Public document

Evaluation with respect to the cost effectiveness

N° FP7-DIGISOIL-D4.3
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The DIGISOIL project (FP7-ENV-2007-1 N°211523) is financed by the European Commission under the 7th Framework Programme for Research and Technological Development, Area "Environment", Activity 6.3 "Environmental Technologies".

Geoscience for a sustainable Earth

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Leandro Chiarantini (GAV)

Iason Diafas (JRC)

Checked by:	**Approved by**:
Name: A.Vagner	Name: G.Grandjean
Date: 29/08/2011	Date: A.Vagner
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Synopsis

The deliverable 4.3 pertains to the third task of DIGISOIL's Work Package 4, "Evaluation with respect to the cost effectiveness". Its main objective is to assess the economic viability of the DIGISOIL technology through the undertaking of a cost-benefit analysis (CBA). For this purpose it relies on data generated by a cost-estimation exercise of the various field trials, while employing as input the findings of the work carried out under Task 4.2, "Evaluation of the DIGISOIL mapping tool according to end-users' needs".

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1. Introduction

It is stated in deliverable 4.1 that despite claims of potential cost savings promised by digital soil mapping, to date there has been no study demonstrating that DSM is an economical alternative to traditional soil mapping methods. The economic appraisal of any new product/technology essentially involves assessing the potential of the said product to create new value. In strict, financial terms, a product's value is determined by the interaction of the forces of supply and demand, which, in turn, reflects the difference between what it costs to produce the product and what a buyer is willing to pay to purchase it. In economics jargon, this difference is made up by the notions of "producer surplus" and "consumer surplus". Producer surplus, or profit, stems from the difference between the selling price of a product and the cost of production. Consumer surplus, on the other hand, is the difference between the price a buyer is willing to pay for the product and the price she actually pays to purchase it. The price that the buyer is willing to pay for a product or service is in turn determined by and reflects her estimation of the returns she expects to obtain from the use of her purchase. For instance, the price that a farmer would be willing to pay to acquire a high-quality digital soil map embodies her estimation of the extra returns that the use of the information will bring. The two forms of residual value, claimed by producers and consumers, are the forces that help generate the economic transactions observed in the markets. In the case in which a producer can charge a price that matches the buyers' maximum willingness to pay, then the whole value created is claimed by the producer. DSM technologies, once tested and established, can and should be amenable to economic assessment based on their potential to create private value as defined above.

Task 4.1 estimated the willingness-to-pay for the final product, which has been envisaged to be a map of several soil properties as these have been identified and studied throughout the course of DIGISOIL project. On the other hand, Task 4.2 has undertaken a cost estimation of the various activities undertaken during the project phase that involved conducting fieldwork and analyzing the data for the purpose of producing maps of the selected soil properties. The current deliverable couples the information generated by the two tasks in an effort to conduct a cost-benefit analysis (CBA) of DIGISOIL's mapping tool as a potential new product.

2. Cost-Benefit Analysis

2.1. BENEFITS

The work carried out for Task 4.1 has taken on end-users' perspective by analyzing their preferences with regard to the use of the DIGISOIL final product as well as the product's various features. The information generated has been the product of two web surveys, the aim of which was to identify potential users, categorize them in terms of their employment and intended use of the technology and elicit their willingness to pay for the product. Figure 1, drawn from an initial, preliminary survey, shows a significant majority of interested end-users would prefer to buy soil properties maps, instead of either buying or leasing the equipment and then generate the maps themselves. Based on this finding, subsequent work focused on assessing users' needs and economic preferences with regard to maps of soil properties displayed in varying resolution and accuracy.

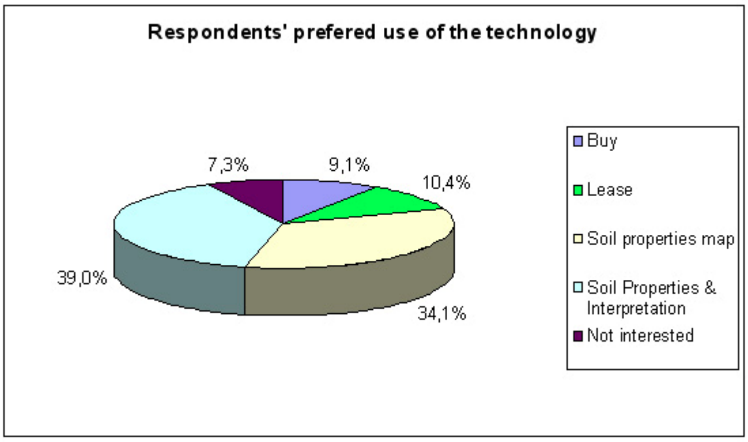

Table 1: Preferred use of the DIGISOIL technology

The results of the second survey are presented in detail in deliverable 4.1. For the purposes of the CBA of the current deliverable, it is the estimates of WTP, shown in Table 1, which are relevant. These estimates are based on responses from 166 respondents who took part in the survey. As explained in D4.1, each number represents the average WTP for obtaining an extra level of the respective attribute. For instance, for the measurement of carbon content, the average respondent would be willing to pay 263€ for obtaining a low-accuracy measurement. In order to have a measurement of high accuracy for the carbon content respondents would be willing to pay 789€ (3 times 263€).

Attribute	WTP/ha	Attribute	WTP/ha
Map Resolution	183€	Water Content	198€
Soil Depth	157€	Clay Content	264€
Bulk Density	210€	Soil Degradation Indicators	811€
Carbon content	263€		

Table 2. Estimates of willingness to pay for low accuracy/resolution maps

2.2. COSTS

Information on the costs associated with the field trials carried out in Luxemburg and in Mugello, as well as with the ensuing data analysis and map generation stages of the project have been tracked and are presented below. Table 2 shows the costs incurred during the operations that employed geoelectric, seismic and GPR/EMI in order to measure the following soil properties: clay content, water content and soil thickness.

a) SEISMIC	**Hours**	**€**
FIELDWORK		
Equipment		
Laptop		600
Geode seismic acquisition unit		24570
Seismic antenna		2000
Geophone sensors (24)		9840
Quad-like vehicle with access ramp		3100
Panda Penetrometer		13000
GPS		60
Labour		
Technician	32	990
Engineer	32	1185
DATA ANALYSIS (validation, calibration & map generation		
Software & Equipment		
Matlab Licence		3000
Surfer Licence		300
Labour		
Engineer	32	1185

b) GEOLECTRIC	**Hours**	**€**
FIELDWORK		
Equipment		
MUCEP device (lease)		4000
Tablet PC		2500
Labour		
Mucep calibration		
1 Technician	2	62
1 Engineer	2	70
Field trial		
2 Technicians	20	620
1 Engineer	10	350
DATA ANALYSIS (validation, calibration & map generation		
Software & Equipment		
ArcGIS		10000
Isatis		10000
PC (3)		2400
Labour		
Engineer (filtering, mapping)	70	2590

c) GPR/EMI	**Hours**	**€**
FIELDWORK		
Equipment		
Vector Network Analyzer with horn antenna		20000
GSSI SIR 20 with 400 MHz antennas		35000
Geonics EM38		12000
GSSI Profiler		20000
Rugged Laptop Panasonic		4000
dGPS Leica		12000
Quad		5000
Labour		
1 engineer for off-ground GPR & EM38	2	70
1 engineer for EMI GSSI Profiler	2.5	88
1 engineer for on-ground GPR	3	105
DATA ANALYSIS (validation, calibration & map generation		
Software & Equipment		
ArcGis licence		10000
Matlab licence		3000
PC (3)		2400
Labour		
Engineer (data processing)	80	2800
Engineer (mapping)	40	1400

Table 3a-c. Costs for geophysical ground methods (Sismic, Geoelectric and GPR/EMI)

Summarizing, the total amounts involved in the execution of the above techniques are the following:

	Fieldwork		Data Analysis		Total
	Equipment	Labour	Equipment	Labour	
Seismic	53170 €	2175 €	3300 €	1185 €	59830 €
Geoelectric	6500 €	1102 €	22400 €	2590 €	32592 €
GPR/EMI	108000 €	263 €	15400 €	4200 €	127863 €
Total	167670 €	3540 €	41100 €	7975 €	**220285 €**

Table 4. Summary costs for geophysical fieldwork & data analysis

Table 4 shows the various costs stemming from the airborne operation undertaken in Mugello using hyperspectral.

HYPERSPECTRAL	**hours**	**€**
FIELDWORK		
Equipment		
ULM aircraft (lease)		5000
SIMGA (lease)		10000
ASD Fieldspec		70000
GPS		170
Aeronautic handie talkie (2)		270
Consumables (fuel and batteries)		400
Labour (2 campaigns)		
SIMGA operation before/after flights &data checks	16	880
Soil sampling	80	2300
DATA ANALYSIS (validation, calibration & map generation		
Software & Equipment		
ENVI Software (without IDL)		2000
IDL-ENVI		7000
MATLAB		150
Graphing and data analysis software (e.g.: Origin)		100
Multivariate data analysis software (e.g.: Umetrics SIMCA)		650
Laboratory illuminating equipment		3000
XR diffractometer		10000
Other devices for laboratory analyses: chemical, mineralogical, geotechnical		4000
PARGE geocoding software licence		3000
ATCOR atmospheric correction SW licence		4000
Workstation for image processing		2000
Consumables		2500
Labour (2 campaigns)		

Data pre-processing & corrections (Calibration, geocoding, atmospheric compensation	100	5000
Data analysis & results		
Soil sample analysis	700	19600
Soil map processing	100	4700

Table 5. Summary cost for Hyperspectral field work & data analysis

Again, summarizing the above data, the total costs of the hyperspectral operation and map generation are:

	Fieldwork		Data Analysis		Total
	Equipment	Labour	Equipment	Labour	
Hyperspectral	85840 €	3180 €	38400 €	29300 €	**156720 €**

Table 6. summary costs for HS operation & mapping

2.3. COST-BENEFIT COMPARISON

The aim of this section is to assess the economic potential of the DIGISOIL mapping tool by comparing the costs of producing the various maps with the economic benefits that these maps can confer to the end users. In order to do so, however, the simple enumeration of the aforementioned costs will not suffice. Instead, they need to be interpreted and put in the right context by making certain points and assumptions that will make them comparable to the estimated benefits.

- The estimated WTP is on a per-hectare basis.

- The area covered by the ground-based techniques in Luxemburg is about 6 hectares.

- The area covered by the airborne hypespectral operation in Mugello is about 130 hectares but the mapped area and the area where soil sampling and analysis was carried out is just over 5 hectares.

- Most of the equipment/software used for both ground-based and airborne operations has been purchased. Exceptions are the SIMGA sensor, the aircraft used and the MUCEP device, which were leased for one day. The purchase price for a system similar to SIMGA is about 250-300K €, while for an aircraft of similar capabilities it is 70K €. The MUCEP device is currently not on sale but only leased out.

- Capital (physical equipment & software) depreciates, and according to the depreciation rate applied, different capital life spans are assumed. An optimistic depreciation rate is 10% for physical capital, implying a time span of 10 years. Computers and software, however, depreciate considerably faster, as newer and more advanced versions spring up regularly, rendering existing ones increasingly obsolete. Thus, with an optimistic 20% rate, software and computer life span is estimated to be 5 years.

- A maximum of 20 operations can be performed each year.

Based on these points, the costs per hectare of a ground-based operation employing the above mentioned techniques can be calculated as follows :

[160570€ (physical equipment) /10years/20times + 4000(MUCEP leased)+ 48200€(software+computers)/5years/20times + 11515€(labour)]/5ha= **3360€/ha**

For the hyperspectral the following calculation yields the relevant costs, based on the assumption of purchasing the SIMGA system and the aircraft instead of leasing them:

[407840€(physical equipment) /10years/20times + 18900€(software+computers)/5years/20times + 32480€ (labour]/128ha= **271€/ha**.

A note of caution is warranted regarding this last result. Though the area covered by the flight operation is about 130 hectares, most of the costs incurred pertain to work carried out on the ground and for laboratory analyses in order to setup and validate the methodology on some well studied test fields. This means that this technique is potentially economically viable only when used for mapping large areas e.g. catchments but not field sized areas, as it is in principle, the aim of remote sensing techniques when observing from airborne and spaceborne platforms. For these reasons the Hyperspectral cost/ha reported above could be considered more representative of the final cost in the “commercial perspective” of Digisoil products exploitation for large-area mapping than for the Digisoil development phase resulting in few hectares of digital validated maps as the above cost figures refer to.

For costs comparison on a common unit area, the same procedure as above has been applied separately for each single technique and results are reported in the following summary table:

	SISMIC	**GEOLECTRIC**	**GPR/EMI**	**HYPER**
equipments total	**59670**	**4000**	**104000**	**407840**
SW & computers	**3900**	**24900**	**19400**	**18900**
labour	**3360**	**3692**	**4463**	**32480**
Costs for 5ha	3697.35	7961	5177	-
Costs for 128ha	-	-	-	34708.2
COSTS/Ha	**739.5**	**1592.2**	**1035.4**	**271.2**

Table 7. Summay Costs/ha of DIGISOIL technologies

2.4. WTP-COST COMPLIANCE

On the basis of the above cost-benefit analysis a summary of costs per-hectare for each method is reported in Table 8. On the basis of these values a WTP compliance analysis is tried in order to perform a "commercial maturity" evaluation of DIGISOIL technologies and final products (soil parameter maps).

In the upper part of the table, the WTP/ha values, as estimated and described in D4.1, are reported both for low quality and high quality maps in terms of map resolution and accuracy.

In the middle part of the table, the different technology costs and instrument configurations for different maps are enhanced. For each kind of map the total cost for the required instrument configuration is also reported.

The lower part of the table shows the results of the compliance (maturity) analysis for low quality and high quality maps in terms of WTP/Cost (%).

		WTP/ha						
		Map resolution	Soil Depth	Bulk Density	Carbon Content	Water Content	Clay Content	Degradation Indices
Low quality		183	157	210	263	198	264	-
High quality		549	471	630	789	594	792	(811)
Technology	***Cost/ha***							
SISMIC	740		X	X				
GEOEL.	1590			X		X	X	
GPR/EMI	1035		X		X	X		
HYPER	270				X		X	
Total	***3635***							
Technology Cost/ha/Map			1775	2330	1305	2625	1860	(9895 = total cost/ha)
Low Quality Map Maturity			8.8%	9.0%	20.1%	7.5%	14.1%	
High Quality Map Maturity			26.5%	27.0%	60.4%	22.6%	42.5%	

Table 8. "Commercial matury" analysis based on cost results and estimated WTP

The cost impact of DIGISOIL technologies is shown in Table 9, where ground geophysical methods show higher costs compared with airborne Hyperspectral technique because of the impact of cost/ha for ground and laboratory work is higher than flight management and airborne data processing.

In Table 10, the impact of each DIGISOIL technologies expressed in % of the total cost/ha (9895**€) is shown. Observing the diagram seems that these five maps are nearly balanced in terms of costs although cost differences between techniques are based on as shown in** Table 9.

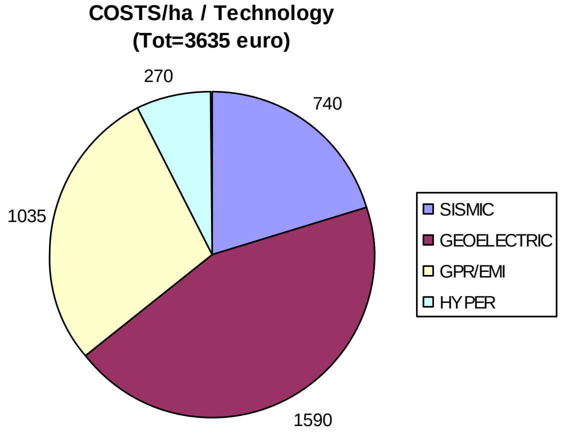

Table 9. Cost impact of DIGISOIL technologies

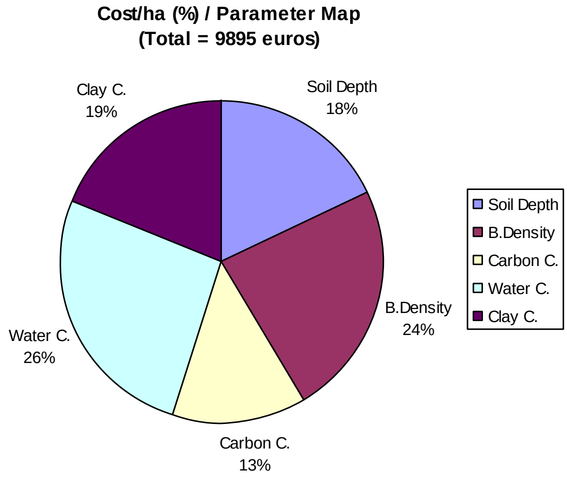

Table 10. Cost impact of DIGISOIL maps

Finally, the compliance (maturity) results shown in the lower part of Table 8 are shown as bar diagram in Table 11 in order to enhance different maturity level (0-1) for low and high quality maps, as well as the “commercial gap” which results from DIGISOIL study. The business development on digital soil mapping, as well as further technology developments and economical studies will be to bridge this gap up to the full commercial maturity.

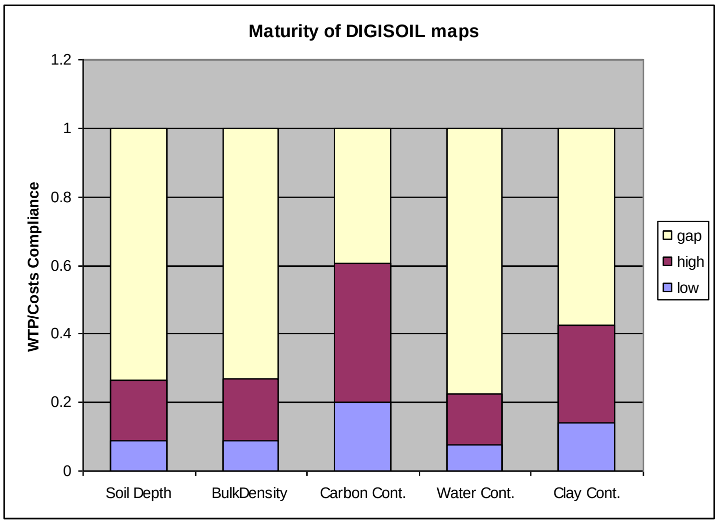

Table 11. "Commercial maturity" of DIGISOIL maps

3. Conclusions

A cost-benefit analysis was performed for DIGISOIL final products (Soil Depth, Bulk density, Carbon content, water content and clay content) and for geophysical methods have been studied (Seismic, geoelectric, GPR, EMI, Hyperspectral).

The work was based on user needs, technical maturity and economical analyses from deliverables D4.1 and D4.2 and in particular on the basis of willingness to pay (WTP) and cost analysis results.

The main result of this work is the commercial maturity estimation for low and high quality maps as shown in Table 11 where:

- The unit cost/ha ranking from (low to high cost) of studied geophysical methods is: 1) Hyperspectral (270€), 2) Seismic (740€), 3) GPR/EMI (1035€), 4) Geoelectric (1590€)

- The maturity ranking of soil maps is 1) Carbon Content (60%), 2) Clay Content (42%), than Bulk Density, Water Content and Soil Depth in the range (23-27%)

- The commercial gap range from 77% to 40% for high quality Water Content map and Carbon Content maps respectively.

The “commercial gap” which results from WTP/cost compliance analysis means that further business development on digital soil mapping, as well as further technology developments and economical studies are needed to bridge this gap up to the full commercial maturity of DIGISOIL products.

4. References

- M.Thörnelöf and M.Fontaine, 2011. Technical maturity of the DIGISOIL output relatively to user needs. Report N° FP7-DIGISOIL-D4.2; 34 pages

- I. Diafas, P. Panagos, 2011. Evaluation of the DIGISOIL mapping tool according to end-users' needs. Report N° FP7-DIGISOIL-D4.1; 21 pages.

Scientific and Technical Centre
RIS Division
3, avenue Claude-Guillemin - BP 36009
45060 Orléans Cedex 2 – France – Tel.: +33 (0)2 38 64 34 34