TULIPS

Demonstrating lower polluting solutions for sustainable airports across Europe

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Abstract
This deliverable reports the results of the land and carbon soil study for Schipol and Larnaca. In particular the study focuses on the biochar characterization and on the definition of biochar field trials set-up.

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List of Acronyms

Acronym	Meaning
BD	Bulk Density
CO2eq	Carbon dioxide equivalent
C	Carbon
EU	European Union
FAO	Food and Agriculture Organization
GA	General Assembly
Ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JRC	Joint Research Center of the European Union
KOM	Kick Off Meeting
LUCAS	Land Use and Coverage Area frame Survey
OC	Organic Carbon
SOC	Soil Organic Carbon
t	tons
WP	Work Package
yr	year

Executive Summary

To achieve carbon neutrality on a global scale, we can act on two pillars: on the one hand by drastically reducing emissions, and on the other hand by increasing carbon sinks. Natural spaces can play a decisive role because they are able to sequestrate carbon from the atmosphere, and store it in soils and biomass. Airports soils assets have been identified as one of the possible options for allowing carbon sequestration, and therefore support the efforts to decarbonize the sector. The TULIPS project aims at evaluating the potential in terms of carbon sequestration at airports level, based on the lands assets for implementing Nature Based Solution, in Turin, Larnaca and Schiphol airports. One of the tested solutions is based on the use of biochar. A biochar experiment has been launched in Larnaca in February 2023, and in Turin in 2023, and is going to be implemented in Schiphol in October/November 2023.

Airports carbon stocks in soils and in the biomass have been assessed for Larnaca and Schiphol, based on the land-use. In Larnaca, carbon stock reaches 44 tons C/ha, accounting for 17 580 tons in 397 ha. Sparse vegetation land and cropland have been identified as promising for carbon sequestration due to their low carbon stocks and high representativeness. In Schiphol, carbon stock reaches 124 tons C/ha, accounting for 421 229 tons in 3 384 ha. Cropland has been identified as promising for carbon sequestration due to its low carbon stock and high representativeness. In the three airports, grasslands are also targeted to improve carbon sequestration, the incorporation of biochar into the soil is one of the studied solutions.

Figure 1: Schiphol airport landscape

Objectives

The main objective of Egis in the TULIPS mission is to evaluate the potential of carbon sink of the natural lands assets of the airports, using nature-based solutions for increasing the carbon storage.

These objectives are achieved implementing land-use changes (e.g. agricultural land transformed in grassland), and/or management changes (e.g. no till, increased manure input). Moreover, to understand better the potential for biomass/soil carbon sequestration, innovative solutions are encouraged in a framework of climate change mitigation. Specifically, biochar application has been investigated as a technical solution increasing carbon stocks in a short period of time while ameliorating different soil functions (e.g. water retention, biodiversity). Under these premises, two main objectives have been delineated for the project:

1. **Objective 1**: Assess current carbon stocks and potential carbon sink increase due to land use and management changes.

2. **Objective 2**: Quantify the effect of biochar application on soil carbon stocks (in collaboration with POLITO and RE-CORD).

Carbon stock and carbon sequestration

Carbon stock

Definition

Carbon is stored in different reservoirs: in the atmosphere (CO_2), in water, in the soil, in minerals and in biomass. Carbon stock designates the quantity of carbon in one or more carbon reservoirs present in the ecosystem considered, at a specific time. The main problem underlying the phenomenon of climate change is linked to the increase of the atmospheric carbon stock.

Evaluation method

The measurement of carbon stocks is done by considering numerous compartments. The main ones are:

1. Biomass: Aboveground biomass (AGB) which includes the aerial part of trees (trunk, branches, foliage), Belowground biomass (BGB) which includes roots and necromass/Dead Organic Matter (DOM) which includes dead biomass overground.

2. Soil Organic Carbon, sometimes broken down into different sub-compartments depending on the speed of decomposition of the organic matter (OM). The measure is taken in the 0-30cm horizon in compliance with IPCC standard. Carbon stocks in the top 30cm of soil is calculated using a recorded bulk density (0-30cm) in g/cm^3, and % soil organic carbon (0-30cm).

Carbon stocks are more or less important depending on land use, from the highest to the lowest: wetlands, grasslands, forests, agricultural crops, artificial areas, other lands.

Carbon sequestration

Definition

Carbon sequestration is the underlying dynamic process that makes it possible to analyze the evolution of carbon stocks. However, its measurement is particularly complex (bidirectional flow analysis – turbulence covariance method, soil respiration with closed chambers, etc.) and is therefore rarely carried out, its modelling is more widespread.

On the planet, constant exchanges of carbon take place between the different reservoirs. Ecosystems have the capacity to store or release carbon. It is a dynamic process that supports the climate regulation service.

Evaluation method

To model the increase/decrease in carbon stocks due to land-use and management changes, the different steps are:

1. Identification of the perimeter of intervention;
2. Land-use assessment through available data and remote sensing;
3. Soil carbon stock assessment via available database (e.g. LUCAS);
4. Land use changes and management design;
5. When available, collection of literature data on the effect of land-use change and management on carbon sinks and stock;
6. Modelling of the effect of land-use and management changes on carbon stocks.

The length of time that land remains in a conversion category after a change in land use is by default 20 years (the time period assumed for carbon stocks to come to equilibrium for the purposes of calculating default coefficients in the 1996 IPCC Guidelines.

Larnaca airport carbon stock evaluation

Location and land-use

Cyprus is situated in the eastern Mediterranean, presents a topographically diverse terrain marked by the Troodos Mountains, fertile plains, and an alluring coastline sea. It is located 104 km west of the Syrian coast. The Troodos Mountains, central to the island, feature verdant landscapes with dense forests and small villages. Contrarily, the Mesaoria Plain, positioned between the Troodos and Kyrenia mountain ranges, is characterized by arable expanses conducive to agriculture.

Larnaca is located in the South-East of Cyprus and is one of the more prominant cities on the island. It is one of the most visited cities as it offers great tourism opportunities and has a large international airport in the city. .

Larnaca airport area is 578 ha and was partly built on a salty lake. The airport is surrounded in the North and in the South by two NATURA 2000 protected areas. Geological layers typologies have been identified through the GEOportal of Cyprus Geological Survey Department data. Salt Lake with alluvium is largely represented within the airport. Terrace deposits are located at the South and West edges of the airport.

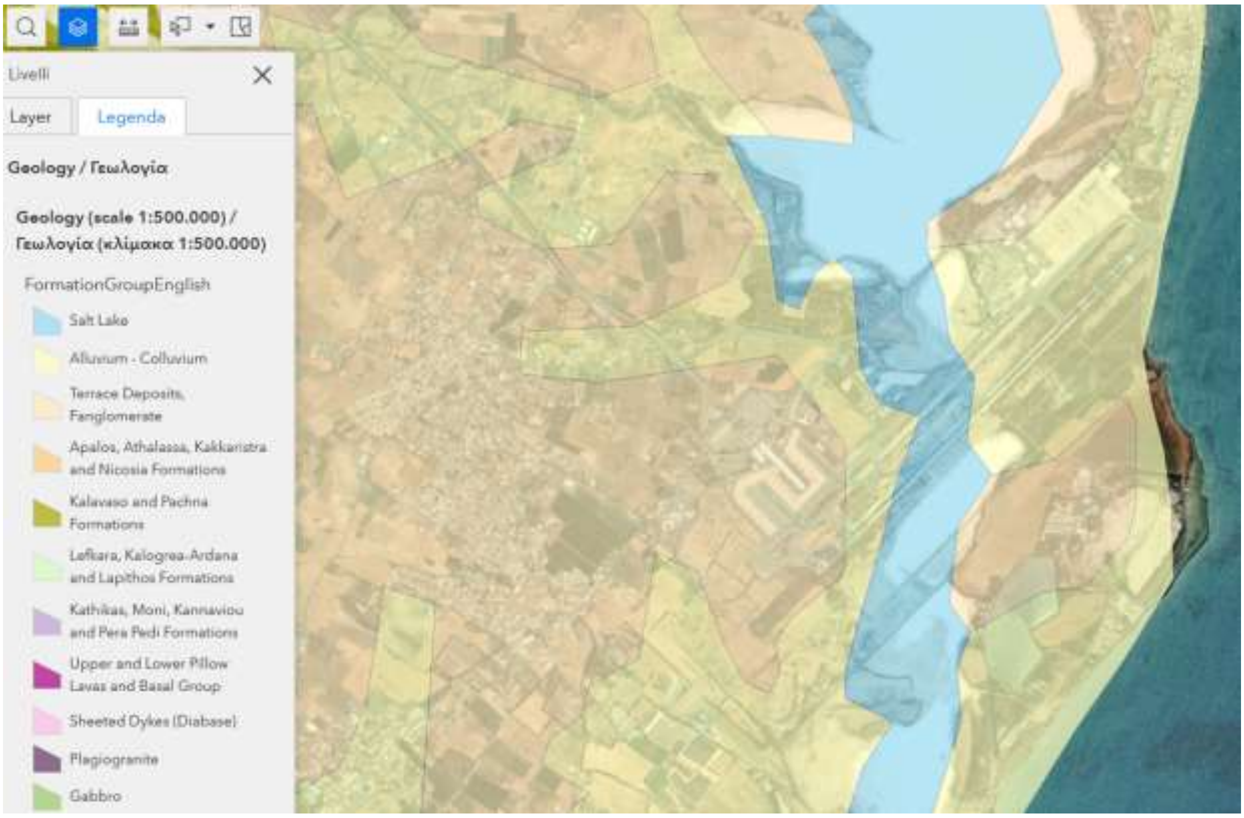

Figure 2: Geological map of the area (Cyprus MOI Geoportal)

Based on remote-sensing, the land-use of the airport has been identified. Built-up area represents 31% of the land area of the airport followed by cropland (23%), grassland (18%) and bare/sparse vegetation (12%). In the South of the airport, water bodies and herbaceous wetland represents 9% and 7% of the total area. The land-use map is presented in Figure 3: Land-use map of Larnaca airport.

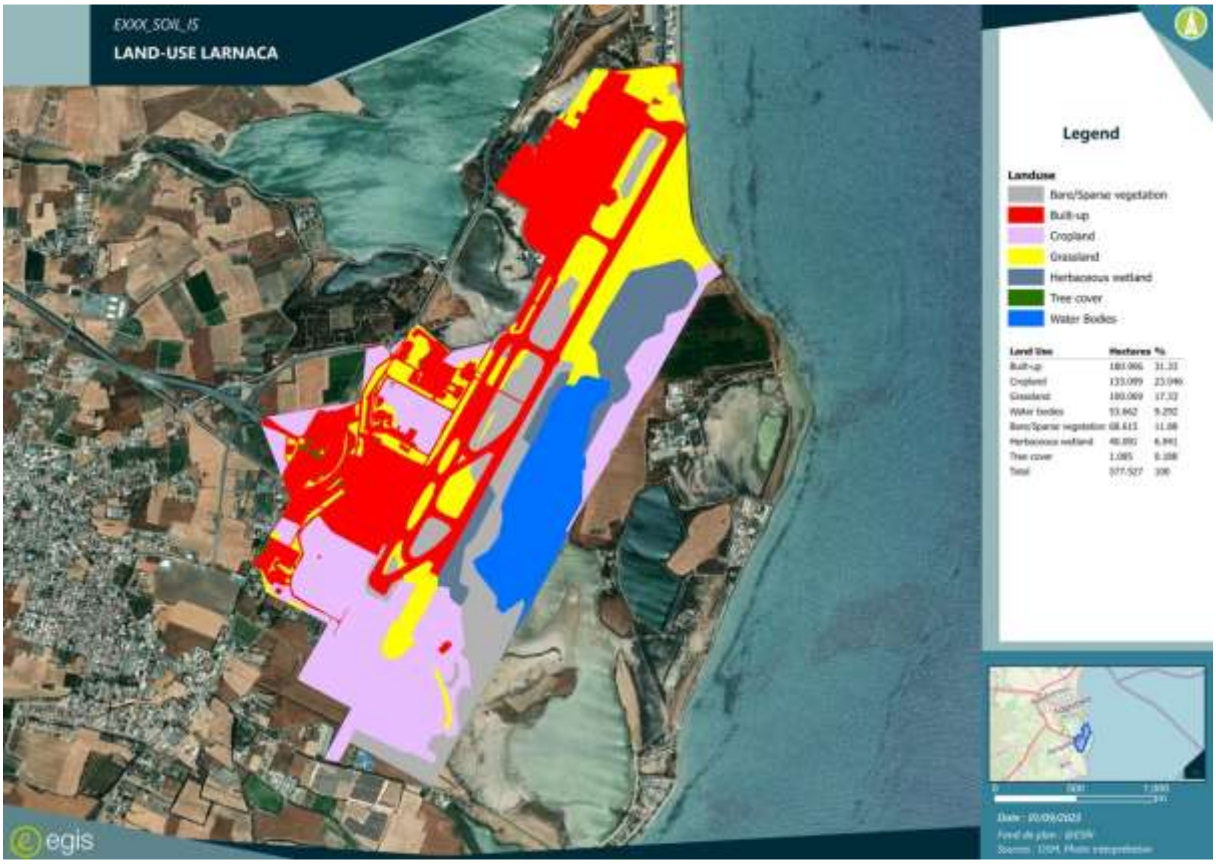

Figure 3: Land-use map of Larnaca airport

Details of land-use categories and areas on Larnaca Airport are in found in Table 1: Land-use categories and area.

Table 1: Land-use categories and area in Larnaca Airport

Land-use category	Area	Ratio
Unit	ha	%
Grassland	100,1	17%
Bare/Sparse vegetation	68,6	12%
Tree cover	1,1	0%
Built-up	180,9	31%
Herbaceous wetland	40,1	7%
Cropland	133,1	23%
Water bodies	53,7	9%
Total	**577,5**	100%

Carbon stocks evaluation

Country specific data have been used to evaluate C stocks (IPCC Tier 2 method). However, a more accurate approach will be applied in areas dedicated to the carbon sequestration program based on field measurements (IPCC Tier 3 method).

Following literature research on available scientific papers, reports, and datasets, two main datasets have been identified in regards to soil organic carbon content:

LUCAS dataset. The JRC LUCAS dataset, produced by the European Commission's Joint Research Centre, stands for "Land Use and Coverage Area frame Survey" (JRC, 2019) (Fernandez-Ugalde, 2022) (Orgiazzi, 2018). It is a comprehensive and high-resolution land-use and land-cover dataset for the European Union (EU) member states and neighbouring countries. The dataset is intended to provide accurate and up-to-date information about the distribution and changes in land use and land cover across the region. In addition to providing land-use and land cover information, the JRC LUCAS dataset also includes data on organic carbon content in the soil which gives valuable information for understanding the health and quality of the land. The dataset's coverage of organic carbon content provides insights on soil fertility, carbon sequestration potential, and overall soil health across the surveyed region. The LUCAS dataset can be found in table 2.

Table 2: Soil Organic Carbon data (LUCAS dataset)

	Organic Carbon	**Bulk Density 0-20**	**Organic Carbon per ha**
Unit	g/kg	g/cm³	t/ha
Oats	13,0	1,206	46,8
Other coniferous woodland	8,1	0,990	24,1
Spontaneously re-vegetated surfaces	14,9	1,182	52,8
Potatoes	14,9	1,296	57,9
Vineyards	10,1	1,021	30,9
Olive groves	10,0	0,885	26,4
Grassland without tree/shrub cover	21,9	1,077	70,8
Mix of cereals	18,3	0,542	29,8
Oranges	16,4	0,885	43,5
Shrubland with sparse tree cover	28,8	1,318	113,9
Permanent industrial crops	22,1	0,990	65,7
Pine dominated coniferous woodland	9,2	0,065	1,8
Grassland with sparse tree/shrub cover	21,5	0,836	53,8
Shrubland without tree cover	17,2	0,921	47,5
Apple fruit	10,1	0,885	26,8
Other fruit trees and berries	20,9	0,969	60,8
Barley	7,9	1,074	25,4
Tomatoes	5,5	0,990	16,3
Other bare soil	17,4	1,016	53,0
Common wheat	9,8	0,943	27,8

Cyprus geochemical atlas. The Geochemical Atlas of Cyprus was a five-year project (2006-2011) funded through a public tender by the Government of Cyprus and it was implemented in collaboration with University of New South Wales Australia (Cohen, 2011). The project involved soil samplings from 5500 selected sites covering a total area of 5,897 km^2 and chemical analyses of some 60 chemical elements. The following charts show quantitative soil organic carbon data aggregated for i) land-use classes used in the geochemical atlas and ii) land-use classes used in the CORINE land cover database (Zissimos, 2019). The land use classes in the CORINE land cover database are found in figure 4.

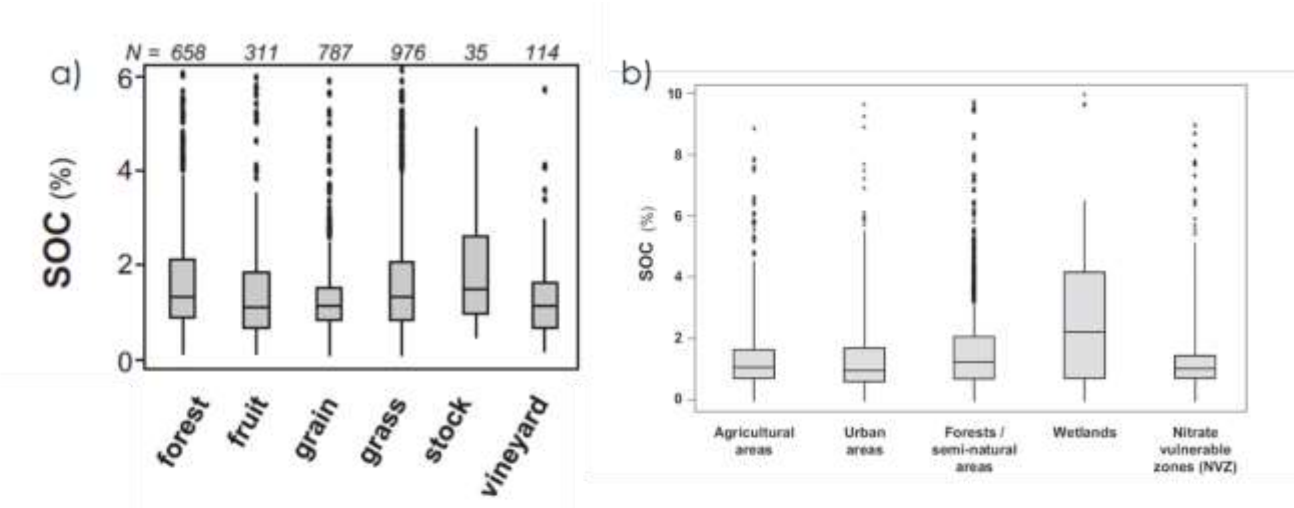

Figure 4: SOC data in Cyprus (Zissimos, 2019)

Biomass carbon stocks evaluation is based on data from the FAO global resources assessment for Cyprus (FAO, 2020). Concerning cropland, given that the biomass is cut and exported and reemitted as CO_2 in a variable time, it was not considered as a C stock. Concerning bare/sparse vegetation and water bodies, data are not available for biomass, but the C stock can be assumed very low.

To ensure a higher representativeness of the data, the SOC data from the Cyprus geochemical Atlas were considered when available, given the high number of survey points utilized for the SOC assessment which can be found in figure 5. To transform the SOC data (in %) to carbon stocks data, bulk density values has been taken from the LUCAS database. Not being available in the abovementioned surveys, IPCC Tier 1 values for carbon stocks in water bodies have been used (Penman, 2003).

The carbon content of soils under "Built-up" areas are not considered as it is highly heterogeneous and studies reveal that more research is needed for its reliable quantification (O'Riordan, 2021).

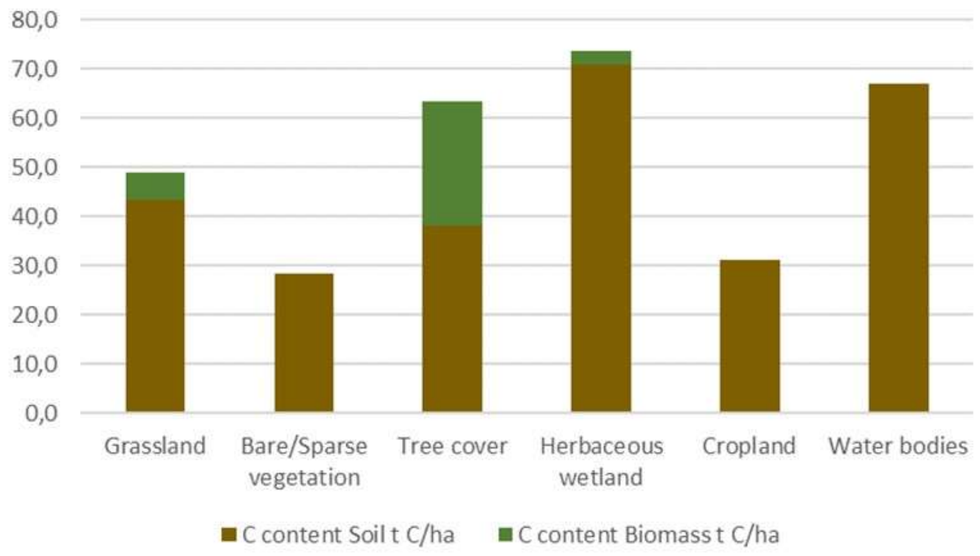

Figure 5: Carbon content in soil and biomass per land-use

The highest carbon stocks can be found in herbaceous wetland, tree cover, grassland and water bodies. Bare/sparse vegetation land and cropland have the lowest carbon stocks.

The total C stock of the airport area is calculated in Table 3: Larnaca airport C stock evaluation per land-use.

Table 3: Larnaca airport C stock evaluation per land-use

Land-use	Area	C content Soil	C content Biomass	C stock
Unit	ha	t C/ha	t C/ha	t C
Grassland	100,1	43,5	5,4	4 893,8
Bare/Sparse vegetation	68,6	28,2		1 937,8
Tree cover	1,1	38,2	25,2	68,8
Herbaceous wetland	40,1	70,7	2,9	2 952,2
Cropland	133,1	31,0		4 132,1
Water bodies	53,7	67,0		3 595,4
Total	**396,6**			**17 580,1**

Larnaca airport's carbon stocks in soils (0-30 cm) and biomass reach 17 580 tons, equivalent to 44 tons C/ha. Cropland and bare/sparse vegetation areas are promising for carbon sequestration program due to their high representativeness and their low carbon content.

Carbon sequestration potential

The objective is to define areas of interest for implementing carbon sequestration solutions at large scale and evaluate ex-ante the carbon sequestration potential. Co-construction workshops will be organized with the airport operator and the stakeholders to define the solutions that could be implemented. Biochar is a high potential solution which is tested on-site within the framework of the TULIPS program.

Schiphol airport carbon stock evaluation

Location and land-use

Schiphol is located in the South-West side of Amsterdam in the Netherlands. Schiphol geological area is characterized by Quaternary Holocene sediment depots. The area is below sea level. Until the 19th century a lake called Haarlemmermeer was present there. The lake has been dewatered from 1840 to 1852 by water-management program consisting on dikes and canals construction. Recovered land was initially used for agricultural activities. The airport construction started in 1916 on the East side of the recovered land.

The total area of the land managed by the airport is 5 044 ha. Remote-sensing has been used to assess the land-use of Schiphol airport. Built-up area represents 33% of the land area of the airport, cropland, 34,5% and grassland 30,1%.

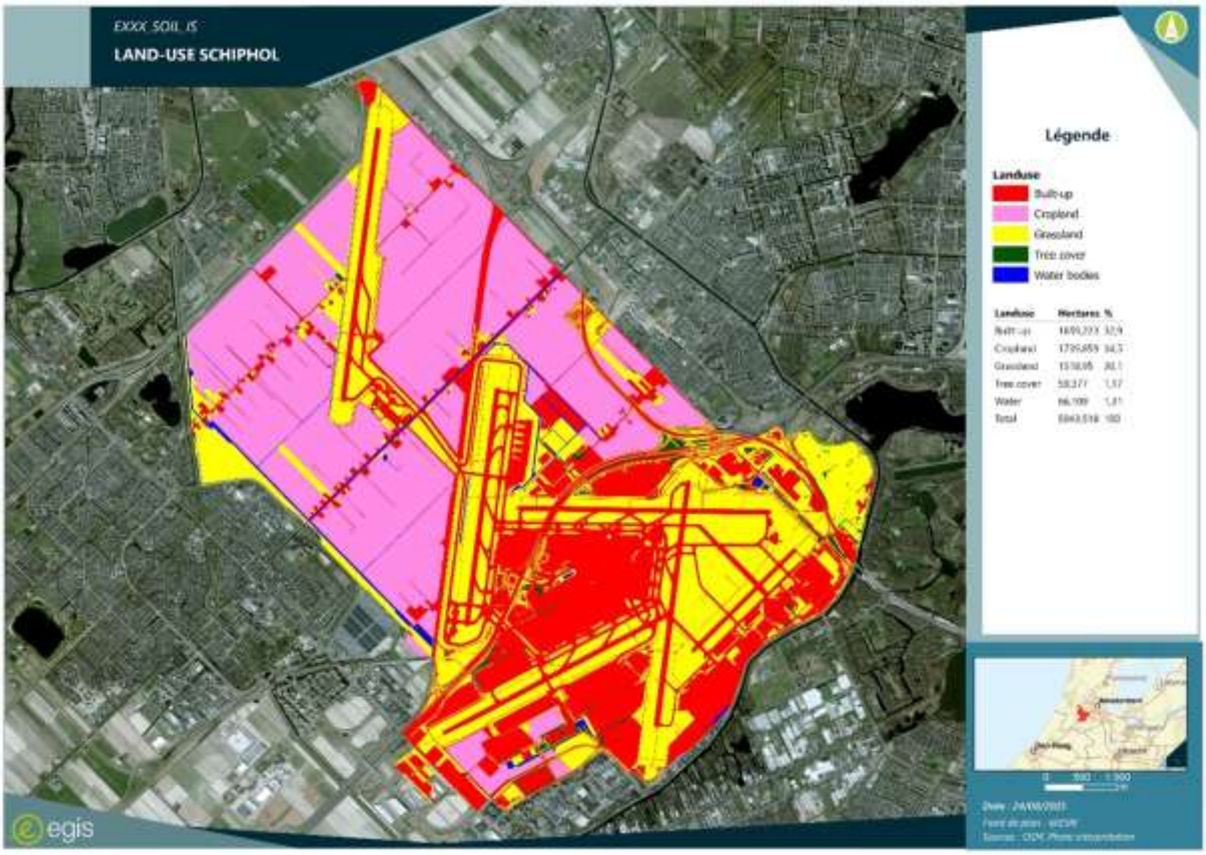

Figure 6: Land-use map of Schiphol airport

Details of land-use categories and areas are in the Table 4: Land-use categories and area.

Table 4: Land-use categories and area

Land-use category	Area	Ratio
Unit	ha	%
Built - up	1 659,2	32,9%
Cropland	1 739,9	34,5%
Grassland	1 519,0	30,1%
Tree cover	59,4	1,2%
Water bodies	66,1	1,3%
Total	5 043,5	100%

Carbon stocks evaluation

Country specific data have been used to evaluate C stocks (IPCC Tier 2 method). However a more accurate approach will be applied in areas dedicated to the carbon sequestration program based on field measurements (IPCC Tier 3 method).

Soil organic carbon % and bulk density data have been taken from the LUCAS database and can be found in table 5.

Table 5: Soil Organic Carbon data (LUCAS dataset)

Type of land	**Organic Carbon**	**Bulk Density**	**Organic Carbon**
Unit	g/kg	g/cm3	t/ha
Sugar beet	29,9	1,283	115,0
Grassland without tree/shrub cover	52,4	1,059	166,4
Common wheat	21,4	1,344	86,4
Other bare soil	19,8	1,495	88,6
Temporary grassland	18,4	1,351	74,6
Potatoes	18,4	1,534	84,5
Barley	48,3	1,461	211,7
Inland marshes	198,4	0,290	172,6
Maize	20,0	1,510	90,8
Broadleaved woodland	41,1	0,977	120,5
Other coniferous woodland	17,0	0,977	49,8
Other artificial areas	25,4	1,495	113,9
Apple fruit	23,5	0,977	68,9
Other mixed woodland	15,3	0,977	44,8
Pine dominated mixed woodland	25,2	0,977	73,9
Grassland with sparse tree/shrub cover	7,5	1,380	31,1
Other root crops	15,0	1,652	74,5
Dry pulses	17,1	1,433	73,5
Floriculture and ornamental plants	14,5	1,091	47,3
Spontaneously re-vegetated surfaces	28,1	1,495	126,0
Shrubland without tree cover	6,0	1,091	19,6

The carbon content of soils under "Built-up" areas are not considered as it is highly heterogeneous and studies reveal that more research is needed for its reliable quantification (O'Riordan, 2021).

To assess the biomass carbon content, the report from Lof at al., 2017 has been used, as the national inventory of SEEA - EEA carbon account for the Netherlands (Wageningen University) (Lof, 2017). In the report, the total biocarbon stocks for each land-use (in MtC) have been divided by the surface area of each corresponding land-use (in ha) to retrieve the average biomass carbon content in tC * ha-1 for the Netherlands territory. Concerning cropland, given that the biomass is cut and exported and reemitted as CO_2 in a variable time, it was not considered as a C stock. Concerning water bodies, data are not available for biomass but the C stock can be assumed very low. A summary of the C stock analysis can be found in figure 7.

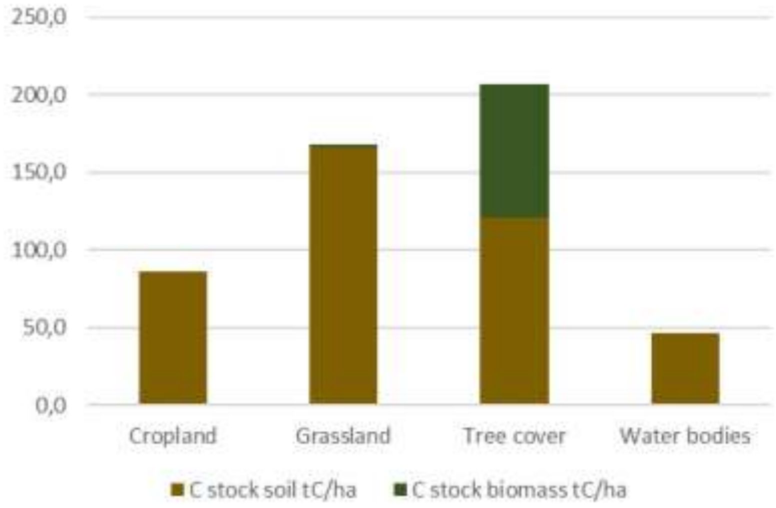

Figure 7: Carbon content in soil and biomass per land-use

The highest carbon stocks can be found in tree cover and grassland areas. Cropland and water bodies have the lowest carbon stocks.

The total C stock of the airport area is calculated in table 6.Table 6: Schiphol airport C stock evaluation per land-use

Land-use	Area	C stock soil	C stock biomass	C stock total
Unit	ha	tC/ha	tC/ha	tC
Cropland	1 739,9	86,4		150 358,7
Grassland	1 519,0	166,4	1,9	255 533,0
Tree cover	59,4	120,5	86,2	12 273,8
Water bodies	66,1	46,3		3 063,5
Total	**3 384,3**			**421 229,0**

Schiphol airport's carbon stocks in soils (0 – 30 cm) and biomass reaches 421 229 tons, equivalent to 124 tons C/ha. Grassland represents the most important carbon sink in the study area. Cropland represents an important carbon stock given its extension. Due to the low amount of carbon content in this type of land use, it represents a very interesting opportunity for carbon content increase through land-use or management changes.

Carbon sequestration program

As for Larnaca, a carbon sequestration study is on-going. The objective is to define areas of interest for implementing carbon sequestration solutions at large scale and evaluate ex-ante the carbon sequestration potential. Co-construction workshops will be organized with the airport operator and the stakeholders to define the solutions that could be implemented. Biochar is a high potential solution which is tested on-site within the framework of the TULIPS program.

The experiment has just started at Schiphol Airport and therefore, the first phase of the project will consist of calculating potentials and defining the scope in which Biochar can be implemented at the airport. Workshops will be organized to involve different departments and measure their role in possible scale up of the Biochar project.

Methodology of the biochar field trials

The trials being carried out in Larnaca, Schiphol and Turin airports have the objective to demonstrate the increase of the organic carbon sequestration in soils after the incorporation of biochar, compared to the business-as-usual management practices.

Biochar production and characterization

Biochar for TULIPS project has been produced in 2022, through a slow pyrolysis process at RE-CORD experimental area premises in Scarperia (Italy), at a temperature of 500°C, in a continuous rotating kiln (figure 8) with an inlet nominal capacity of 100 kg/h.

The feedstock used was poplar woodchips, and three biochar batches were produced, each containing 150 kg of biochar (dry basis), to be dispatched to the 3 different locations (Larnaca, Schiphol, Turin).

Figure 8: Rotating Kiln at RE-CORD premises used in the TULIPS project

The results of the characterisation of poplar biochar are shown in Table 7 with the relevant analysis procedures. The values were compared with the limits of the European fertiliser Regulation for the category pyrolysis and gasification materials (CMC14) and for the category organic soil improver (PFC3) (Reg. (EU) 2019/1009, Annex I).

Table 7: Biochar characterization

RE-CORD sample code		**RES.22.051.001**	
Project		H2020-TULIPS	
Parameter	**Value**	**Reg. (EU) 2019/1009**	**Standard**
Moisture (%wt w.b.)	9.4	total dry matter <20%*	UNI EN ISO 18134-2:2017
Ash content (%wt d.b.)	4.6		UNI EN ISO 18122:2016
Volatile matter (%wt d.b.)	11.8		UNI EN ISO 18123:2016
Carbonio fisso (%wt d.b.)	83.6		Calculated
C (% m/m d.b.)	88.5		UNI EN ISO 16948:2015
H (% m/m d.b.)	2.4		UNI EN ISO 16948:2015
N (% m/m d.b.)	0.4		UNI EN ISO 16948:2015
S (% m/m d.b.)	0.03		ASTM D4239-14
C inorganic (%wt d.b.)	0.09	C organic > 7% wt*	D.M. 13/09/99 Met. V.1

pH	8.8		UNI EN 13037:2012
Specific surface area (m^2/g)	67		ASTM D6556-10
Specific pore volume (cm^3/g)	0.047		ASTM D6556-10
Microelements (mg/kg d.b.)			
Al	172		UNI EN ISO 16967:2015 / UNI EN ISO 16968:2015
B	b.d.l.		
Ba	21		
Ca	10885		
Co	b.d.l.		
Cr	b.d.l.		
Cu	b.d.l.	300 mg/kg d.b.*	
Fe	358		
K	6291		
Li	b.d.l.		
Mg	1568		
Mn	88		
Mo	b.d.l.		
Na	126		
Ni	b.d.l.	50 mg/kg d.b.*	
P	573		
Pb	b.d.l.	120 mg/kg d.b.*	
Si	64		
Ti	b.d.l.		
V	b.d.l.		
Zn	72	800 mg/kg d.b.*	
Cl^-	32.3	30000 mg/kg d.b.**	DM 13/09/1999 SO n 185 GU n 248 21/10/1999 Met IV.2 DM 25/03/2002 GU n 84 10/04/2002
As	0.18	40 mg/kg d.b.*	EPA 3050B 1996 + EPA 6020B 2014
Cd	0.11	2 mg/kg d.b.*	
Tl	< 0.1	2 mg/kg d.b.**	
Hg	< 0.1	1 mg/kg d.b.*	
Cr VI	< 0.2	2 mg/kg d.b.*	CNR IRSA 16 Q 64 Vol 3 1986
PAH-16 (mg/kg)			
Benzo(a)antracene	< 0.01		EPA 3550C 2007 + EPA 8270E 2018
Benzo(a)pirene	< 0.01		
Benzo(b)fluorantene	< 0.01		
Benzo(e)pirene	< 0.01		
Benzo(g,h,i)perilene	< 0.01		
Benzo(j)fluorantene	< 0.01		
Benzo(k)fluorantene	< 0.01		
Crisene	< 0.01		
Dibenzo(a,e)pirene	< 0.01		
Dibenzo(a,h)antracene	< 0.01		

Dibenzo(a,h)pirene	< 0.01		
Dibenzo(a,i)pirene	< 0.01		
Dibenzo(a,l)pirene	< 0.01		
Indeno(1,2,3-c,d)pirene	< 0.01		
Naftalene	0.022		
Pirene	< 0.01		
Total PAHs	<0.172	6 mg/kg d.b.**	
PCBs (mg/kg)			
PCB 101	< 0.001		EPA 3545A 2007 + EPA 8270E 2018
PCB 105	< 0.001		
PCB 110	< 0.001		
PCB 114	< 0.001		
PCB 118	< 0.001		
PCB 123	< 0.001		
PCB 126	< 0.001		
PCB 128 + PCB 167	< 0.001		
PCB 138	< 0.001		
PCB 146	< 0.001		
PCB 149	< 0.001		
PCB 151	< 0.001		
PCB 153	< 0.001		
PCB 156	< 0.001		
PCB 157	< 0.001		
PCB 169	< 0.001		
PCB 170	< 0.001		
PCB 177	< 0.001		
PCB 180	< 0.001		
PCB 183	< 0.001		
PCB 187	< 0.001		
PCB 189	< 0.001		
PCB 28 + PCB 31	< 0.001		
PCB 52	< 0.001		
PCB 77	< 0.001		
PCB 81	< 0.001		
PCB 95	< 0.001		
PCB 99	< 0.001		
PCB Total	< 0.001		
PCB no dioxin like	< 0.001	< 0.8 mg/kg d.b.**	
PCDD + PCDF sum (mgTE/kg)	<0.00004	20 ngTE/kg**	EPA 3545A 2007 + EPA 8280B 2007
Escherichia coli (UCF/g)	< 1	1000 UCF/g o ml*	Rapporti ISTISAN 2014/18 pag 36 Met ISS F 001A
Salmonella spp (pres.-abs./25g)	absence	Absence in 25 g o 25 ml*	Rapporti ISTISAN 2014/18 pag. 78 Met. ISS F 002C

Field trials design

The field trials are designed following principle of comparative experimental method, through measurement, of the effects of biochar. To this end, two treatments in two separated field strips are devised. One is a treatment excluding biochar, called Control (no biochar added) and the second is a treatment where biochar is added to soil, called Biochar (biochar is added).

Parameters to be assessed are (at a minimum): Soil Organic Carbon, Soil Bulk Density (undisturbed sample) and biomass productivity.

The methods used are collection of soil and biomass samples before biochar addition and after biochar addition.

To define the exact locations of the field trials in each airport, the method used was:

1. Revision of airport maps provided by airports operators.
2. Definition of potential sites for biochar application.
3. Field visit to identify the chosen site.
4. GPS identification of the 2 treatment strips
5. Soil sampling.
6. Biochar incorporation in soil through usual machinery.
7. Subsequent soil and biomass sampling.

Expected results

The expected results from the field trials involving biochar are mainly listed below.

1. Quantified data to decarbonize the airport emissions through the use of biochar incorporation as a sustainable agricultural management practice.
2. Knowledge is transferred to airport operators on the advantages of biochar use in Landside/Airside soils.
3. Know-how (e.g. operating instructions, use of machinery) is shared with airport operators on the incorporation of biochar in agricultural soil.

Larnaca airport biochar experiment

The design of the experiment is consisting of two strips of 100m length and 3m width one next to the other, with a 1m respect area in between. On one strip biochar is applied while the other strip is kept as control.

Biochar is incorporated with regular agricultural machinery, with minimum tillage practices (disc harrow).

For the sampling, 3 carbon pools are assessed: living above ground biomass, necromass and soil. The sampling has the following steps:

1. Select three sampling points and take coordinates with GPS. In case of Larnaca airport the GPS coordinates have been taken by the cartographer of the airport.
2. Collection of the biomass and necromass in a known area. To delimit the known area a plastic frame 40x40cm is used. Inside the frame, with the help of scissors, all the living biomass is collected and labelled in a plastic bag. After all the necromass (dead leaves, fruits, seeds, twigs, dead branches) is collected in another bag and labelled.

Figure 9: Soil sampling in Larnaca

3. Using an auger, three soil samples at 0-10cm are collected in the same sampling area and merged in a single composite sample in a labelled bag. In the same spot, other 3 samples are collected at 10-30cm and merged in a second composite samples, bagged and labelled.
4. Finally, in the centre of the collection area, one undisturbed samples for bulk density is collected at 0-10cm depth with the use of a cylinder of known volume. In the same spot, a second undisturbed samples is collected at 10-30cm.

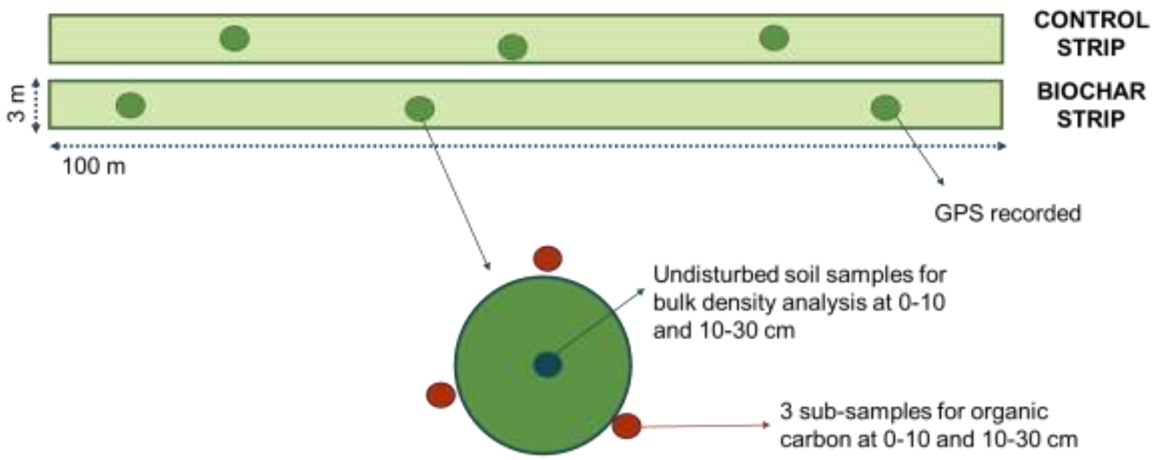

Figure 10: Soil sampling methodology

For each site and sampling missions the following samples were collected:

1. 6 biomass samples

2. 6 necromass samples
3. 6 soil samples 0-10 for carbon analysis 0-10cm
4. 6 undistrubed soil samples for bulk density analysis 0-10cm
5. 6 soil samples 0-10 for carbon analysis 10-30cm
6. 6 undistrubed soil samples for bulk density analysis 10-30cm

Analysis

1. Biomass and necromass: oven dry and weight to have the dry weight. The carbon content is measured using literature values for biomass conversion in carbon and transformed in tC/ha.
2. Soil samples for carbon analysis: soil samples are analysed for carbon and nitrogen using the Walkley-Black method.
3. Bulk density: for bulk density soils are oven dryied at 105°, and weighted. After the coarse fraction >2mm is separated and weighted. Bulk density = (Soil weight – coarse fraction weight)/ soil volume.
4. To estimate carbon stocks, the carbon concentration (%) is multiplied by the bulk density. Carbon stocks is assessed at 0-10 and 10-30cm depth.

Sampling

The sampling is performed at time 0 before the soil work and will be repeated after 1 year from the biochar application. The difference in carbon stocks between biochar and control treatments gives the potential increase of carbon stocks thanks to biochar application.

Results

The first lab results have been provided in Larnaca. Analysis of these results are on-going to assess the soil carbon stock. Resampling will be needed to assess the carbon sequestration potential of biochar application in Larnaca airport.

Schiphol airport field experiment preparation

After preliminary discussion with Schiphol staff and RE-CORD on 5 potential sites for the biochar field trials, a field visit was performed on April 4th to perform a final choice.

An extended discussion on the operating details – in particular, available machinery – took place with Schiphol staff, RE-CORD and the land lessor RVR Loonbedrijf.

The final choice ended on option 3, refer to Figure 11: Biochar survey site in Schiphol.

In May 2023, the biochar was prepared for expedition at RE-CORD premises, and the expected start of the experiment is set in October/November 2023.

Figure 11: Biochar survey site in Schiphol

Turin SAGAT airport experiment

In Turin airport, the experimentation took place thanks to the close collaboration with the Operational Technical Management of SAGAT, experts from Polytechnic of Turin (POLITO) and agronomists from the Renewable Energy Consortium for Research and Demonstration (RE-CORD) based in Florence.

The first biochar distribution of the TULIPS project took place on October 19th, 2022, on a landside plot of the SAGAT Airport in Turin.

Initial soil samples were collected to measure organic carbon content and other parameters in soil at the start of the test, following the same methodology illustrated for Larnaca Airport. These results will then be compared with the subsequent samplings planned for the forage collection in order to be able to determine the variations of organic carbon in soil.

Figure 12: Soil sampling operations (A) and sample collection tools (B).

Subsequently, the soil was prepared with minimum tillage practices, to reduce soil disturbance. Biochar was then incorporated into the top 30 cm of soil and finally the agricultural species (raygrass) was sown. An additional plot without biochar addition was also prepared, tilled and sown as a blank control.

Figure 13: Biochar application and incorporation within the soil.

Further soil and biomass samples will be undertaken to monitor changes in soil organic carbon and the assessment of ray grass biomass yield.

This will enable the simulated calculation and modelling of the effects of biochar application on Certification for Voluntary Carbon Markets (VCM) and RED-II Esca factor, thanks to the expertise of Polytechnic of Turin (POLITO) to provide SAGAT Airport with additional data on the various decarbonisation options.

Conclusion

Carbon stocks have been assessed in the airports and results will be used to evaluate the carbon sequestration potential. Field surveys have started and will continue in the 2^{nd} semester of 2023. Co-construction workshops will be organized with stakeholders to identify applicable carbon sequestration solutions in each airport. Biochar experiments are on-going in Larnaca, Turin and Schiphol airports. Impacts in terms of carbon sequestration are monitored, results are expected in 2025.

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