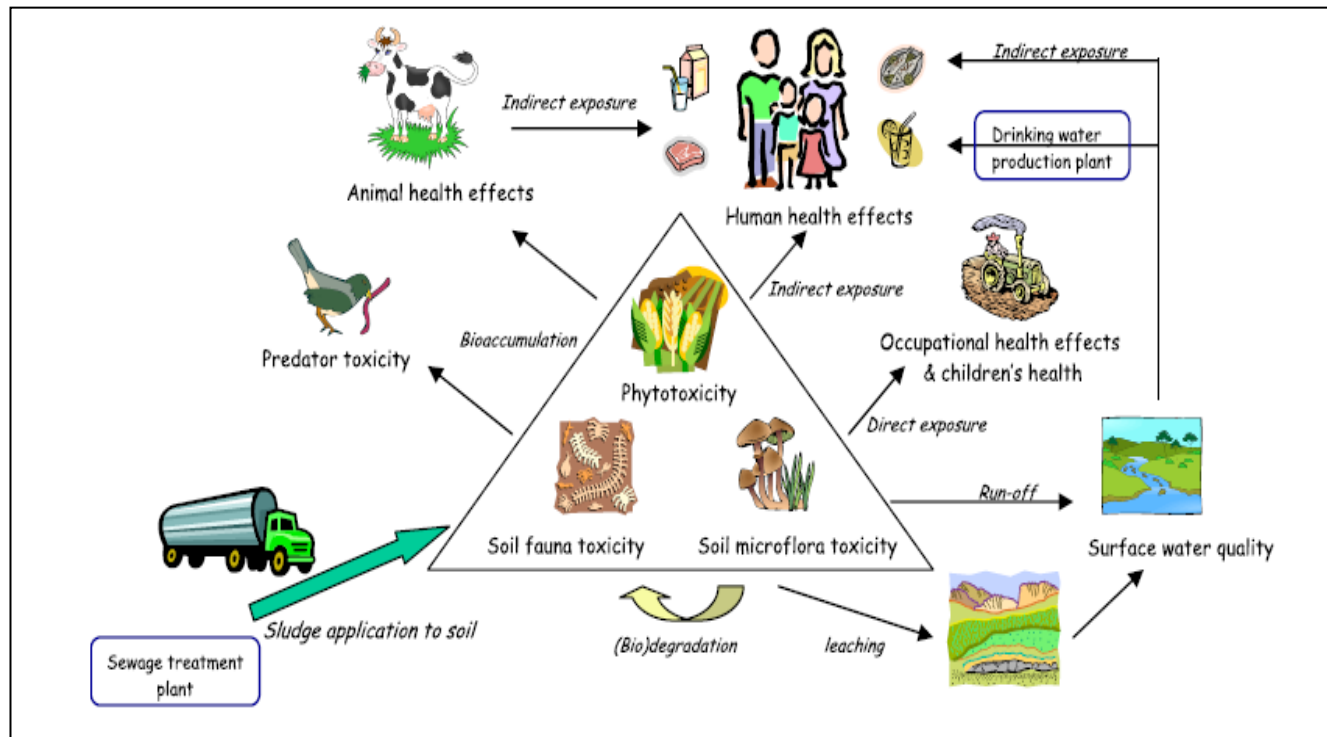
- most economic solution
- recovery of nutrients for plants → reduction of the spread of inorganic fertilizers on lands
- improvement of soil physical properties (soil structure, bulk density, soil moisture, compaction and aeration) through the addition of organic matter
- macronutrients (such as calcium, potassium and sulphur)
- micronutrients (copper and zinc)

BUT...

- toxic elements (heavy metals, organic contaminants)
- pathogens



potential threat to human health and environment



REGULATIVE FRAMEWORK

Directive 86/278/EEC

- encourages the application of sewage sludge in agriculture
- regulates its use to prevent harmful effects on soil, vegetation, animals and man



D. Lgs. 99/1992

Italian transposition



Regional legislation

DIRECTIVE 86/278/EEC

- sludge treatment before land application
“biological, chemical or heat treatment, long-term storage or any other appropriate process so as to significantly reduce its fermentability and the health hazards resulting from its use”
- maximum concentration values of heavy metals in soil and sludge
- maximum annual dose of heavy metals brought to soil

DIRECTIVE 86/278/EEC

- areas in which sludge application is totally banned or allowed only for limited periods
 - grassland or forage crops
 - soil in which fruit and vegetable crops are growing
 - ground intended for the cultivation of fruit and vegetable crops normally in direct contact with the soil and normally eaten raw
- agricultural sludge reuse = agricultural practice

“sludge shall be used in such a way that account is taken of the nutrient needs of the plants”

D. LGS. 99/1992

- possible use of both urban sewage sludge and industrial sludge of similar characteristics
- fertilizing and/or soil conditioning effect
- prohibition to use sludge containing toxic and noxious substances and/or persisting ones and/or bio-accumulating ones in such a concentration to result harmful to soil, cultures, animals, men and environment
- limits in heavy metal contents in soil and sludge
- maximum value for pathogens (Salmonella)

D. LGS. 99/1992

pH	Cationic exchange capacity (C.E.C.) [meq/100 g]	Maximum sludge applicable quantity [t_{DM} /ha in 3 years]
< 5	any	not allowed
any	< 8	not allowed
> 5	8 – 15	7.5
5 - 6	> 8	7.5
6 – 7.5	> 15	15
> 7.5	> 8	22.5

D. LGS. 99/1992

agricultural sludge reuse banned in:

- areas already recommended in Directive 86/278/EEC
- wet lands
- flooded or marshy areas
- frozen or snow-covered grounds
- landslides
- sloping lands (with slope higher than 15% if the dry matter content is less than 30%)

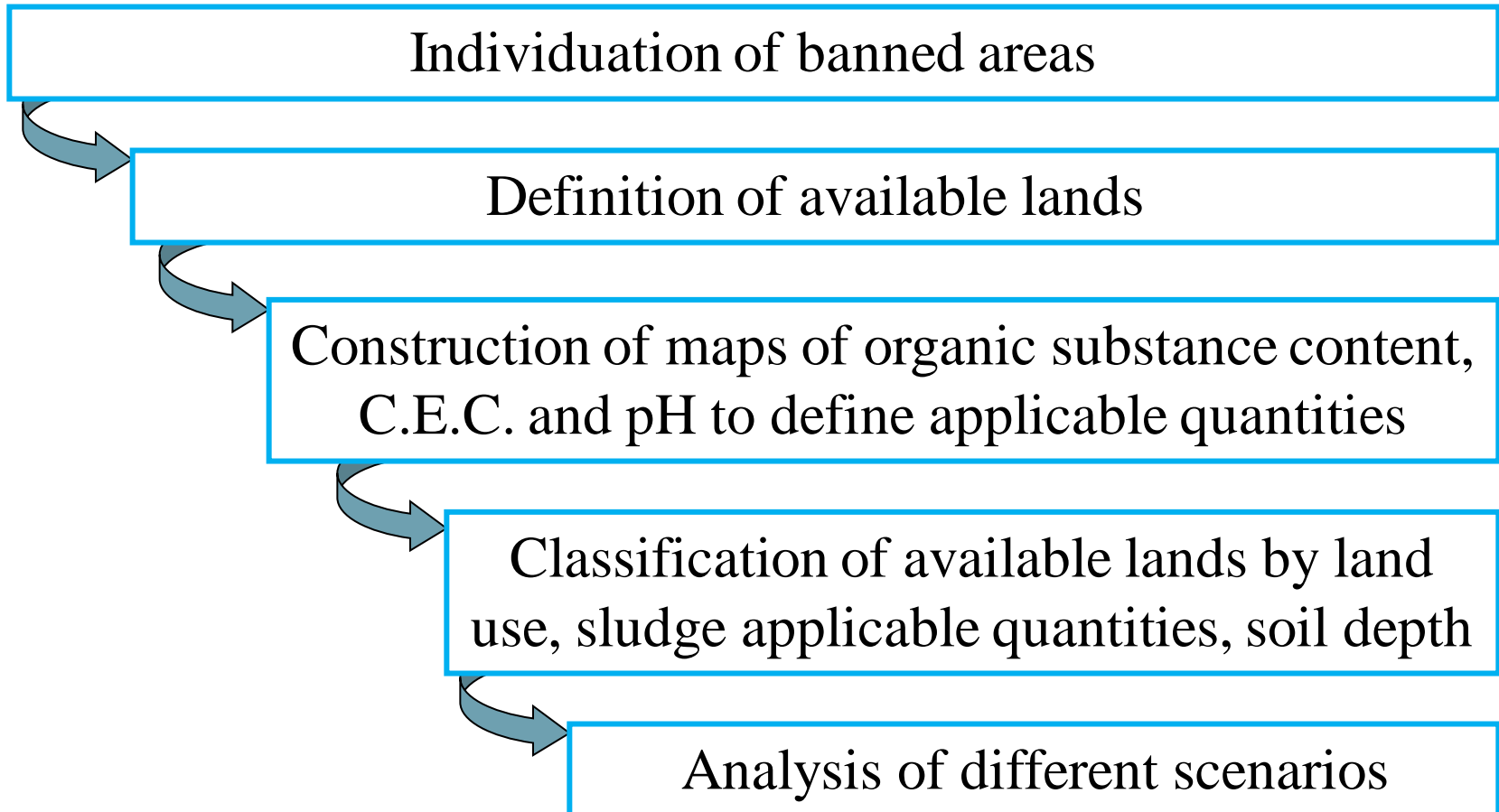
APULIAN REGIONAL LEGISLATION

sludge application forbidden in:

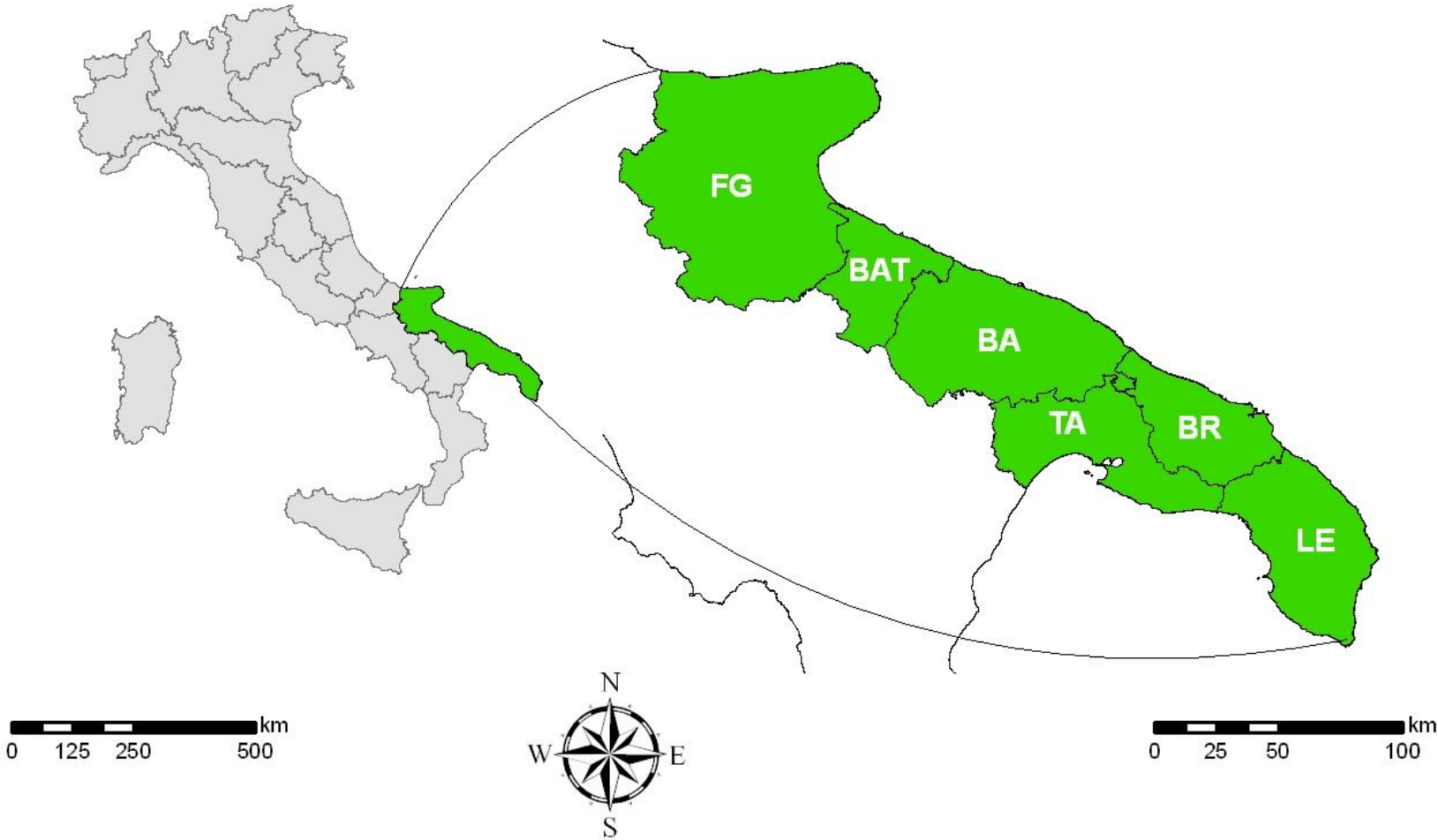
- buffer zones around built-up areas, streets, drinkable and not drinkable water wells, rivers, strand, etc.
- natural parks
- pastures
- vegetable crops
- groundwater protection areas
- areas under hydrogeological protection
- areas with organic substance content higher than 5%

further limitations in applicable quantities when soil is shallow

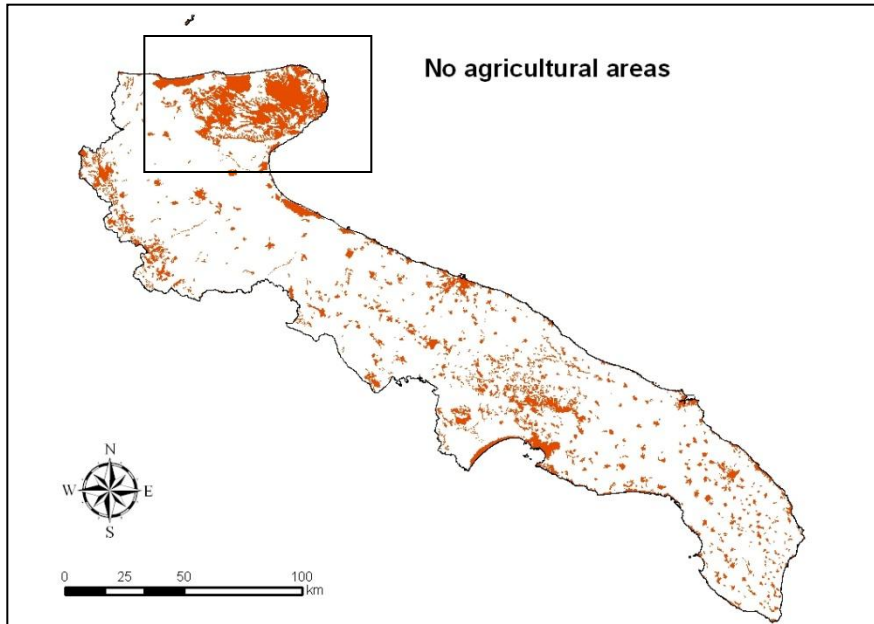
OUTLINE OF THE WORK



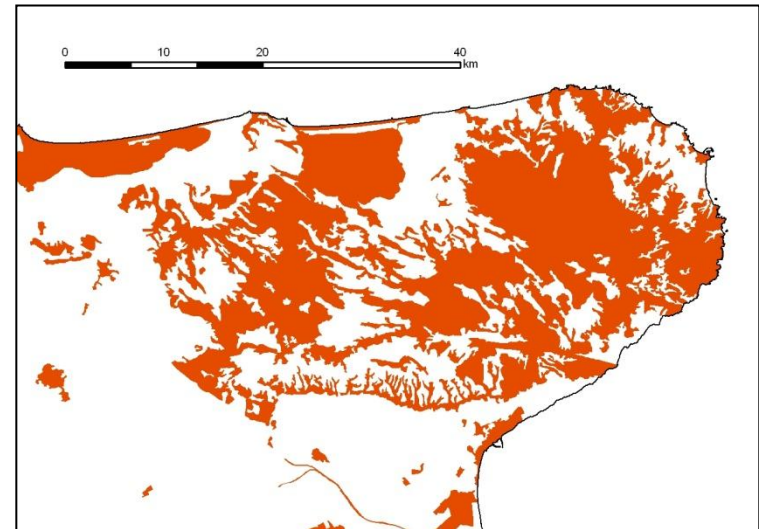
GEOGRAPHICAL CONTEXT



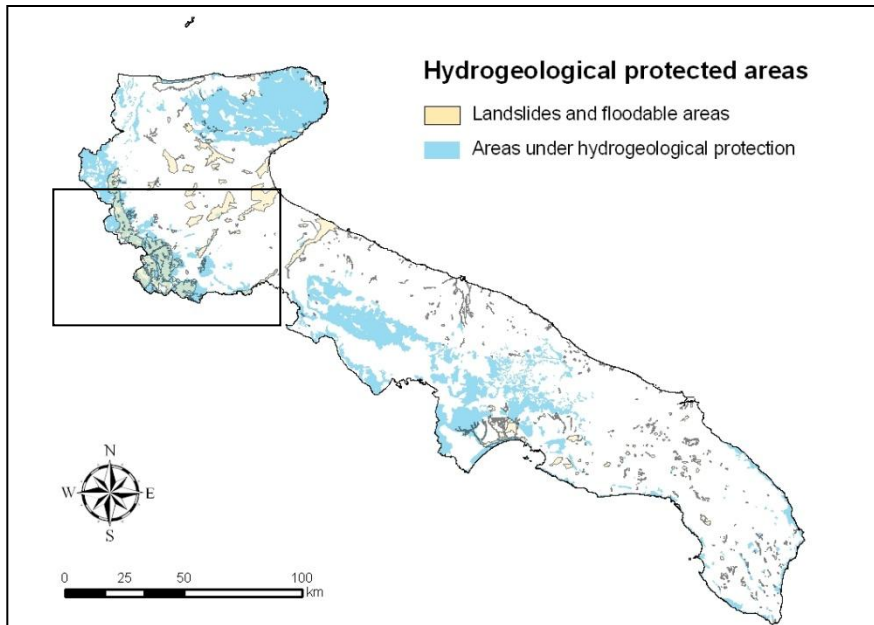
BANNED AREAS



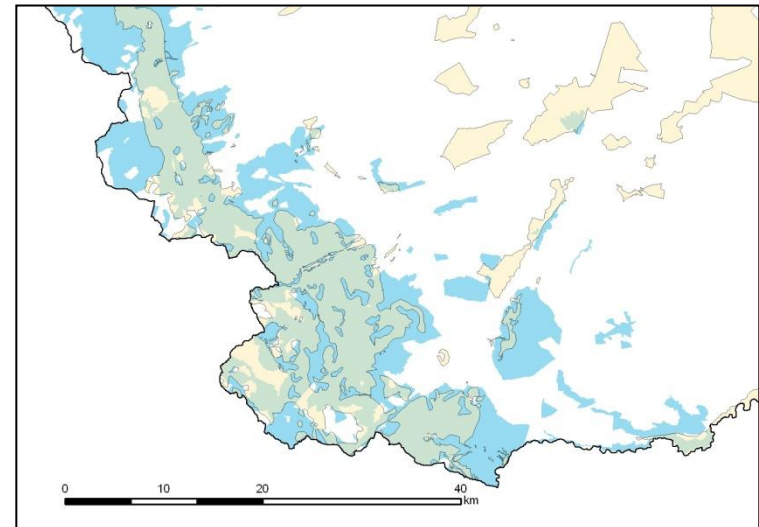
- no agricultural areas



BANNED AREAS

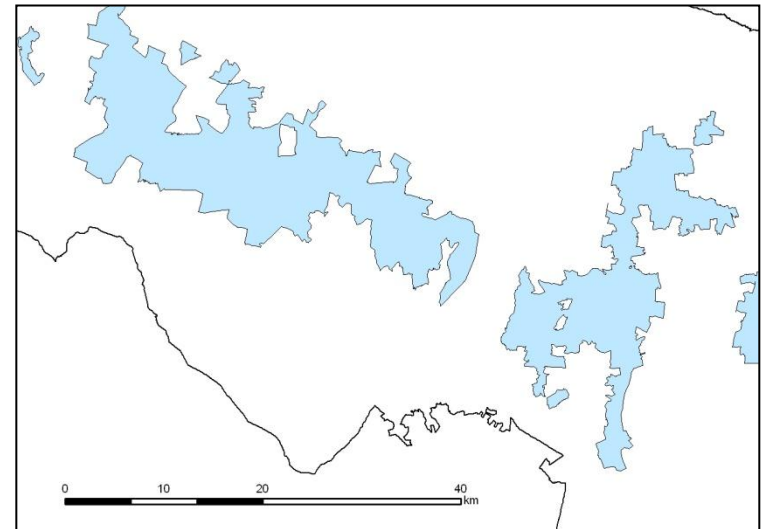
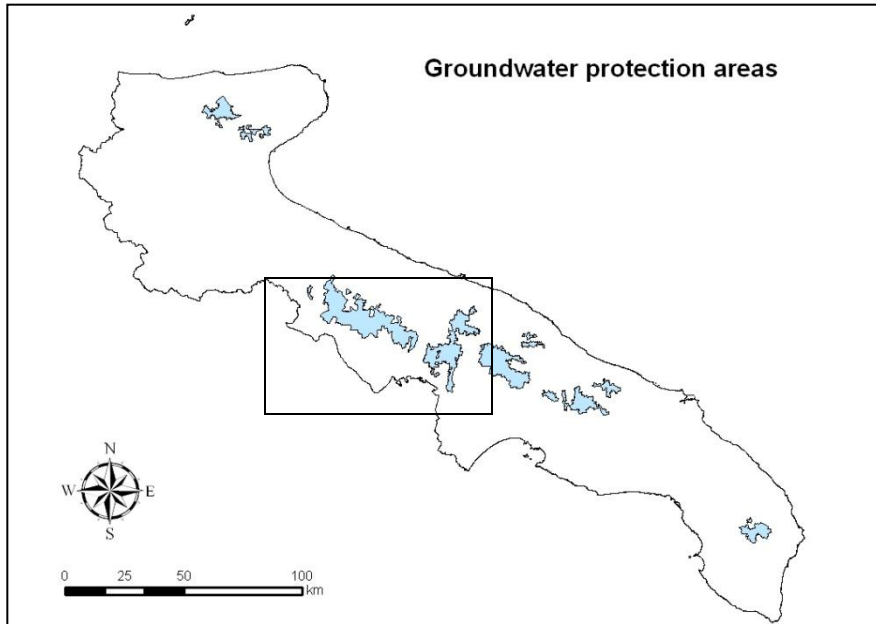


- landslides
- areas under hydrogeological protection

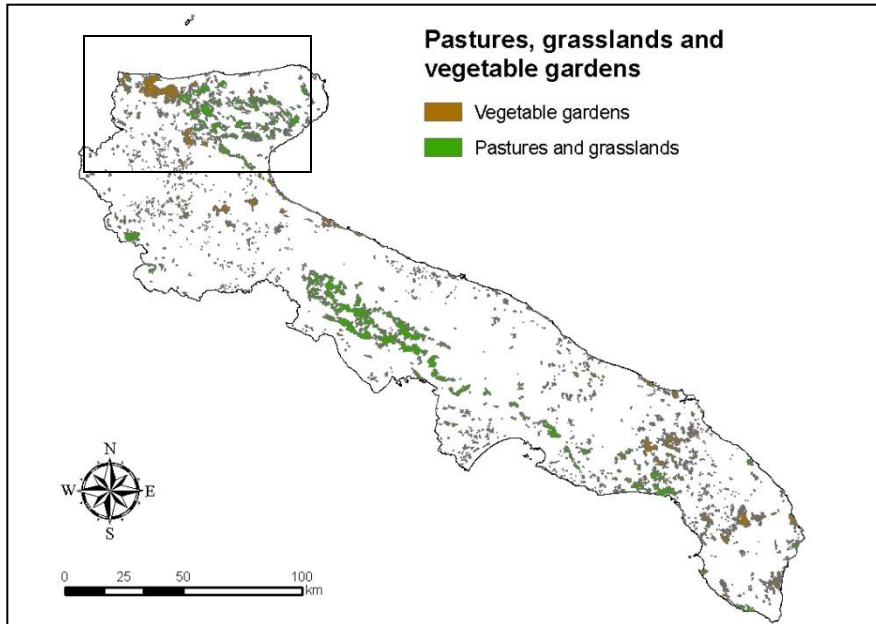


BANNED AREAS

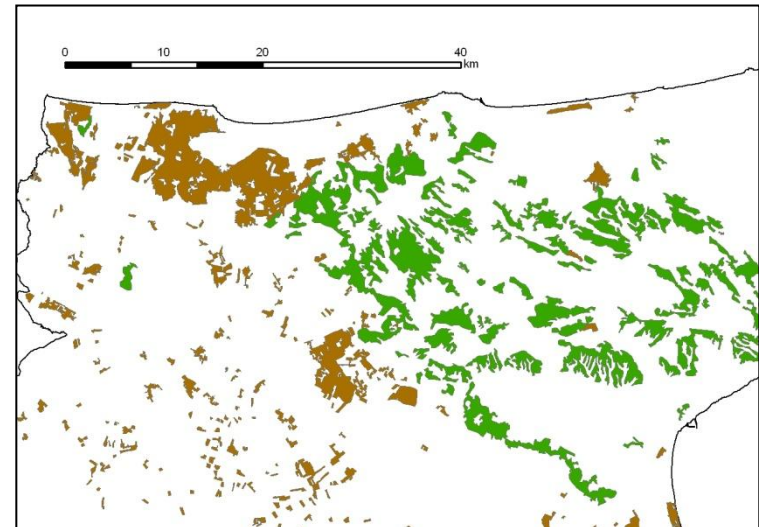
- groundwater protection areas



BANNED AREAS

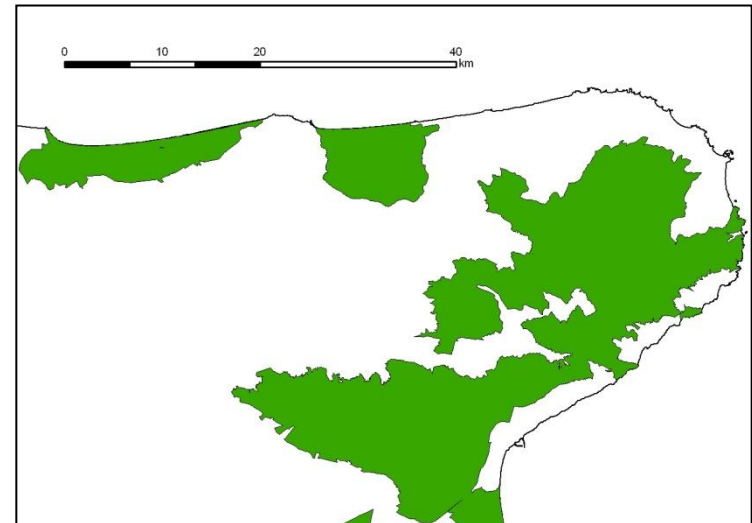
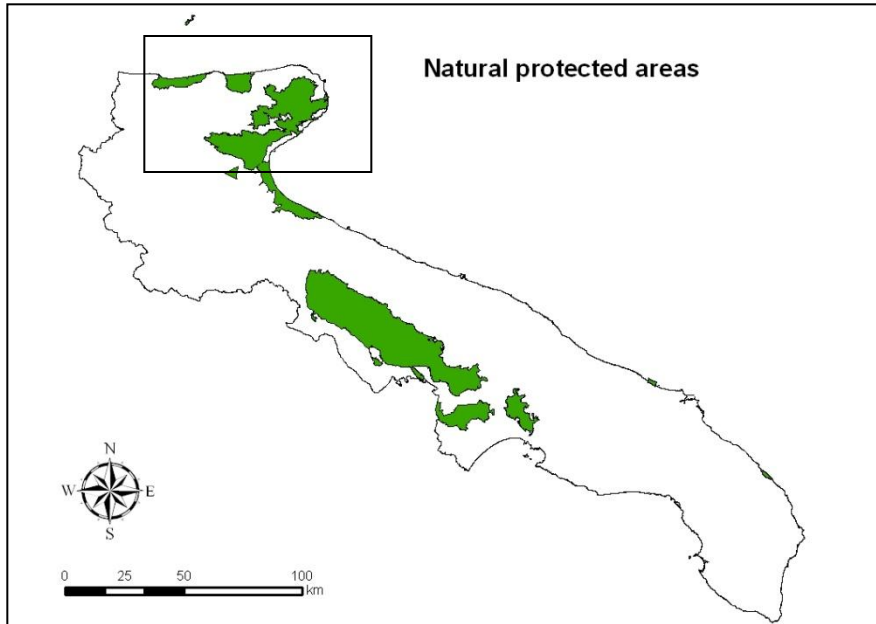


- pastures and grassland
- vegetable crops



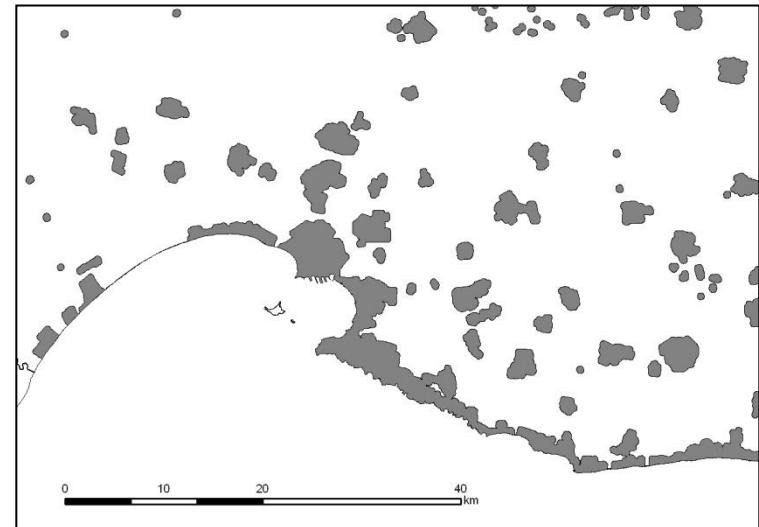
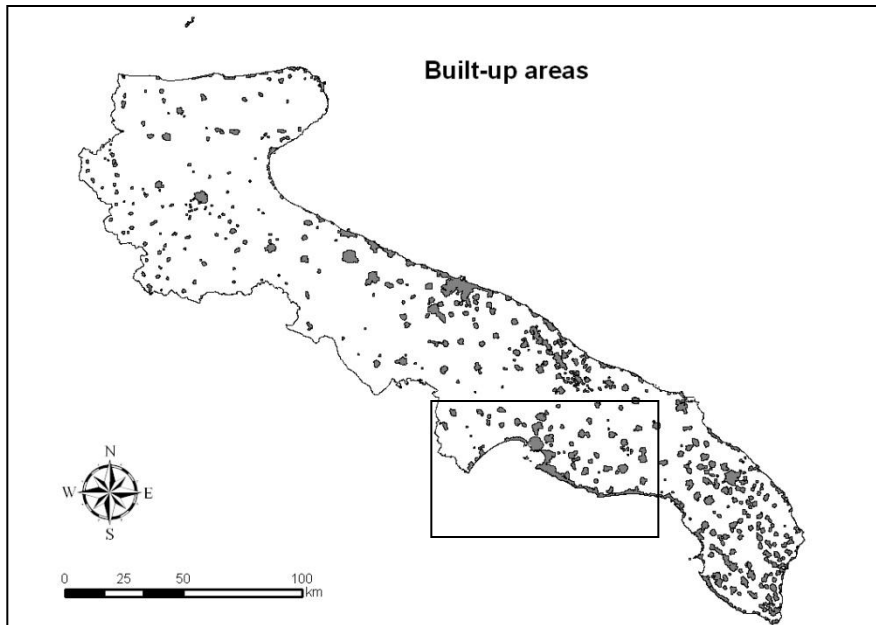
BANNED AREAS

- natural protected areas



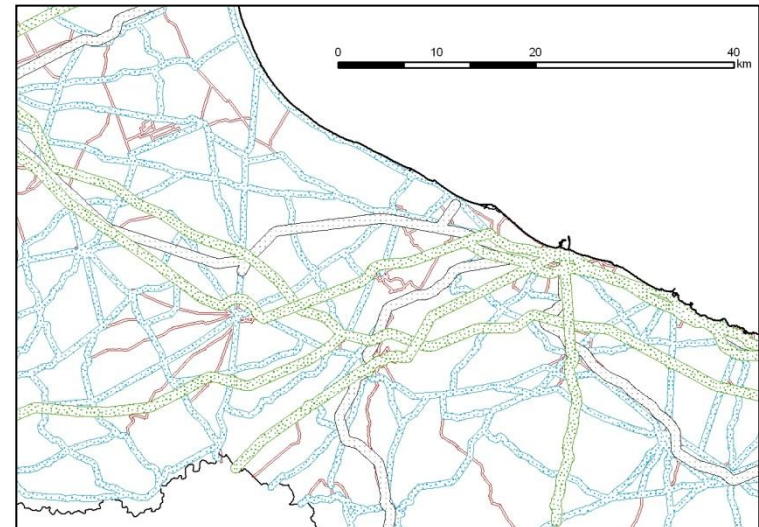
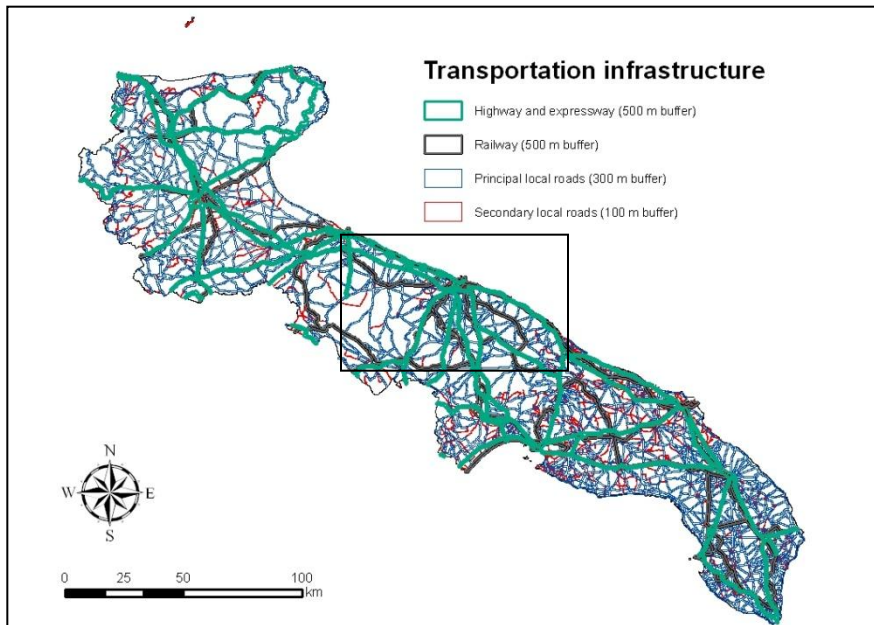
BANNED AREAS

- buffer zone around built up-areas (300 m)



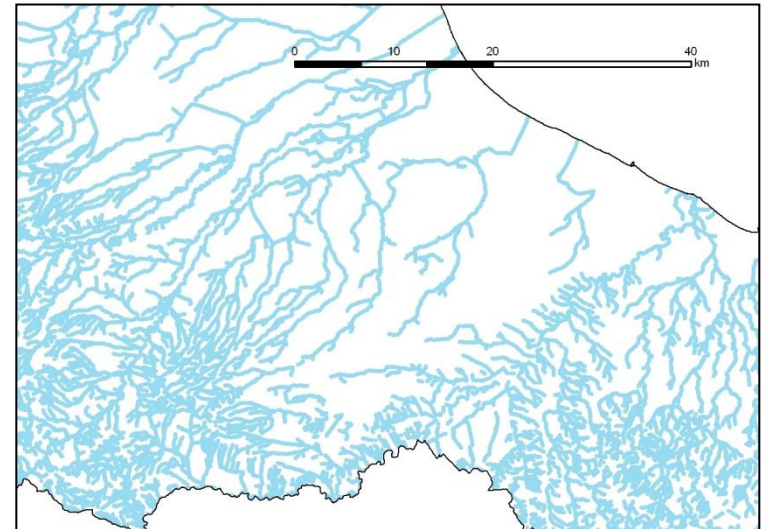
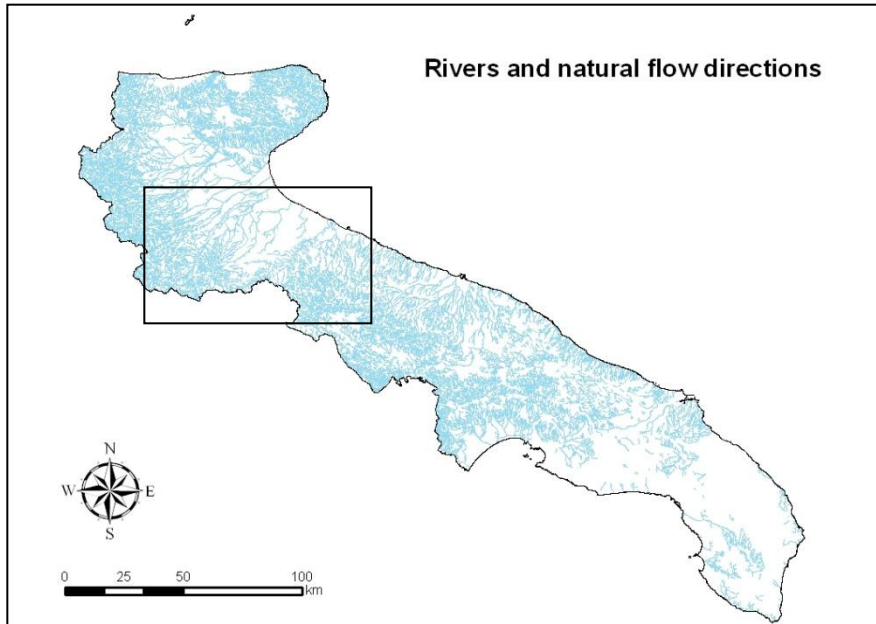
BANNED AREAS

- buffer zone around transportation infrastructure
 - highways and railways (500 m)
 - principal local roads (300 m)
 - secondary local roads (100 m)

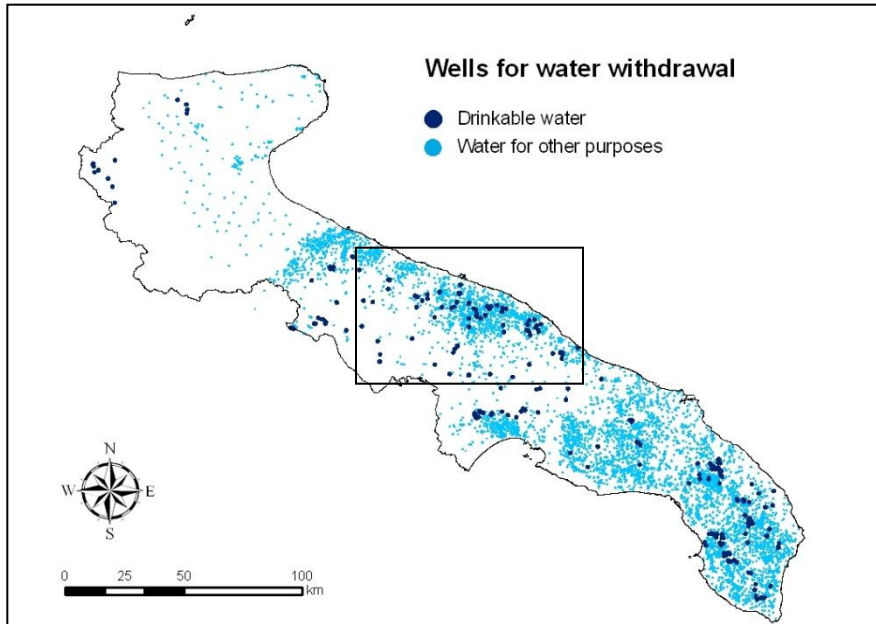


BANNED AREAS

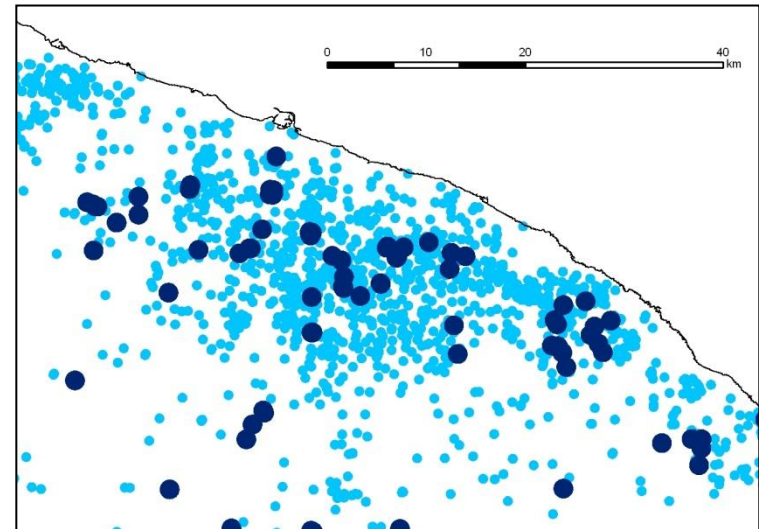
- buffer zone around rivers (200 m)



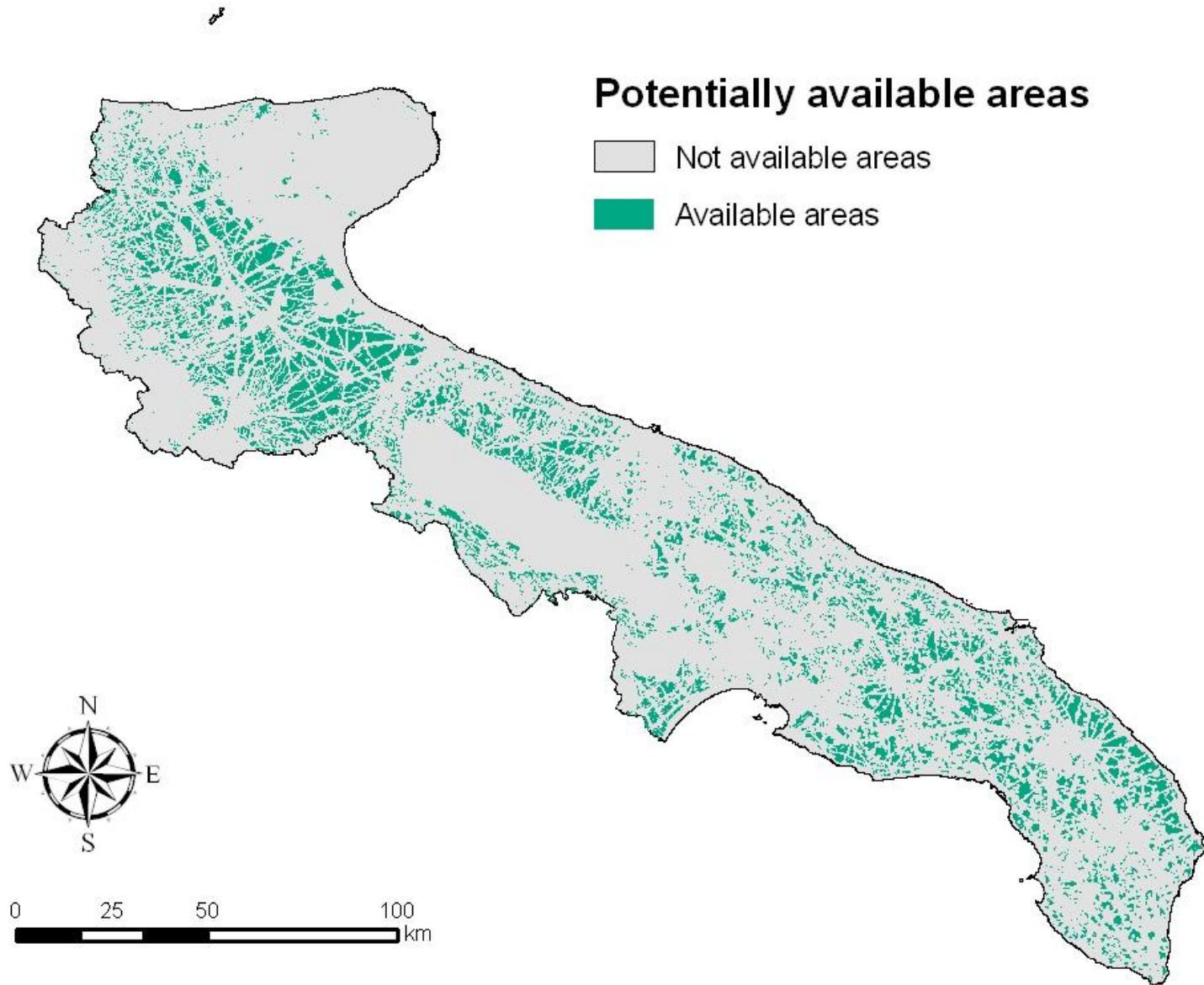
BANNED AREAS



- buffer zone around wells for water withdrawal
 - drinkable water (1000 m)
 - other purposes (500 m)

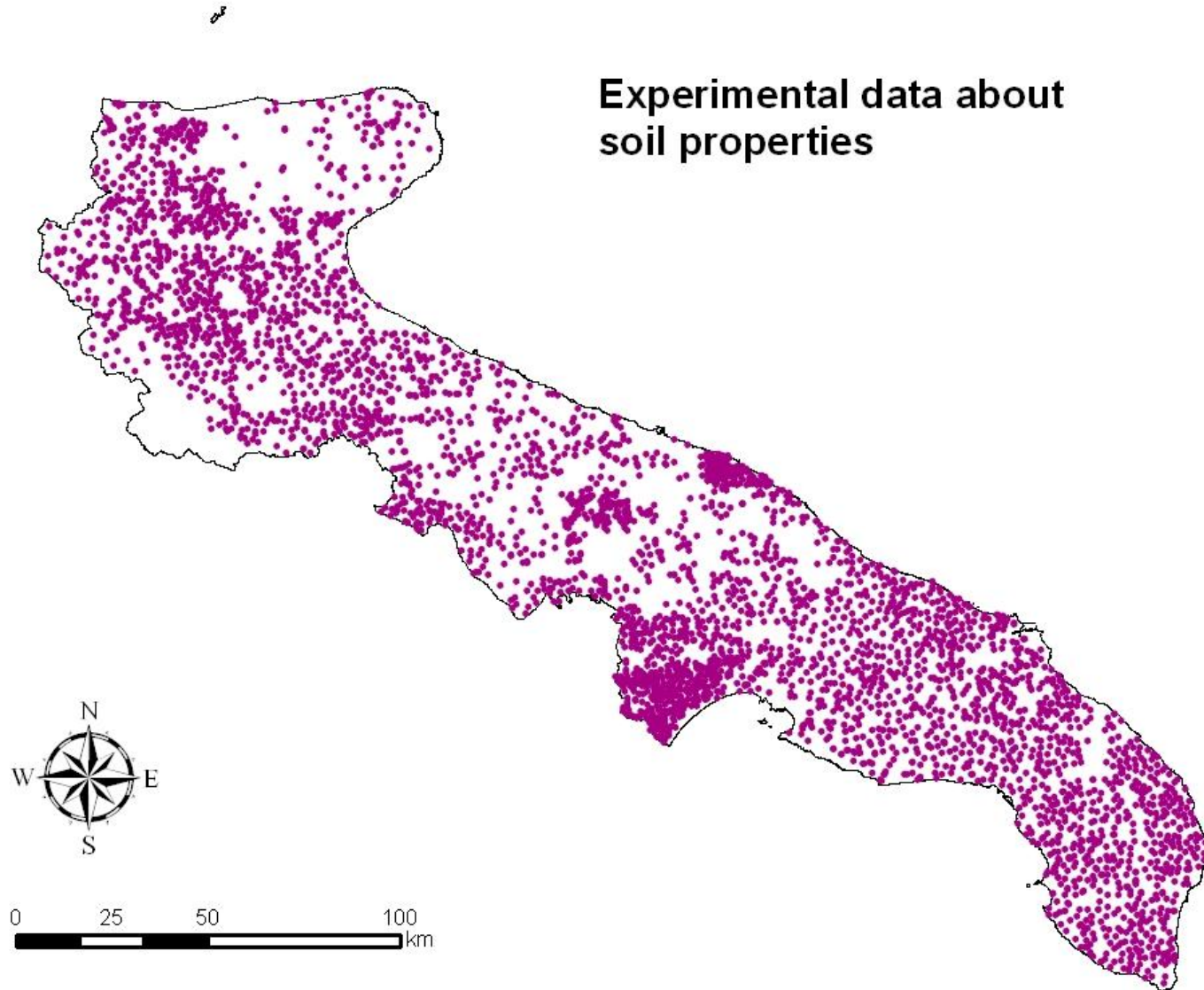


POTENTIALLY AVAILABLE AREAS

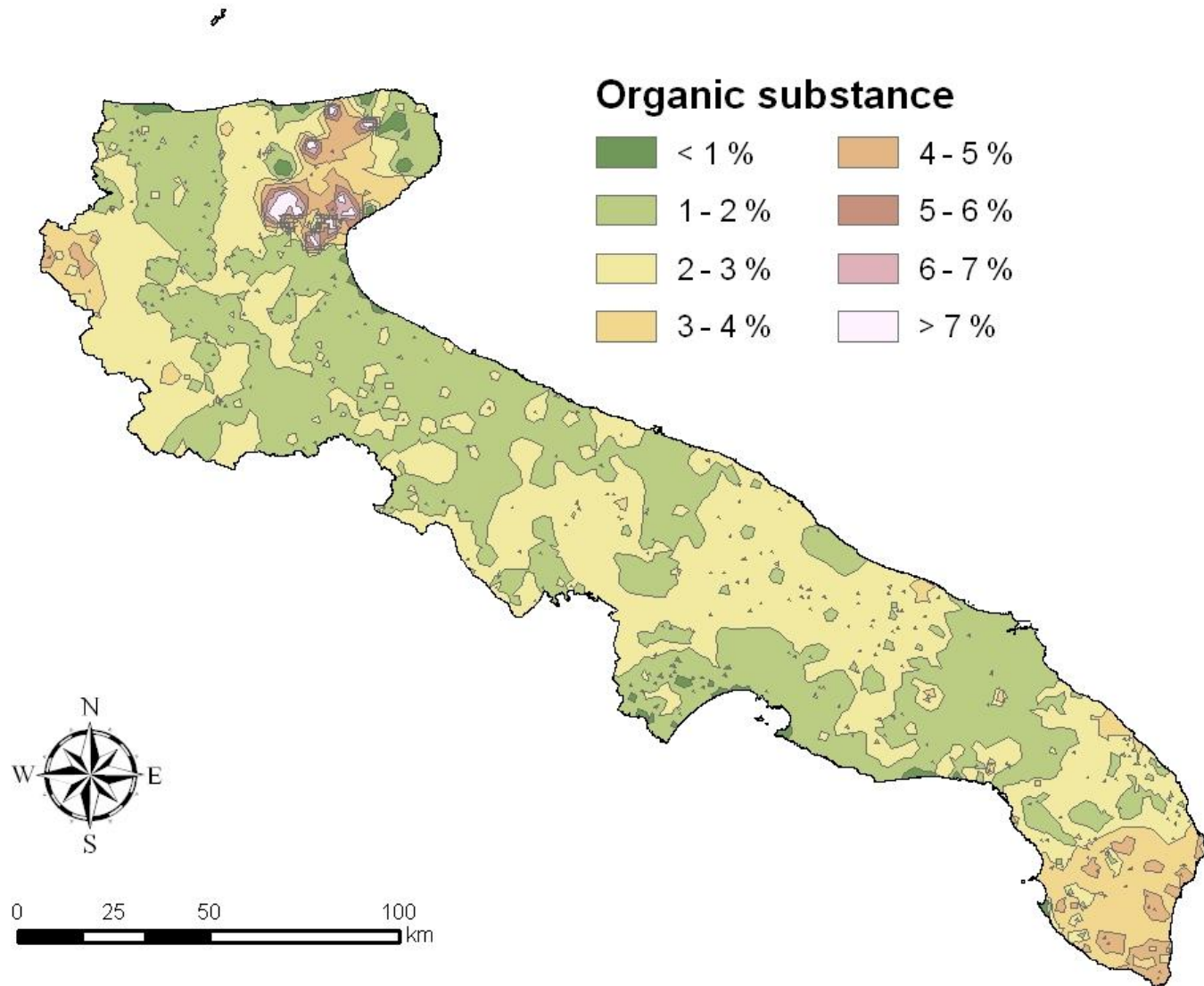


SOIL PROPERTIES

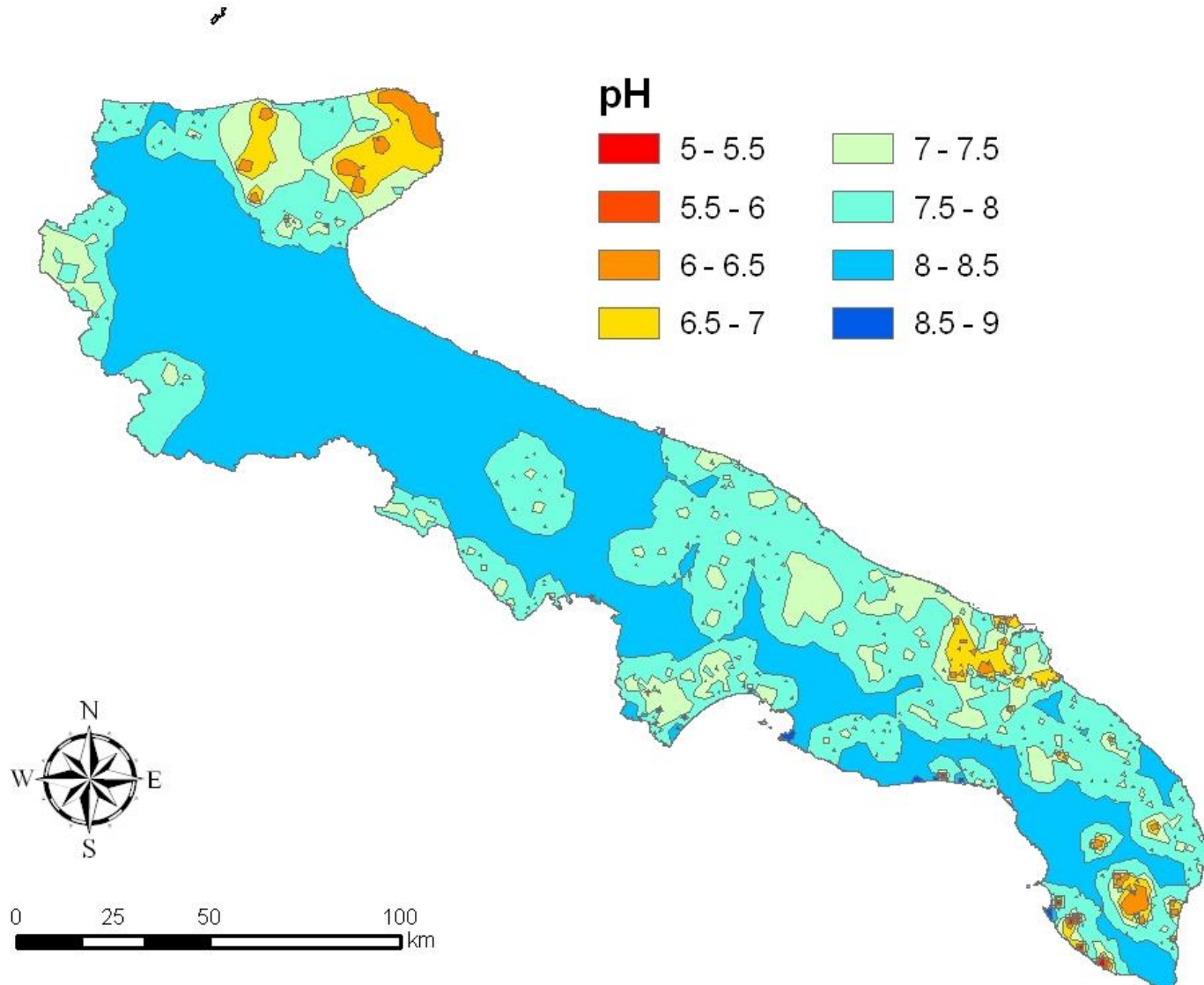
Experimental data about soil properties



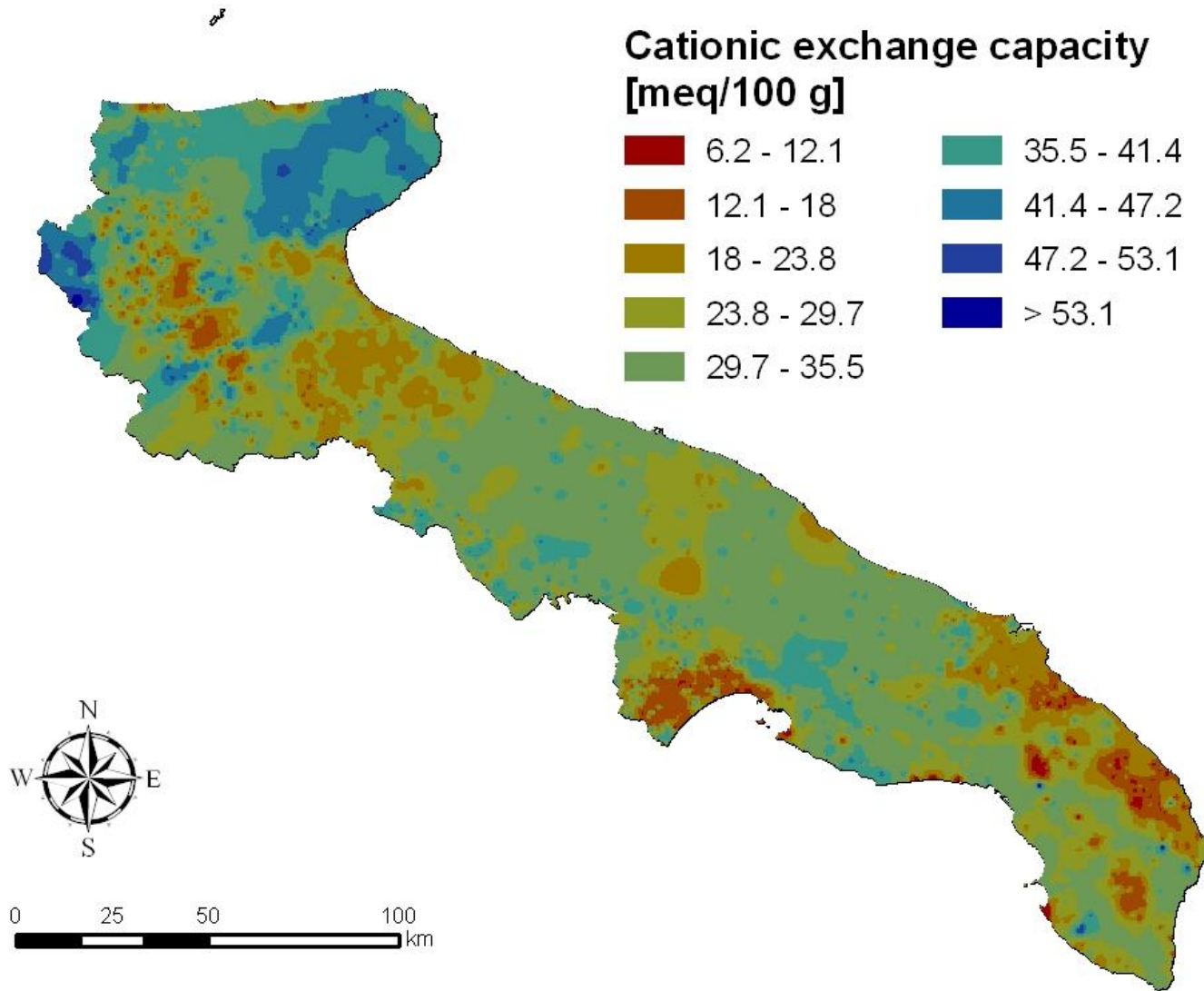
SOIL PROPERTIES



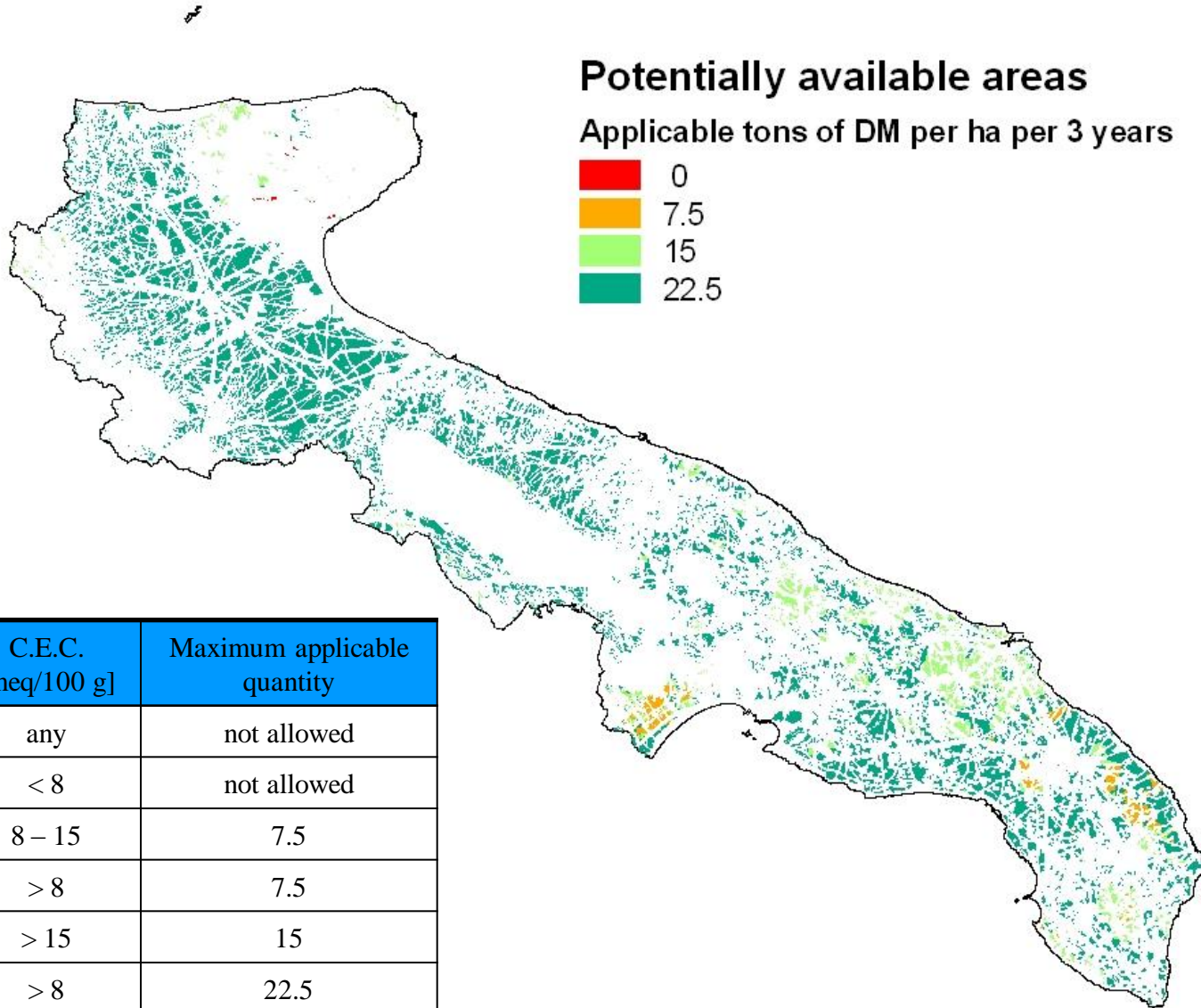
SOIL PROPERTIES



SOIL PROPERTIES

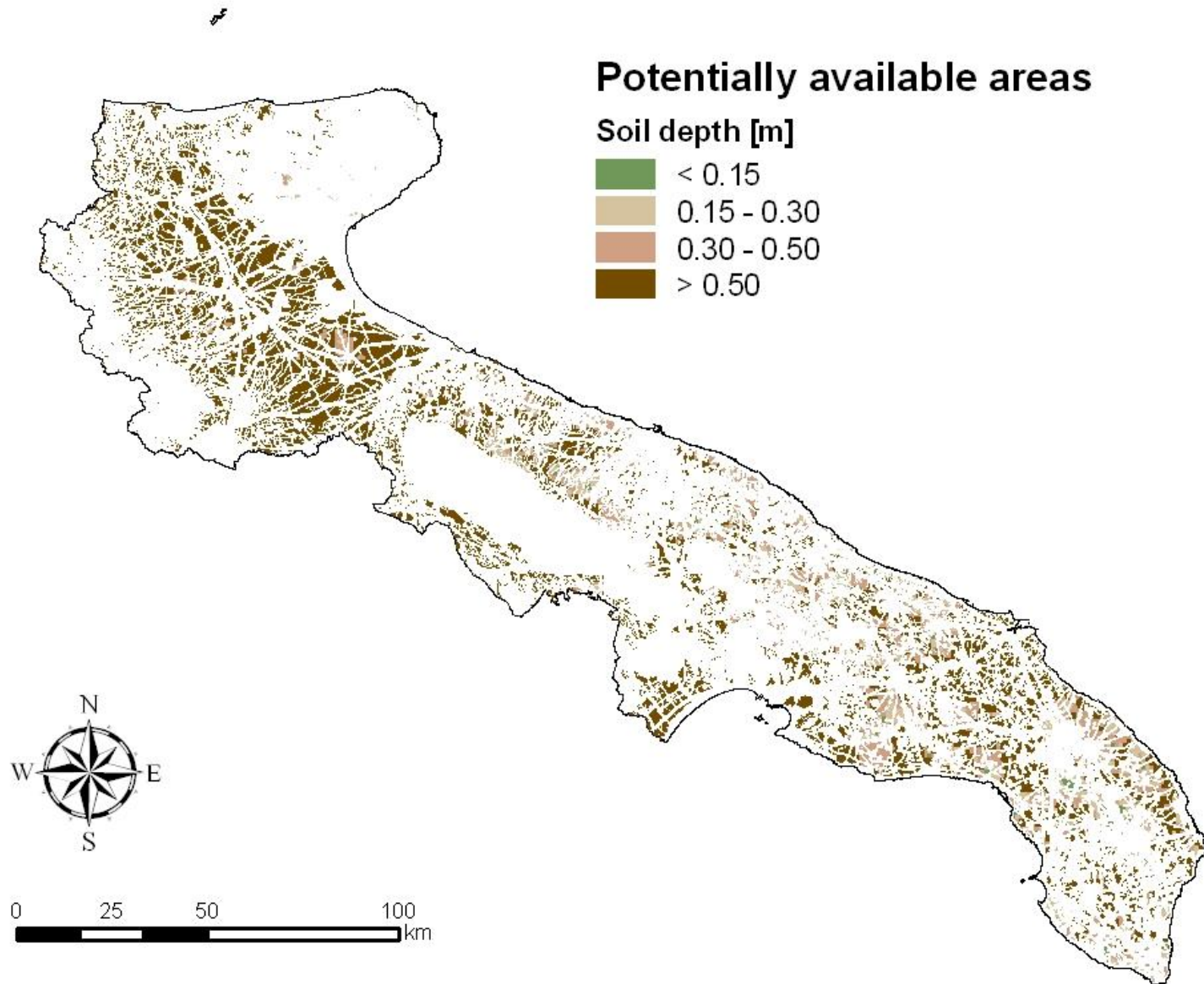


POTENTIALLY AVAILABLE AREAS

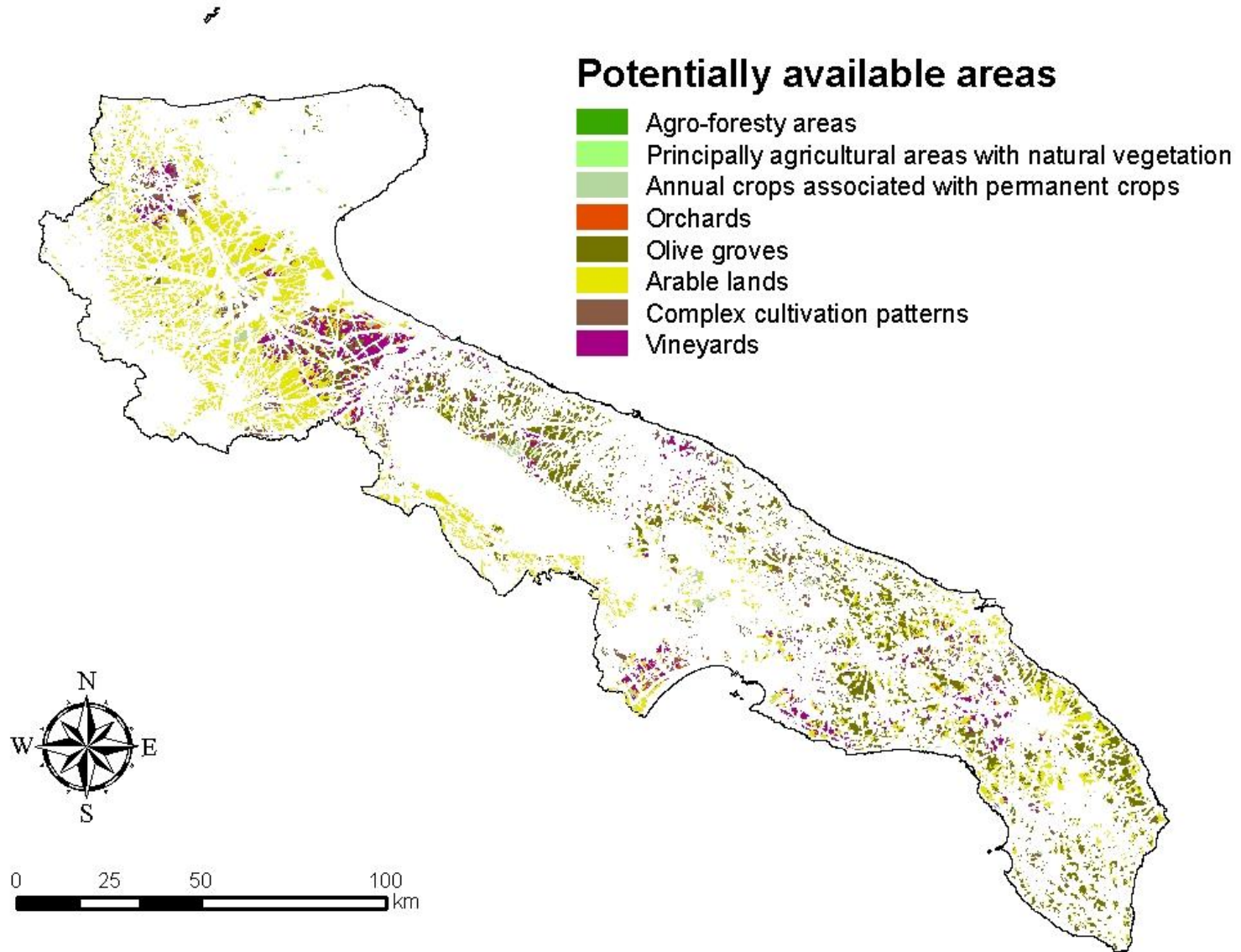


pH	C.E.C. [meq/100 g]	Maximum applicable quantity
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any	< 8	not allowed
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POTENTIALLY AVAILABLE AREAS



POTENTIALLY AVAILABLE AREAS



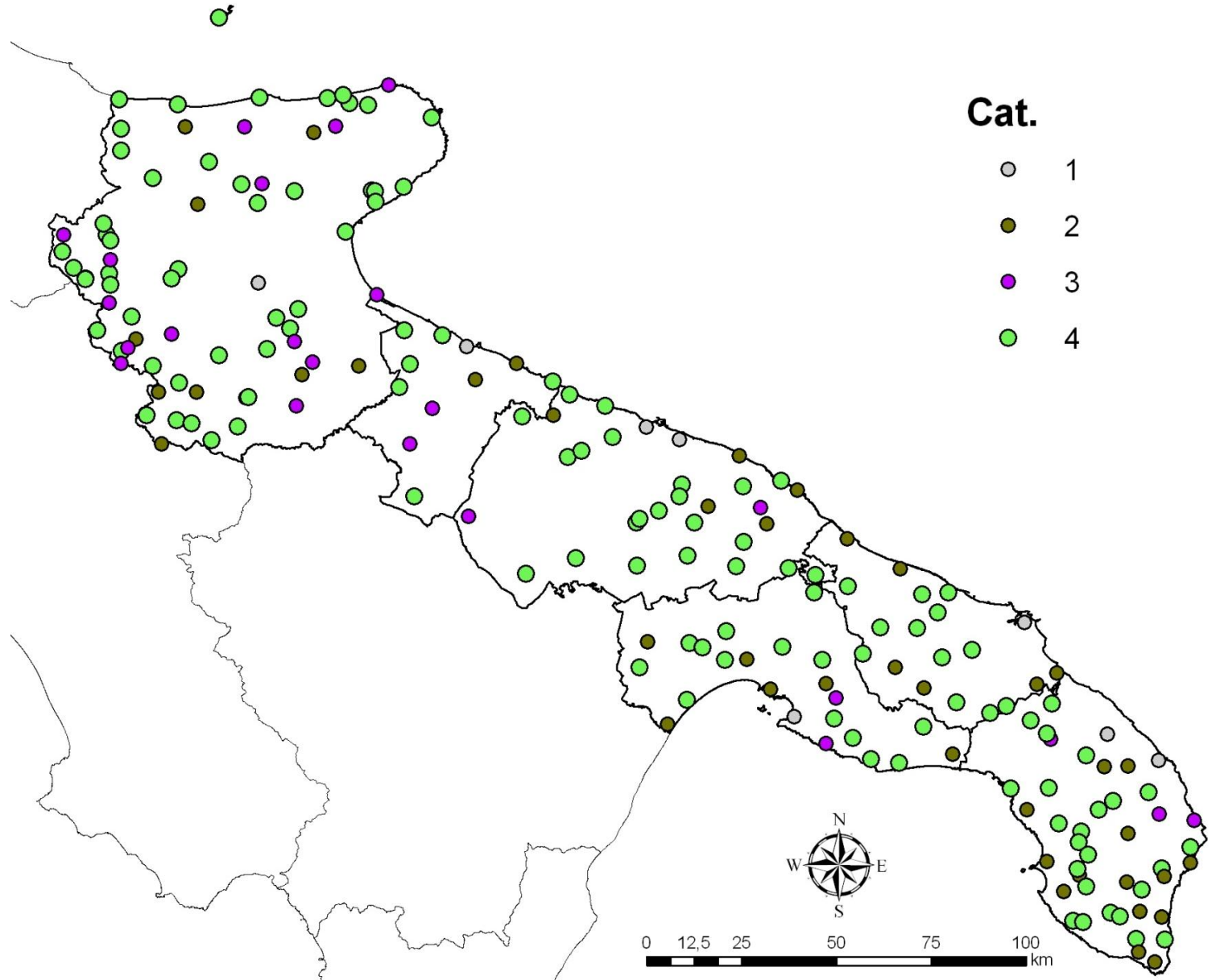
SLUDGE PRODUCTION (SLUDGE EMERGENCY PLAN 2009)

Sludge production computed depending on the composition of the influent

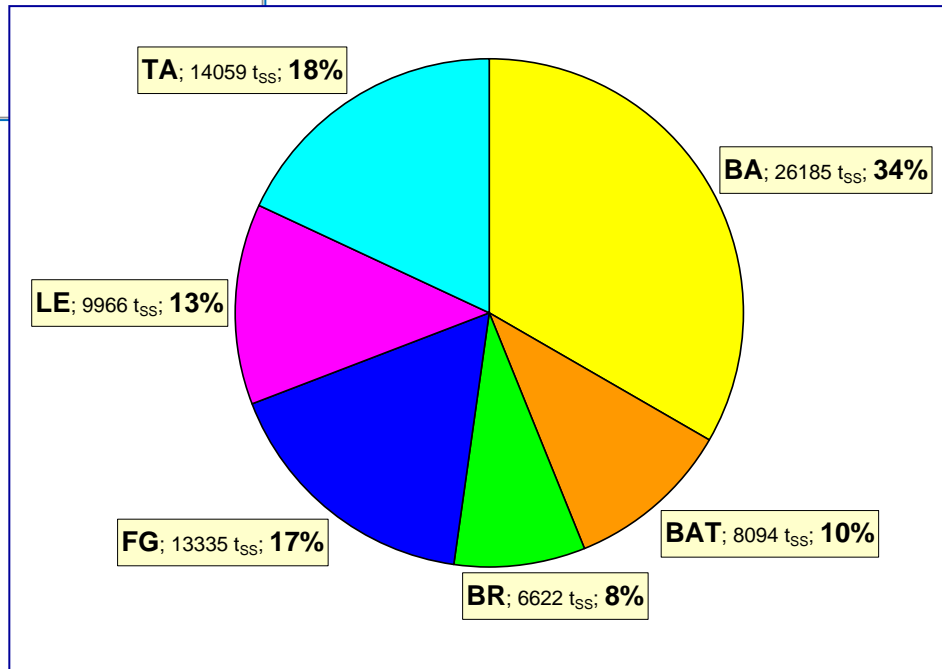
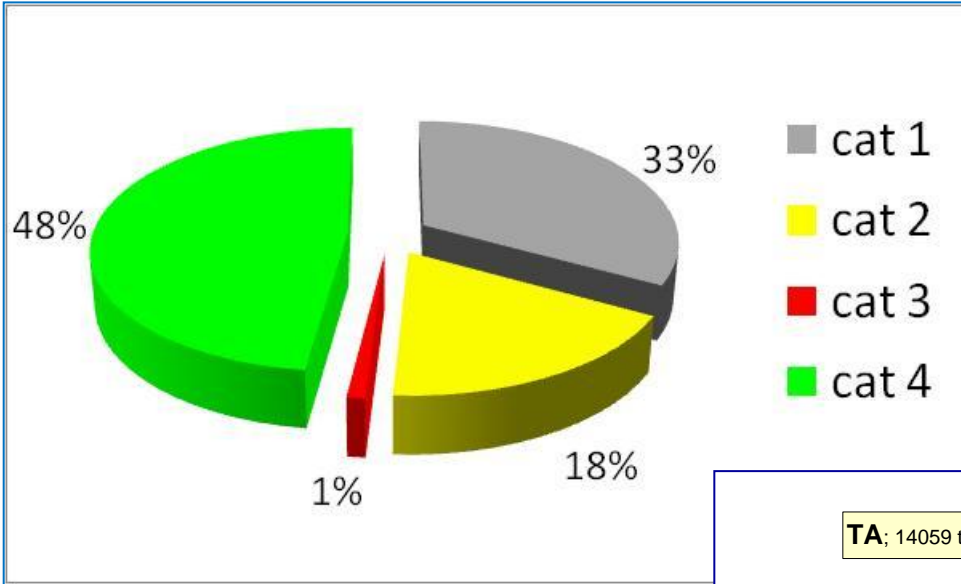
Classification of WWTPs in 4 categories:

1. large WWTPs with relevant industrial component;
2. WWTPs treating liquid wastes
3. WWTPs with primary treatment only
4. WWTPs with prevalent domestic component

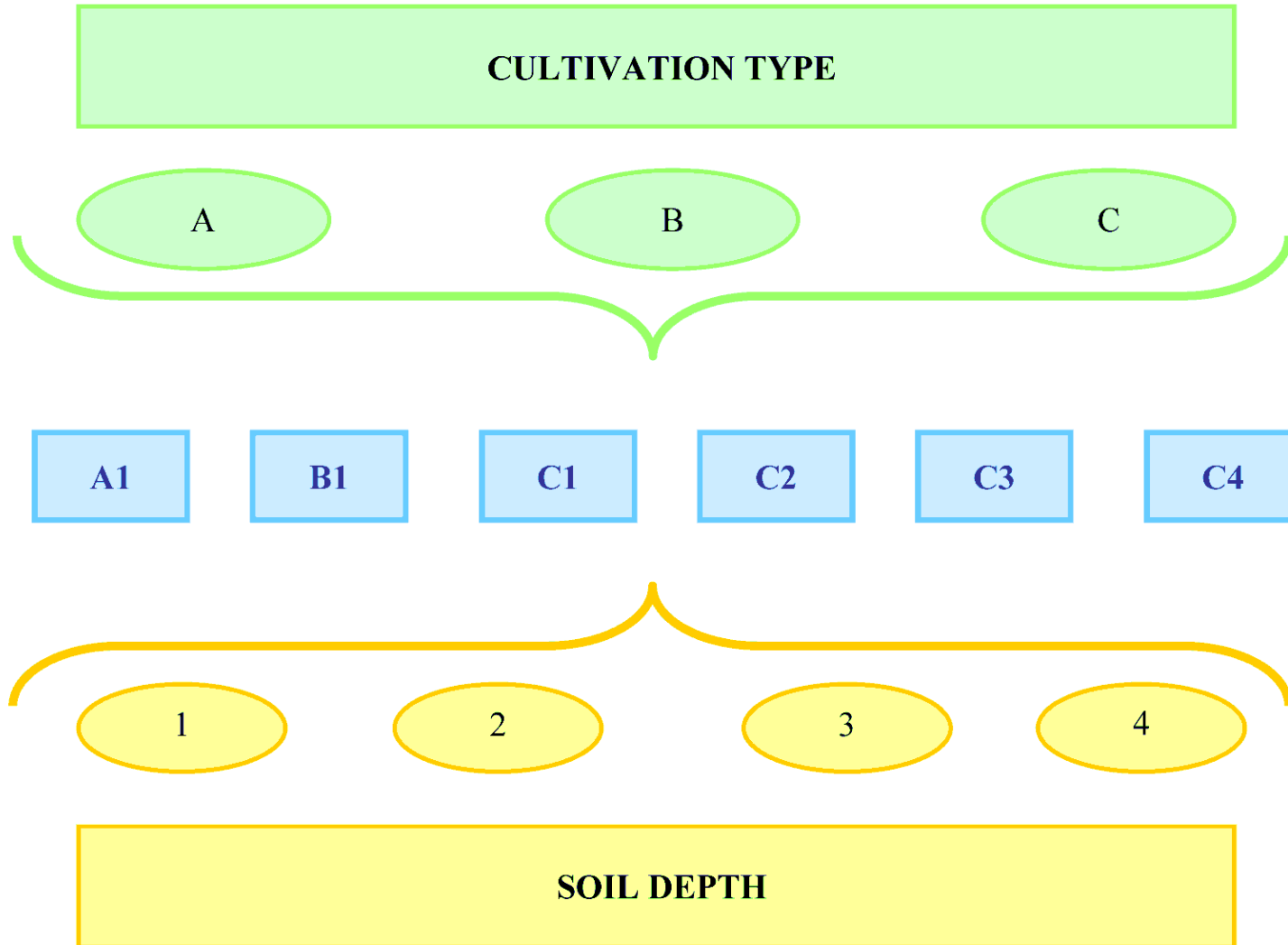
SLUDGE PRODUCTION (SLUDGE EMERGENCY PLAN 2009)



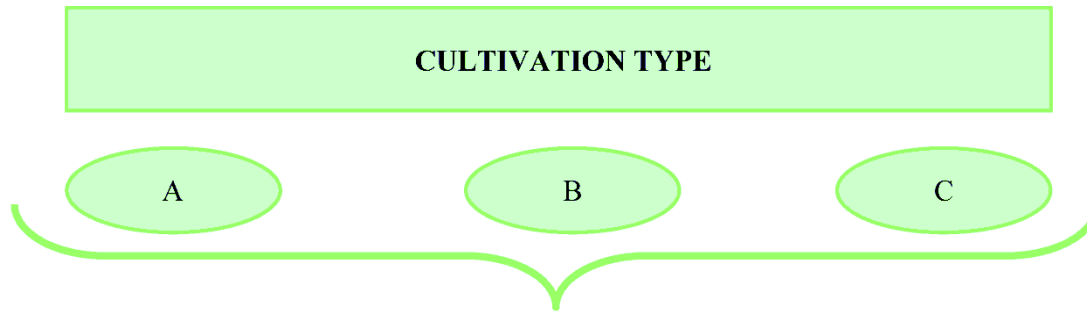
SLUDGE PRODUCTION (SLUDGE EMERGENCY PLAN 2009)



SCENARIOS



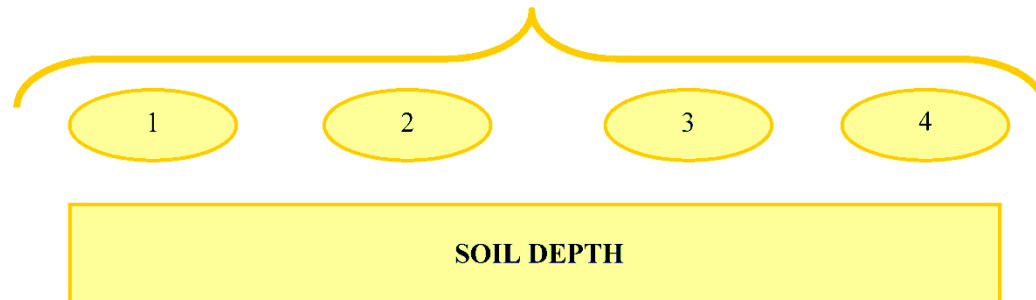
SCENARIOS: CULTIVATION TYPES



- A. total availability of all areas (100%);
- B. reduced availability of non-irrigated arable lands and permanently irrigated lands (50%) and complete availability of all the other areas (100%);
- C. reduced availability of principally agricultural areas with natural vegetation, agro-forestry areas and complex cultivation patterns (75%), annual crops associated with permanent crops (50%), non-irrigated arable lands and permanently irrigated lands (33%).

SCENARIOS: SOIL DEPTH

Scenario	Soil depth $d < 0.15$ m	Soil depth $0.15 \text{ m} < d < 0.3$ m	Soil depth $0.3 \text{ m} < d < 0.5$ m
1	0.25	0.5	0.75
2	0.167	0.333	0.556
3	0	0	0.5
4	0	0	0

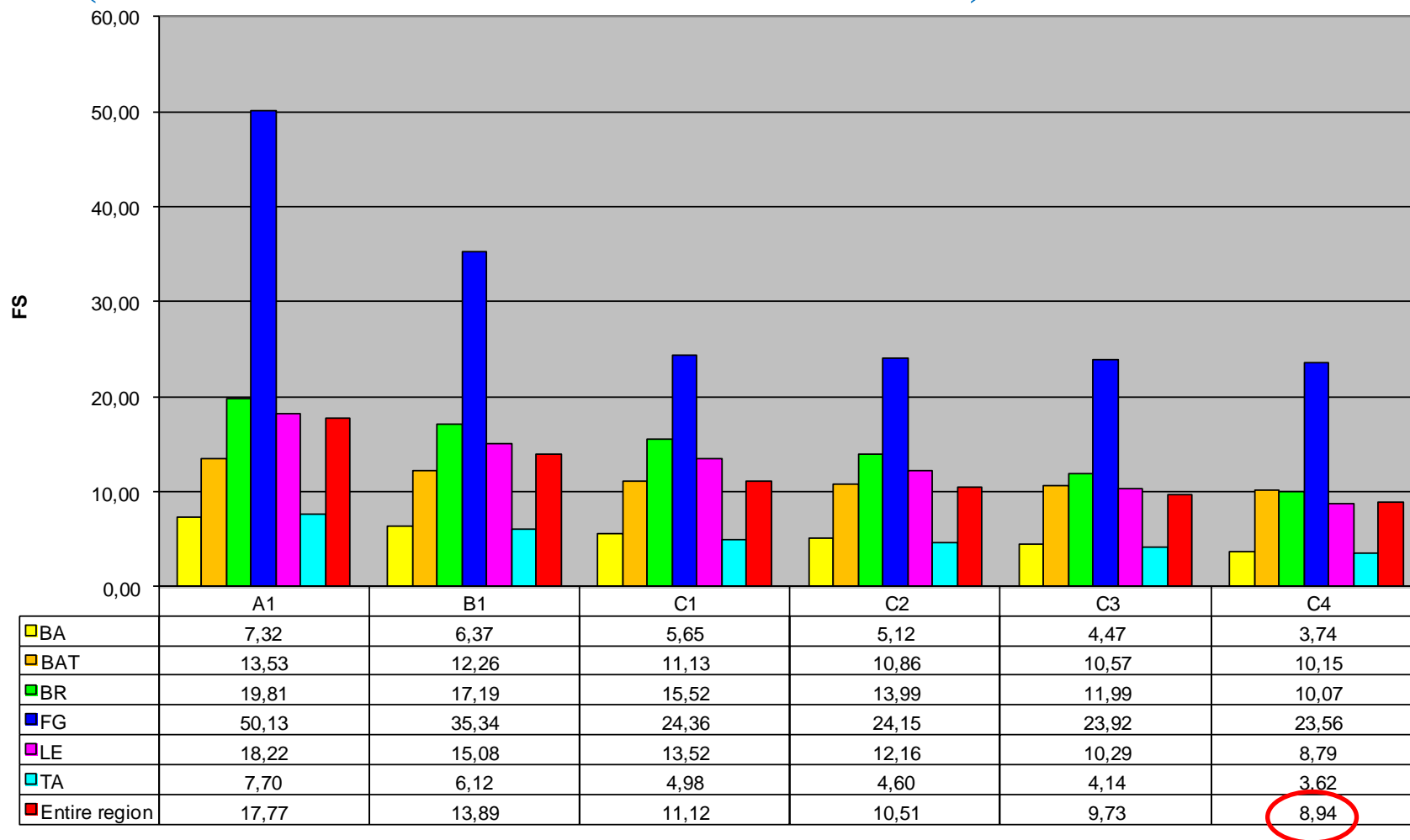


DISPOSABLE CAPACITY

SECURITY FACTOR (SF)

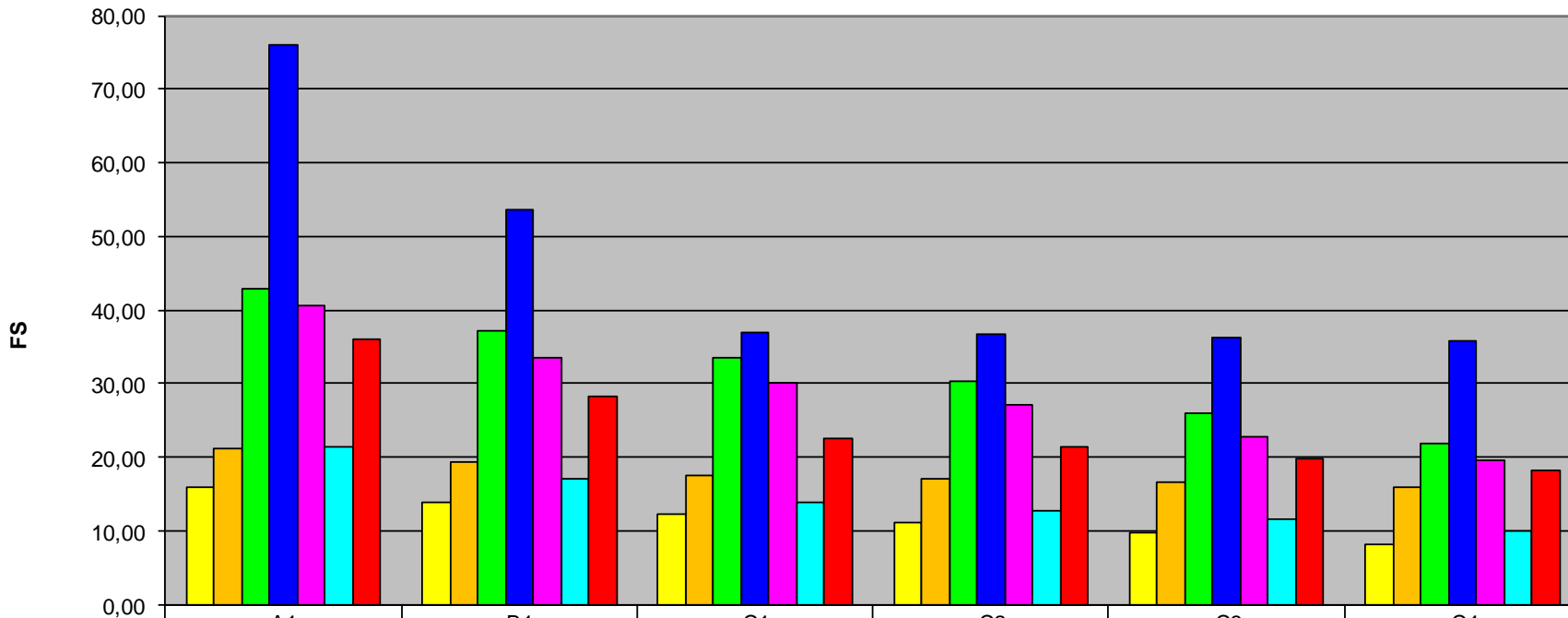
ratio between the total amount of sludge that can be used in agriculture in three years and the sludge produced in five years

SLUDGE PRODUCTION (SLUDGE EMERGENCY PLAN 2009)



scenarios

SLUDGE PRODUCTION (SLUDGE EMERGENCY PLAN 2009)



	A1	B1	C1	C2	C3	C4
BA	15,92	13,86	12,30	11,14	9,72	8,14
BAT	21,24	19,25	17,48	17,06	16,61	15,94
BR	42,84	37,18	33,55	30,24	25,93	21,77
FG	76,00	53,58	36,94	36,61	36,26	35,72
LE	40,50	33,52	30,06	27,04	22,87	19,54
TA	21,35	16,95	13,81	12,76	11,47	10,03
Entire region	36,02	28,17	22,55	21,31	19,73	18,12

scenarios

SLUDGE PRODUCTION: ESTIMATION

present sludge production \longrightarrow **20 kg DM** per year per population equivalent

future projection \longrightarrow **25 kg DM** per year per population equivalent

Population equivalents have been fixed in **4,700,000** and **6,000,000** respectively for present and future situation, as deduced from regional planning documents.

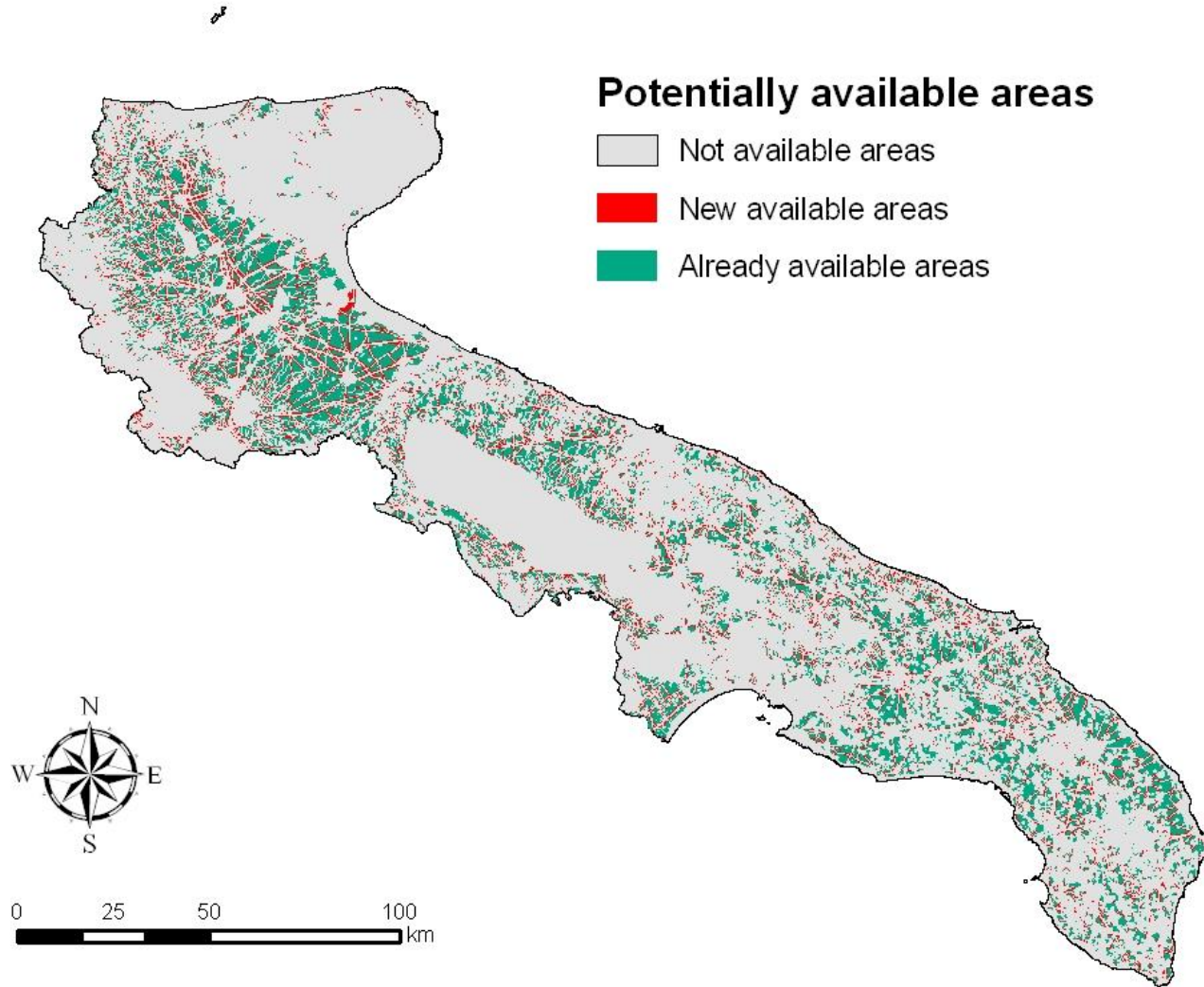
All the produced sludge is assumed to be sufficiently good to be recycled in agriculture, which implies an overestimation of the real quantities that can be disposed in such a way.

LEGISLATIVE REVISION

opportunity to introduce some **modifications** in order to:

- homogenize all the limits imposed by the laws that during the years have affected agricultural sludge use → introduction of **“relaxed” constraints** for some excessively restrictive “objective limits” (distances from streets and rivers)
- better stress the agricultural value of this practice in the specific local context → **nitrogen needs of crops**

LEGISLATIVE REVISION



LEGISLATIVE REVISION

reduced applicable quantities referred to nitrogen needs calculated considering a mean content of nitrogen of 5% and an average nitrogen availability of 70% in three years:

- 8,6 t DM/ha in three years for non-irrigated arable lands and permanently irrigated lands, annual crops associated with permanent crops, complex cultivation patterns, principally agricultural areas with natural vegetation, agro-forestry areas;
- 11,6 t DM/ha in three years for vineyards;
- 11,1 t DM/ha in three years for orchards;
- 12 t DM/ha in three years for olive groves.

DISPOSABLE CAPACITY

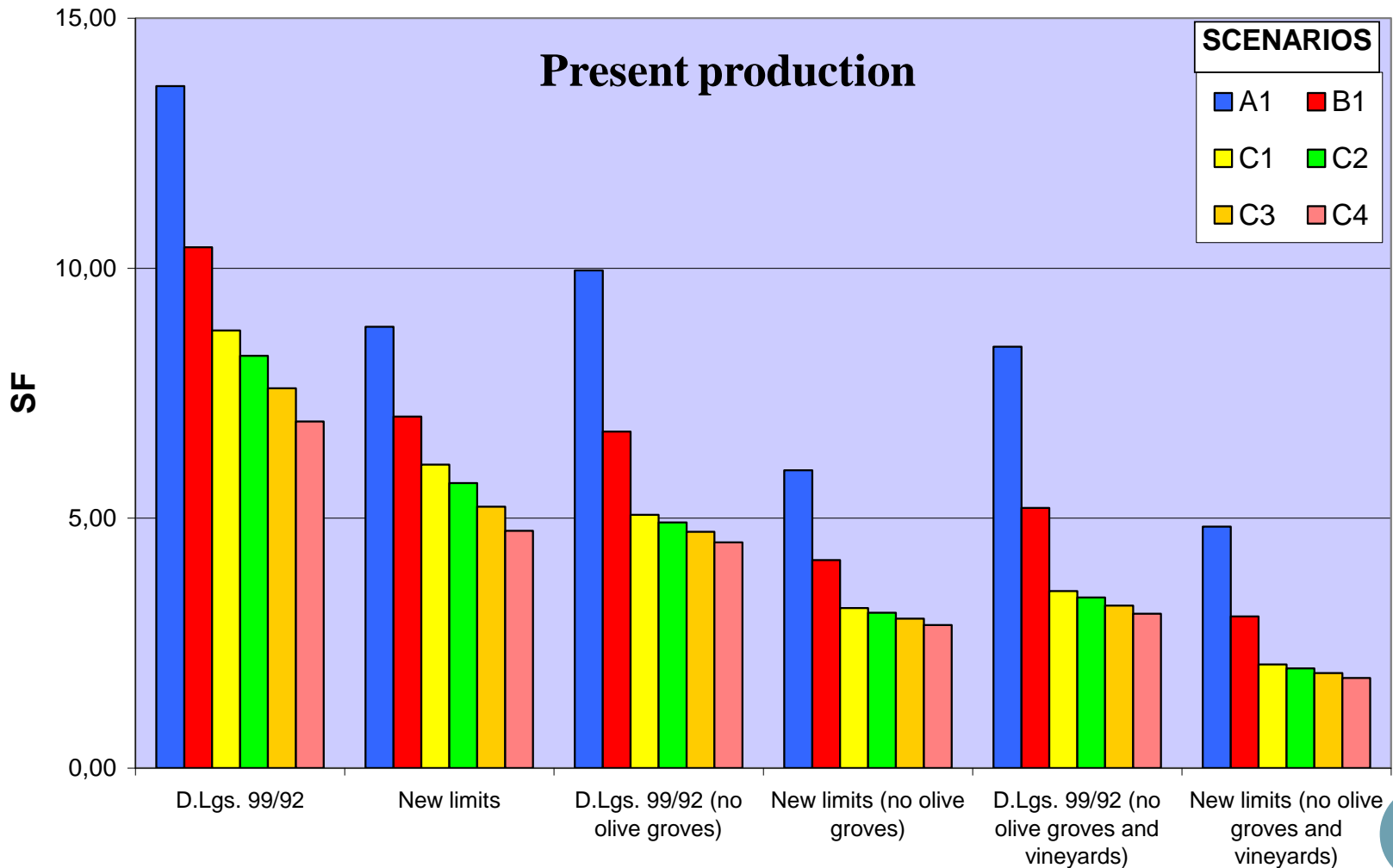
	Scenario	Disposable sludge [t _{DM}]	Present SF	Future SF
Present limits	A1	6,411,933	13,64	8,55
	B1	4,896,064	10,42	6,53
	C1	4,114,997	8,76	5,49
	C2	3,875,708	8,25	5,17
	C3	3,570,413	7,60	4,76
	C4	3,258,504	6,93	4,34
New limits	A1	4,148,236	8,83	5,53
	B1	3,303,201	7,03	4,40
	C1	2,852,294	6,07	3,80
	C2	2,678,884	5,70	3,57
	C3	2,457,908	5,23	3,28
	C4	2,231,387	4,75	2,98

FURTHER LIMITATIONS...

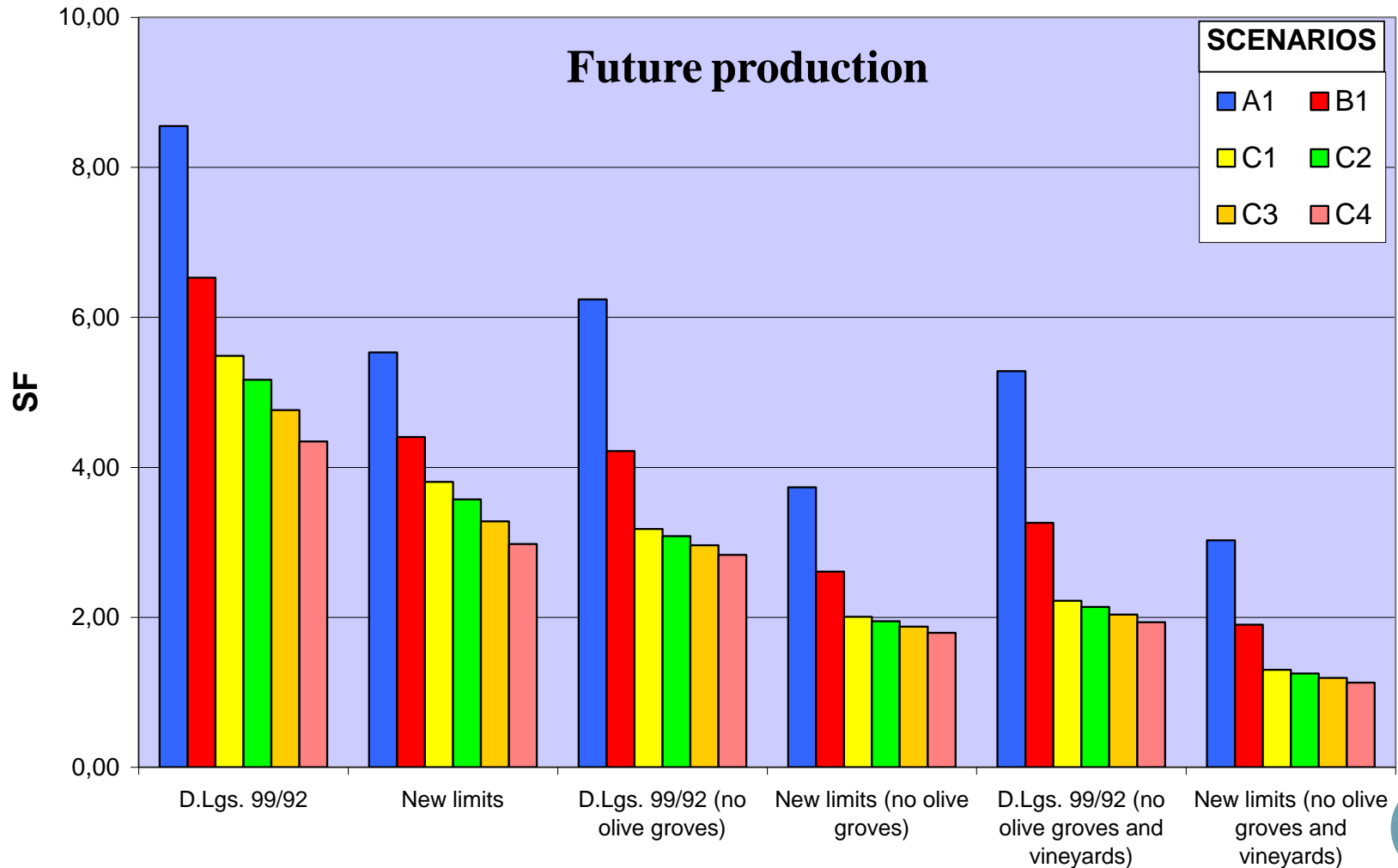
olive groves → nutrient needs already satisfied by olive oil mill effluents

vineyards → difficult application for operational reasons

FURTHER LIMITATIONS...



FURTHER LIMITATIONS...



CONCLUSIONS

RESULTS WITH CURRENT LIMITS:

- potentially available areas are **wide enough** to tackle the outlet of both the present and expected future sludge production, even when introducing some limitations to applicable quantities to take into account agricultural cycles, soil depth and actual availability of some areas
- the lower security factors obtained show that potentially available areas would be able to handle a sludge production **three or two times higher than the present and expected production** respectively

CONCLUSIONS

PROPOSAL OF A LEGISLATIVE REVISION:

- enlarge the types and location of areas to be potentially considered eligible for sludge application
- conversely restrict the maximum applicable quantities per hectare to meet crop nitrogen requirements



- sufficient reuse potential even in the most conservative hypothesis, as security factors are never less than one

CONCLUSIONS

The proposed analysis would suggest moving the focus of political decisions from **general** but in many cases **generic** law constraints towards **specific** ones closely related to the **environmental and agricultural local practices and standards** (cultivation cycles, crop rotations, high olive mill effluent production, etc.).

The realised maps can be used to plan a **strategic upgrading of wastewater treatment plants**, aimed at improving sludge quality in those plants located in areas suitable for sludge agricultural use or at detecting different disposal routes for those plants for which these areas are scarce.

CONCLUSIONS

Land is available.....

...but **is there anyone who wants to use sludge?**

Farmers are still suspicious about the possibility to use sludge in their lands.

There is **the need to guarantee sludge quality and to promote agricultural sludge use at regional level.**