SWISS-ITALIAN PILOT AREA

LOMBARDIA AREA

Stefano Brenna, Alberto Rocca - 2005, May

NAMES OF THE PARTICIPANTS TO THE WORK

institution	name	action field
ERSAF	Stefano Brenna	pedology
	Alberto Rocca	soil database, GIS
	Silvia Solaro	geology, elaboration on organic carbon content
REA s.c.r.l.	Anna Gentilini, Michele D'Amico	excursion area soil survey

GENERAL DESCRIPTION OF THE AREA

The Swiss-Italian pilot area, 400 km^2 wide, is located between the lakes of Lugano and Como, all around the southeast region of "Canton Ticino" called "Malcatone" (see figure 1).
The extent is 20 km both longitudinal and latitudinal.
The reference grid contains 1km x 1km cells; pilot area is formed by a set of 400 regular cells or pixel. Table 1 reports area spatial localization (longitude and latitude) according to Lambert Azimuthal Equal Area Coordinate System.

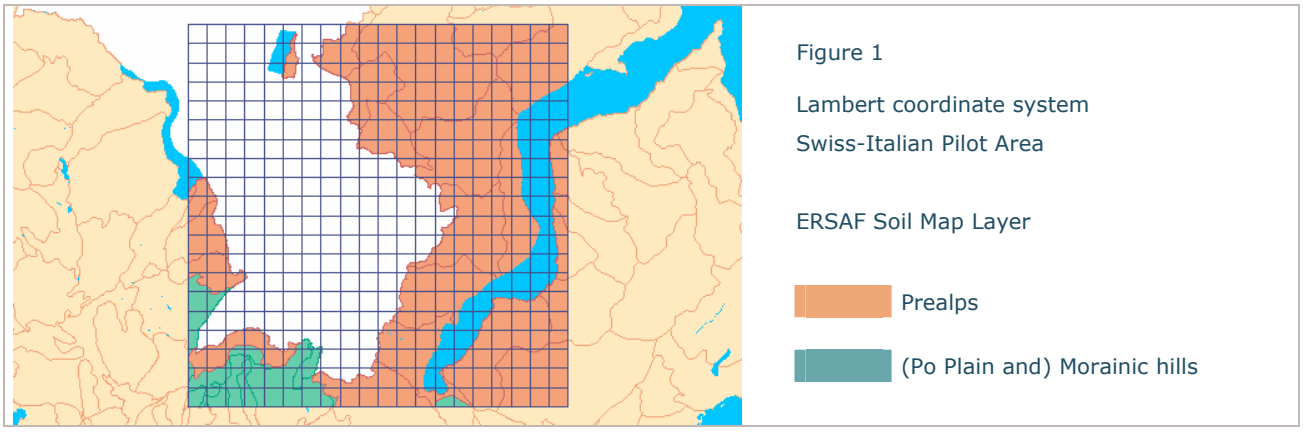


Table 1 – Geography of pilot area in Lambert coordinate system

Unit	Km
[Xmin, Ymin]	[4236, 2522]
Range X	[4236-4256]
Range Y	[2522-2542]

The Lombardia area is characterized:
- in the central and northern part mainly by calcareous rocks (Jurassic age) with steep slopes and high plateau;
- near the lake of Lugano by vulcanites (mainly granophires);
- at the southern margin of Prealps by Cenozoic sandstones and conglomerates (Gonfolite) often with a coverage of glacial deposits;
- in the south and in the south-western part by Morainic Hills and glacial deposits.

The altitude is ranging from 200 m. to over 1680 m.; the rainfall on the average from 1400 mm in the south to 1800 mm in the north. The area is highly urbanized in the southern part, near Como and locally along the lakeside.
Forestland (broad-leaved trees, such as Castanea, Fraxinus, Carpinus, Quercus, Robinia, with rarely Pinus Sylvestris) is widespread in the area with grass and pasture lands on the plateau and on the intermorainic plains. Instead arable lands are rare, only occurring in the south.
Cambisols and Leptosols occur in the Prealps (figure 2).
Cambisols, Umbrisols and Luvisols occur in the Morainic zone; Luvisols are localized in the south-western corner of the pilot area when old morainic surfaces (middle-late Pleistocene) are present.

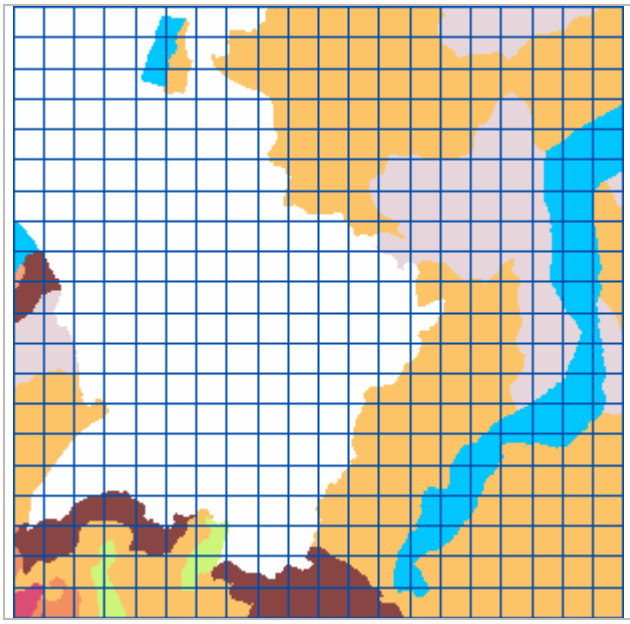


Figure 2

Lambert coordinate system
Swiss-Italian Pilot Area
Reference Soil Groups (WRB, 1998)

MAIN DATA SOURCE

- Georeferenced soil database of Lombardia - scale 1:250.000
- Regional land use map (DUSAF project, 2002) - scale 1:10.000

SOFTWARE AND GIS PACKAGE USED

- Microsoft ACCESS: query on soil database;
- Microsoft EXCEL: soil data elaborations;
- ESRI ARC GIS v. 8.2: Geographical Information System

GEOGRAPHICAL DATA CONVERSION AND PROJECTION SYSTEMS

Projection to Lambert System

For the sake of the ECALP project, Lombardia soil and land use maps are used.
The original coordinate system is EDT50 Gauss-Boaga West.
Map has been projected to Lambert system by means of ARC GIS v. 8.2 software.
Datum transformation used is [ED_1950 to WGS_1984_1].
Table 2 reports the surface distribution obtained with the use of ERSAF GIS layers

Table 2 - Pilot area surface distribution with ERSAF GIS layers

	Italy	Switzerland	border	total
pixel	200	125	75	400
area (km^2)	237,51	162,49		400
area (%)	59,4	40,6		100

Grid transformation in Gauss-Boaga West coordinate system

Pilot area has been projected from Lambert system to Gauss-Boaga West system.
This transformation is not automatically supported by Arc Gis software; so it is necessary to define transformation method type and related input values.
The conversion has been performed by means of a geocentric translation, using the negative values for the transformation [ED_1950 to WGS_1984_1].
Pilot area in Gauss-Boaga West system is shown in figure 3. We can observe that:

- grid is not perfectly squared;
- grid cells sides are segmented;
- grid cells area is less then 1 km^2 (mean value is 0,9992 km^2).

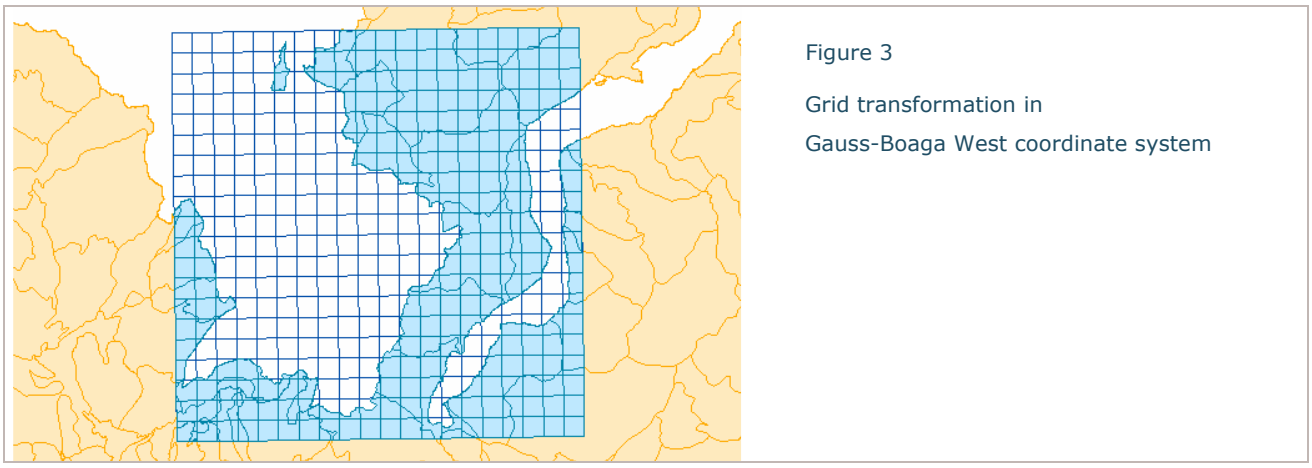


Figure 3

Grid transformation in
Gauss-Boaga West coordinate system

Comparison

A comparison between two coordinate systems has been carried out; we have followed the method described in ECALP_Projection_Technical Note, using the ERSAF soil map of Lombardy.
After having spatially overlaid soil map units with projected grid in Gauss-Boaga West coordinate system, we have calculated the percentage of cell's area occupied by each fraction of soil map unit. The same operation has been applied in Lambert system: in this case projected soil map units have been spatially overlaid with the original grid.
Finally we have compared the percentage of cell occupied by each fraction of soil mapping unit in both coordinate systems.
The result of this comparison is:

- difference between the two cases fits a Gaussian distribution: mean value 0,08 and standard deviation 6,4;
- no perfect equivalence: error is relevant in some cells (more than 10 %).

For this reason we have chosen Lambert system for working with pedological data.

CRITERIA AND RULES FILLING THE EXCHANGE FORMAT

Soil coverage: SUR-BARE, SUR-URB, W-BODY, STU-TOT

Step 1 - ERSAF land use categories has been classified according to ECALP pixel coverage classes (see table 3):

- rock or bare deposits [SUR-BARE]
- urban areas [SUR-URB]
- water bodies [W-BODY]
- total soil coverage [STU-TOT]

Land use categories referred to agricultural use have been subsequently identified.

Step 2 – Using land use map, we determined in each pilot area pixel with respect to the total Lombardia area the soil coverage area percentages [SUR-BARE, SUR-URB, W-BODY, STU-TOT] and the agricultural area percentages.

It means that [SUR-BARE + SUR-URB + W-BODY + STU-TOT] is equal to 100% if the Lombardia area covers the whole pixel; instead it is lower than 100% for the pixel at the Swiss-Italian border ("crossing over"-"shared" pixel).

In correspondence to each pixel total coverage [SUR-BARE + SUR-URB + W-BODY + STU-TOT] is equal to Italian area.

AGRI-USE

The presence of agricultural use is related to the whole pixel and not to the dominant STU. Code for agricultural use (AGRI-USE=1) is done when agricultural area is larger than 10 per cent of STU-TOT area of the pixel.

Dominant STU

Soil and land use maps have been spatially overlaid with pilot area grid, in order to determine the effective soil area for each soil mapping unit (SMU) in each pixel (so that the sum of these surfaces corresponds to STU-TOT - see page 5). For example in pixel where STU-TOT is null, e.g. pixel surface totally urbanized or occupied by water bodies, dominant STU research has automatically stopped.

Then two ACCESS tables have been considered for dominant STU identification:

- [SMU-STUTOT_pixel]: it provides soil coverage area fraction for each soil mapping unit (SMU) occurring in the pixel [percentage calculated on pixel total area];
- SMU-STU: it provides area fraction occupied by the STU occurring in the soil mapping unit (SMU) [percentage calculated on SMU area].

The two tables are related by means of field [SMU] (soil mapping unit).

Dominant STU calculation is based on a sequence of data selection queries, developed in collaboration with ARPA Veneto. The aim is to define:

- the area (percentage) of each STU inside the soil coverage of each pilot area pixel;
- the STU that is correspondent to the maximum area in the pixel (dominant STU).

At page 6 an example of the application of ACCESS queries for dominant STU determination.

In some circumstances (17 pixels) the resulting maximum STU area is correspondent to two STU. However it has been observed that the two STU belong to the same soil unit (the most wide SMU in the pixel, sometime the only one). In these cases the dominant STU has been identify on the basis of an expert judgment procedure.

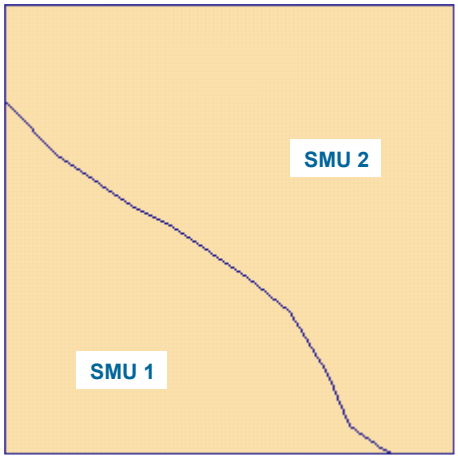
Dominant STU has been calculated in 263 pixel, where STU-TOT is not null.

Table 3 – ERSAF land use categories classified according to ECALP pixel coverage classes

code	description	pixel coverage	agri-use
L1	frutteti e frutti minori	STU-TOT	yes
L2	vigneti	STU-TOT	yes
L2f	vigneti misti a frutteti	STU-TOT	yes
L2o	vigneti misti ad oliveti	STU-TOT	yes
L3	oliveti	STU-TOT	yes
L3v	oliveti misti a vigneti.	STU-TOT	yes
L5	castagneti da frutto	STU-TOT	yes
L7	pioppeti	STU-TOT	yes
L8	alter legnose agrarie	STU-TOT	yes
P1	marcite	STU-TOT	yes
P2	prati permanenti di pianura	STU-TOT	yes
P2p	prato viene a pascolo	STU-TOT	yes
P2s	prati permanenti di pianura associati ai seminativi.	STU-TOT	yes
P2sa	presenza diffusa di filari arborei	STU-TOT	yes
P2sc	presenza rada di filari arborei	STU-TOT	yes
P4	prati e pascoli	STU-TOT	yes
P4a	prati e pascoli: presenza di essenze arboree isolate	STU-TOT	yes
S1	seminativo semplice	STU-TOT	yes
S1c	seminativo semplice: presenza rada di filari arborei	STU-TOT	yes
S1r	seminativo semplice con risaie	STU-TOT	yes
S2	seminativo arborato	STU-TOT	yes
S3	colture ortoflorovivaistiche a pieno campo	STU-TOT	yes
S3l	vivai prevalentemente di colture di essenze legnose agrarie forestali ed ornamentali	STU-TOT	yes
S4	colture ortoflorovivaistiche protette	STU-TOT	yes
S4l	vivai prevalentemente di colture di essenze legnose agrarie forestali ed ornamentali	STU-TOT	yes
S6	orti familiari non in ambito urbano	STU-TOT	yes
S7	risaie	STU-TOT	yes
S7s	risaie miste a seminativo	STU-TOT	yes
B1	boschi di latifoglie	STU-TOT	
B1d	boschi di latifoglie governati a ceduo	STU-TOT	
B1e	boschi di latifoglie allevate ad alto fusto	STU-TOT	
B1u	vegetazione arbustiva e arborea di ambiente ripariale	STU-TOT	
B4	boschi di conifere	STU-TOT	
B5	boschi misti di conifere e di latifoglie	STU-TOT	
B5d	boschi misti di conifere e di latifoglie	STU-TOT	
B5e	boschi misti di conifere e di latifoglie allevate ad alto fusto	STU-TOT	
N1/N2	vegetazione palustre e delle torbiere	STU-TOT	
N3	vegetazione rupestre e dei detriti	STU-TOT	
N4	vegetazione rupestre e dei detriti	STU-TOT	
N5	vegetazione dei greti	STU-TOT	
N5g	argini artificiali sopraelevati vegetati e/o percorsi da strade	STU-TOT	
N8	vegetazione arbustiva e cespuglieti	STU-TOT	
N8b	macchie di vegetazione in avanzata evoluzione verso forme forestali	STU-TOT	
N8t	vegetazione incolta (superfici agricole abbandonate)	STU-TOT	
R1	accumuli detritici e affioramenti litoidi privi di vegetazione	SUR-BARE	
R2	aree estrattive	SUR-URB	
R2q	aree estrattive: recuperate	SUR-URB	
R3	discariche	SUR-URB	
R3q	discariche: recuperate	SUR-URB	
R4	ambiti degradati soggetti ad usi diversi	SUR-URB	
U	aree urbanizzate ed infrastrutture	SUR-URB	
A1	ghiacciai e nevai	W-BODY	
A2	laghi, bacini, specchi d’acqua	W-BODY	
A2x	laghi, bacini, specchi d’acqua - dovuti a sbarramenti artificiali	W-BODY	
A2y	laghi, bacini, specchi d’acqua - dovuti ad attività estrattive interessanti la falda	W-BODY	
A3	alvei fluviali e corsi d’acqua artificiali	W-BODY	
R5	aree sabbiose, ghiaiose e spiagge	W-BODY	

DOMINANT STU – Spatial overlay of soil map with land use map

Soil Map



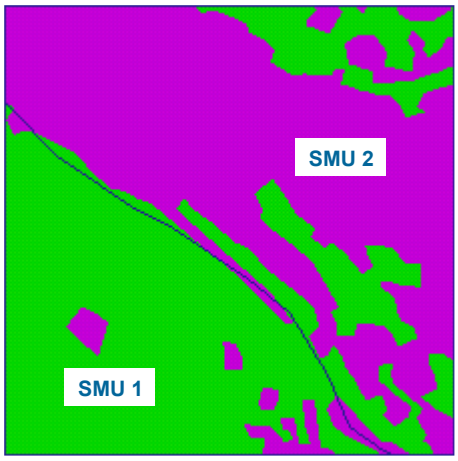
pixel	4247_2523

SMU	ID	area %
SMU 1	02.02.04.001	37,4
SMU 2	02.02.04.002	62,6
sum		100

SMU	n° STU	STU	STU-SMU %
SMU 1	1	M2.UMxx.003	65
SMU 1	2	M2.FLxx.001	35
SMU 2	1	M2.CMxx.004	100

Without considering land use, dominant STU should be M2.CMxx.004 entirely located in SMU 2.

Land use and soil map



pixel	4247_2523

			soil coverage	
SMU	ID	area %	STU-TOT	SUR-URB
SMU 1	02.02.04.001	37,4	34,7	2,7
SMU 2	02.02.04.002	62,6	14,7	47,9
sum		100	49,4	50,6

pixel	SMU	soil SMU %	n° STU	STU	STU-SMU %	STU %
4247_2523	SMU 1	34,7	1	M2.UMxx.003	65	22,6
4247_2523	SMU 1	34,7	2	M2.FLxx.001	35	12,1
4247_2523	SMU 2	14,7	1	M2.CMxx.004	100	14,7

Sum = STU-TOT	49,4

By considering not the whole soil mapping unit but the fraction related to soil (STU-TOT), dominant STU is M2.UMxx.003 located in SMU 1.

DOMINANT STU - application of ACCESS queries [pixel = 4236_2529]

Tables

SMU-STUTOT-pixel

pixel	SMU	soil SMU %
4236_2529	02.02.02.017	22,7
4236_2529	02.02.02.018	28,4

SMU-STU

SMU	STU	n° STU	STU-SMU %
02.02.02.017	M2.LPxx.004	1	40
02.02.02.017	M2.CMxx.003	2	20
02.02.02.017	M2.LPxx.001	3	20
02.02.02.017	M2.CMxx.011	4	20
02.02.02.018	M2.CMxx.001	1	30
02.02.02.018	M2.CMxx.003	2	30
02.02.02.018	M2.LPxx.001	3	20
02.02.02.018	M2.CMxx.011	4	20

Selection data queries

Query 1 It calculates the area (%) of each STU in soil fraction of every SMU.

Q1

pixel	SMU	soil SMU %	n° STU	STU	STU-SMU %	STU %
4236_2529	02.02.02.017	22,7	1	M2.LPxx.004	40	9,08
4236_2529	02.02.02.017	22,7	2	M2.CMxx.003	20	4,54
4236_2529	02.02.02.017	22,7	3	M2.LPxx.001	20	4,54
4236_2529	02.02.02.017	22,7	4	M2.CMxx.011	20	4,54
4236_2529	02.02.02.018	28,4	1	M2.CMxx.001	30	8,53
4236_2529	02.02.02.018	28,4	2	M2.CMxx.003	30	8,53
4236_2529	02.02.02.018	28,4	3	M2.LPxx.001	20	5,69
4236_2529	02.02.02.018	28,4	4	M2.CMxx.011	20	5,69

Query 2 It calculates the total area of each STU in each pixel, so that for each pixel:

$\sum_{stu}$ (STU area %) = STU-TOT

Q2

pixel	STU	Sum of STU %
4236_2529	M2.CMxx.003	13,07
4236_2529	M2.LPxx.001	10,23
4236_2529	M2.CMxx.011	10,23
4236_2529	M2.LPxx.004	9,08
4236_2529	M2.CMxx.001	8,53

Query 3 It chooses the maximum STU area in each pixel.

Q3

Pixel	Max (Sum of STU %)
4236_2529	13,07

Query 4 It points out the STU which has the maximum area in the pixel.

Q4

Pixel	STU	Max (Sum of STU %)
4236_2529	M2.CMxx.003	13,07

Another three queries [Q4-dup, Q4-dup2. Q5] identify dominant STU when more than one STU (member of the same SMU) are correspondent to the maximum area in the pixel.

DOMINANT_STU TABLE

AGLIM1, AGLIM2
Dominant and secondary limitation to agricultural use of the STU.
No information available.

ROO
Depth class of an obstacle to roots in the STU.
Starting information: rooting depth, depth (cm) where a layer providing unfavorable root environment occurs.

IL
Depth class of a presence of an impermeable layer in the STU.
Starting information: occurrence of rocks, pan and/or fine textured and massive horizons.

TOP-DEP
Depth of topsoil of the STU.
Topsoil is considered as the horizon/s at soil surface (A and/or E and/or AB horizons).

TEXT-TOP-DOM
Dominant topsoil textural class of the STU.
Starting information: sand, clay, silt (weighted average of all topsoil horizons).
Textural class has been derived from these values.

TEXT-TOP-SEC
Secondary topsoil textural class of the STU.
No information available.
According to exchange format, TEXT-TOP-DOM value has been entered for TEXT-TOP-SEC.

TEXT-SUB-DOM
Dominant subsoil textural class of the STU.
Subsoil is considered as the portion of the STU between the bottom of topsoil and the depth to obstacle for roots: sum of underlying horizons (B and/or C horizons except R horizons).
Starting information: sand, clay, silt (weighted average of all subsoil horizons).
Textural class has been derived from these values.

TEXT-SUB-SEC
Secondary subsoil textural class of the STU.
No information available.
According to exchange format, TEXT-SUB-DOM value has been entered for TEXT-SUB-SEC.

PAR-MAT-DOM-AR
Code for dominant parent material of the STU
Starting information: soil map (scale 1:250.000).

PAR-MAT-SEC-AR
Code for secondary parent material of the STU
No information available.
According to exchange format, PAR-MAT-DOM-AR value has been entered for PAR-MAT-SEC-AR.

WM1, WM2
Water management system in agricultural land.
No information available. Information more related to land than to soil.

WR
Dominant annual average soil water regime class of the the STU.
Starting point: soil drainage.

WR	Drainage	Drainage classes *
0		
1	well drained	1,2,3
2	moderately well drained	4
3	imperfectly drained	5
4	poorly drained	6,7

* Lombardia Soil Information System

WRB – LEV1/ADJ1-2/FULL

WRB classification (1998)

Some codes have been added.

WRB_LEV1	
LU	Luvisols (alic features)

WRB-ADJ1, WRB-ADJ2	
ed	epidystric
eg	endogleyic
el	endoleptic
ep	epileptic
hd	hyperdystric
he	hypereutric
mh	mollihumic
od	orthidystric

WRB-FULL field is so formed:

[WRB-FULL] = [WRB-LEV1]+[WRB-ADJ2]+[WRB-ADJ1]

New fields

[stu]

Code that identify soil typological unit in ERSAF georeferenced soil database of Lombardia

PIXEL TABLE

OC-S-30/ OC-S-100

Soil organic carbon content in the pixel (t/ha), calculated from 0 to 30 cm / from 0 to 100 cm. Weighted average of all STUs in the pixel.

The procedure used to evaluate soil organic carbon content is based on the following steps:

1. acquisition of input data for each horizons of every STU:
   thickness (cm), bulk density (g/cm^3), organic carbon content (%), rock fragments quantitative (%);
2. determination of total organic carbon content (mg/m^2) in soil by means of formula (Batjes, 1996):

$$T_d = \Sigma [\rho_i \cdot P_i \cdot D_i \cdot (1 - S_i)]$$

where
- T_d = total organic carbon content (mg/m^2)
- Σ = sum extended to all horizons (or layers) of the profile
- ρ_i = density of [i] horizon (mg/m^3)
- P_i = organic carbon content of [i] horizon (g of C/g of soil thin)
- D_i = thickness of [i] horizon (m)
- S_i = volume (%) of fragments having diameter > 2 mm in the [i] horizon

3. determination of total organic carbon content (mg/m^2) for different thickness (30, 100 cm);
4. conversion of values into t/ha
5. weighted average of all STUs in the pixel; data are expressed as t/ha of the total soil coverage [STU-TOT] (not of the whole pixel).

OC-S-HUM

Soil organic carbon content in the pixel (t/ha): calculated only for surface organic layers.

No information available.

S-LOSS

Actual soil loss in the pixel (t/ha/year).

Information not available yet

New fields

[stu]

Code that identify soil typological unit in ERSAF georeferenced soil database of Lombardia

[area-I]

Italy area in the pixel (%)

[id-country]

Code for identify the country where the pixel is located:

I	pixel entirely in Italy
f-I	shared-pixel: (Italian area) > 50 %
f-CH	shared-pixel: (Swiss area) > 50 %

[SUR-TOT]

Total pixel coverage (%):

SUR-TOT = SUR-BARE + SUR-URB + W-BODY + STU-TOT

Tables description [in blue new fields]

DOMINANT_STU	
PX-ID	Pixel identification number (INSPIRE)
stu	Dominant STU code
DOM-STU	dominant STU coverage (%)
AGLIM1	Code for dominant limitation to agricultural use of the STU
AGLIM2	Code for secondary limitation to agricultural use of the STU
IL	Depth class of a presence of an impermeable layer in the STU
ROO	Depth class of an obstacle to roots in the STU
TOP-DEP	Depth of topsoil (cm)
TEXT-TOP-DOM	Dominant topsoil textural class of the STU
TEXT-TOP-SEC	Secondary topsoil textural class of the STU
TEXT-SUB-DOM	Dominant subsoil textural class of the STU
TEXT-SUB-SEC	Secondary subsoil textural class of the STU
PAR-MAT-DOM-AR	Code for dominant parent material of the STU
PAR-MAT-SEC-AR	Code for secondary parent material of the STU
WM1	Code for normal presence and purpose of an existing water management system in agricultural land on more than 50% of the STU
WM2	Code for the type of an existing water management system
WR	Dominant annual average soil water regime class of the the STU
WRB-ADJ1	First soil adjective code of the STU from the World Reference Base (WRB) for Soil Resources
WRB-ADJ2	Second soil adjective code of the STU from the World Reference Base (WRB) for Soil Resources
WRB-LEV1	Soil Reference Group code of the STU from the World Reference Base (WRB) for Soil Resources
WRB-FULL	Full soil code of the STU from the World Reference Base (WRB) for Soil Resources

PIXEL	
PX-ID	Pixel identification number (INSPIRE)
stu	Dominant STU code
area-I	Italy area (%)
id_country	Code for identify the country where the pixel is located
SUR-BARE	Rock or bare deposits (%)
SUR-URB	Urban (%)
W-BODY	Water bodies (%)
STU-TOT	Total soil coverage (%). (Sum of all STUs coverage)
SUR-TOT	Total pixel coverage [SUR-BARE + SUR-URB + W-BODY + STU-TOT]
AGRI-USE	Code for presence/absence of agricultural use in the pixel
PX-CFL	Confidence level of pixel description
PX-AVLB	Soil data availability
PX-SCALE	Scale of the main map used as soil data source
PX-OBS	Number of total observations in the pixel
PX-NPROF	Number of profiles in the pixel
OC-S-30	Soil organic carbon content in the pixel (t/ha), 30 cm from the mineral soil
OC-HUM	Soil organic carbon content in the pixel (t/ha) holorganic layers
OC-S-100	Soil organic carbon content in the pixel (t/ha) 0-100 cm from the mineral soil
S-LOSS	Actual soil loss in the pixel (t/ha/year)

CONCLUSION, FINAL CONSIDERATIONS AND REMARKS

The experience made with ECALP project suggests these considerations for the future:

1. the "focus" should be concentrated on the "relevant" information: which kind of information is relevant and for what, also improving the capacity to compare and share methods and criteria to determine that information;
2. the growth of the "network" among the Regional Soil Services is the most important goal to be followed up; infect the relevant information has to be produced by those services;
3. an Alpine database should be formed by both soil information and other thematic information (climate, geology, …); much of this one should be more properly derived from "layers" rather than a soil map;
4. the problem of coordinates translation should be properly studied, considering the opportunity to get a coherent system for regional, national and European purposes.