DELIVERABLE D.T3.2.1.

ASSESSMENT OF SOIL AND CLIMATE CONDITIONS FOR 4 SMALL SPOTS WITH RECOMMENDATION OF PLANTS

Impulse Region

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Introduction

Pilot actions in functional urban areas will consist of the implementation of four interventions in the framework of green and blue infrastructure in 4 small spots. These will be located in 4 FUAs which differ in scale, climate conditions, history, culture and development priorities. Therefore the experience from pilots will be valuable in showing solutions as a part of the urban environmental acupuncture approach supporting integrated environmental management in the scope of urban area. This document summarizes the characteristics of 4 small spots in Erfurt, Weimar, Jena and Apolda including laboratory examinations of soil and analysis of climate conditions. Based on soil and climate characteristics planting of native or climate-resistant plants are proposed.

1. General information about the city

Erfurt

Erfurt is the capital and largest city (214.000 inhabitants) in the state of Thuringia. Erfurt is situated in the south of the Thuringian basin, a fertile agricultural area between the Harz mountains and the Thuringian forest to the southwest. Whereas the northern parts of the city area are flat, the southern ones consist of hilly landscape up to 430 m of elevation. In this part lies the municipal forest of Steigerwald with beeches and oaks as main tree species. To the east and to the west are some non-forested hills so that the Gera river valley within the town forms a basin. North of the city are some gravel pits in operation, while others are abandoned, flooded and used as leisure areas.

Erfurt's old town is one of the best preserved medieval city centres in Germany. The city's economy is based on agriculture, horticulture and microelectronics. Its central location has led to it becoming a logistics hub for Germany and central Europe. The city is situated on the Via Regia, a medieval trade and pilgrims' road network.

Modern day Erfurt is also a hub for ICE high speed trains and other German and European transport networks. Erfurt was first mentioned in 742, as Saint Boniface founded the diocese. Although the town did not belong to any of the Thuringian states politically, it quickly became the economic centre of the region and it was a member of the Hanseatic League. It was part of the Electorate of Mainz during the Holy Roman Empire, and later became part of the Kingdom of Prussia in 1802. From 1949 until 1990 Erfurt was part of the German Democratic Republic (East Germany).

Weimar

Weimar is a city in the federal state of Thuringia, Germany. It is located in Central Germany between Erfurt in the west and Jena in the east. The city itself counts a population of 65.000 inhabitants.

Weimar is situated within the valley of Ilm river, a tributary of Saale river on the southern border of the Thuringian Basin, a fertile agricultural area. The municipal terrain is hilly; the height of the city centre in Ilm valley is approximately 200 m of elevation. To the north, the terrain rises to Ettersberg, the city's backyard mountain, 482 m in height. The range of hills in the south of Weimar rises up to 370 m and is part of the Ilm Saale Plate Muschelkalk formation.

The eastern, central and western parts of the municipal territory are in agricultural use, whereas the Ettersberg and some southern areas are wooded.

Weimar is well known because of its large cultural heritage and its importance in German history. The city was a focal point of the German Enlightenment and home of the leading personalities of the literary genre of Weimar Classicism, the writers Johann Wolfgang von Goethe and Friedrich Schiller. Until 1948, Weimar was the capital of Thuringia. Today, many places in the city centre have been designated as UNESCO World Heritage sites (either as part of the Weimar Classicism complex or as part of the Bauhaus complex) and tourism is one of the leading economic sectors of Weimar.

Jena

Jena is a German university city and the second largest city in Thuringia (110.000 inhabitants). Jena is a centre of education and research. The Friedrich Schiller University and the Ernst-Abbe-Fachhochschule are some examples. Furthermore, there are many institutes of the leading German research societies.

Jena was first mentioned in 1182 and stayed a small town until the 19th century, when industry developed. For most of the 20th century, Jena was a world centre of the optical industry around companies like Carl Zeiss, Schott and Jenoptik. The city's economy is based on the high-technology industry and research. The optical and precision industry is the leading branch to date, while software engineering, other digital businesses and biotechnology are of growing importance. Furthermore, Jena is also a service hub for the surrounding regions.

Jena lies in a hilly landscape in the east of Thuringia, within the wide valley of the Saale river. Due to its rocky landscape, varied substrate and mixed forests. The municipal terrain is hilly with rugged slopes at the valley's edges. The city centre is situated at 160 m of elevation, whereas the mountains on both sides of Saale valley rise up to 400 m. The mountains belong to the geological formation of Ilm Saale Plate (Muschelkalk) and are relatively flat on their peaks but steep to the valleys in between. Due to its jagged surface, the municipal territory isn't very suitable for agriculture all the more since the most flat areas along the valley were built on during the 20th century. At the mountains is some forest of different leaf trees and pines.

Apolda

The city of Apolda, which has about 23,000 inhabitants, is located in the state of Thuringia, in the Lower Ilm Valley on the edge of the Thuringian Basin. Only a narrow plateau separates it from the Saale valley. Apolda is county seat of the district Weimarer Land, whose territory encloses the district-free city of Weimar. The city is known for her former bells foundry and her past as a city of knitters. Today it is a regular meeting place for the participants and guests of the Apolda European Design Award, a European competition for textile and fashion design in the knitwear region of Apolda.

2. Climatic condition

The climatic conditions for each city are described as temperate. Mean, max and min temperature, as well as the sum of precipitation, are presented in the following tables.

Table 1. Basic climatic parameters for Erfurt

	Mean temperaure (° C)	Min. temperature (° C)	Max. temperature (° C)	Rainfall (mm)
Jan	-0.4	-2.9	2.2	27
Feb	-0.1	-3.4	3.2	24
Mar	3.7	-0.5	8	31
Apr	7.9	2.8	13	40
May	12.6	7.1	18.1	53
Jun	15.7	10.2	21.3	68
Jul	17.4	12.2	22.7	59
Aug	16.9	11.6	22.3	56
Sep	13.7	8.5	18.9	41
Oct	8.9	4.7	13.2	39
Nov	4.1	1.5	6.7	35
Dec	1.1	-1.2	3.4	29

Erfurt has a humid continental climate or an oceanic climate (Table 1). Summers are warm and sometimes humid with average high temperatures of 22 °C and lows of 11 °C. Winters are relatively cold with average high temperatures of 3 °C and lows of −3 °C. The city's topography creates a microclimate caused by the location inside a basin with sometimes inversion in winter and inadequate air circulation in summer. Annual precipitation is only 502 millimeters with moderate rainfall throughout the year. Light snowfall mainly occurs from December through February, but snow cover does not usually remain for long.

Table 2. Basic climatic parameters for Weimar

	Mean temperaure (° C)	Min. temperature (° C)	Max. temperature (° C)	Rainfall (mm)
Jan	-0.3	-2.8	2.2	36
Feb	-0.4	-3,5	2.8	25
Mar	3.5	-0,6	7.7	33
Apr	7.7	2,7	12.7	42
May	12.5	7,1	17.9	53
Jun	15.6	10,2	21.1	77
Jul	17.4	12,3	22.6	67
Aug	16.7	11.4	22	59
Sep	13.3	8.2	18.4	45
Oct	8.7	4.6	12.9	45
Nov	4.1	1.5	6.7	34
Dec	1.7	-0.6	4	32

Weimar has a humid continental climate or an oceanic climate (Table 2). Summers are warm and sometimes humid with average high temperatures of 22 °C and lows of 11 °C. Winters are relatively cold with average high temperatures of 2 °C and lows of −3 °C. The city's topography

creates a microclimate caused through the basin position with sometimes inversion in winter. Annual precipitation is only 548 millimeters with moderate rainfall throughout the year. Light snowfall occurs, mainly from December through February, but snow cover does not usually remain for long.

Table 3. Basic climatic parameters for Jena

	Mean temperaure (° C)	Min. temperature (° C)	Max. temperature (° C)	Rainfall (mm)
Jan	0.3	-2.2	2.8	37
Feb	0.6	-2.5	3.7	31
Mar	4	-0.1	8.2	36
Apr	7.9	3	12.9	47
May	13	7.6	18.5	55
Jun	15.8	10.4	21.3	77
Jul	17.6	12.4	22.8	66
Aug	16.5	11.2	21.9	59
Sep	13.3	8.2	18.4	44
Oct	8.8	4.7	13	43
Nov	4.1	1.5	6.7	34
Dec	1.5	-0.7	3.8	36

Jena has a humid continental climate or an oceanic climate (Table 3). Summers are warm and sometimes humid, winters are relatively cold. The city's topography creates a microclimate caused through the basin position with sometimes inversion in winter and heat and inadequate air circulation in summer. Annual precipitation is 565 millimeters with moderate rainfall throughout the year. Light snowfall mainly occurs from December through February, but snow cover does not usually remain for long.

Table.4. Basic climatic parameters for Apolda

	Mean temperaure (° C)	Min. temperature (° C)	Max. temperature (° C)	Rainfall (mm)
Jan	0.1	-2.3	2.6	36
Feb	0.3	-2.8	3.4	29
Mar	3.8	-0.3	7.9	35
Apr	7.8	2.9	12.8	44
May	12.9	7.5	18.3	54
Jun	15.9	10.5	21.3	76
Jul	17.6	12.4	22.8	66
Aug	16.7	11.4	22	59
Sep	13.3	8.3	18.4	43
Oct	8.9	4.8	13	43
Nov	4.1	1.6	6.7	34
Dec	1.6	-0.7	3.9	34

Apolda has a humid continental climate or an oceanic climate (Table 4). Summers are warm and sometimes humid with average high temperatures of 21 °C and lows of 11 °C. Winters are relatively cold with average high temperatures of 3 °C and lows of −2 °C. Annual precipitation is only 553 millimeters with moderate rainfall throughout the year. Light snowfall occurs, mainly from December through February, but snow cover does not usually remain for long.

3. Description of the area of intervention, including results of soil analyses

3.1. Sampling and samples analyses methodology

- collected using a split tube soil sampler or garden shovel
- soil was taken from the depth 0-20 cm
- five representative soil samples were taken, location of the sampling points was determined on the base of detailed plan, depend on the area shape and size
- separate five soil samples from each investment area were labelled (i.e):

A) sample No. 1 (No. from 1 to 5)

B) date of the sampling : 06.08.2019

C) investment palce: Erfurt - E/1 (Schützenhofstraße St.)

- weight of the each of the soil sample was at least 500 g of fresh weight
- each of the taken sample got own GPS coordinates
- collected soil was putted into plastic sample bag.

Physicochemical soil characteristic as pH and electrical conductivity were measured according to standardized methods. The pH was determined in H_2O and 1M KCl (ratio 1:2.5 m/v) with a combination glass and calomel electrode (OSH 10-10, METRON, Poland) and pH-meter (CPC-551, Elmetron, Poland). While, EC was measured by an ESP 2ZM electrode (EUROSENSOR, Poland) according to the Polish standard PNISO 11265:1997, using the same device as for pH. Available phosphorus and potassium in soil were assessed by means of Egner-Riehm method. Total N content of soil was determined by the Kjeldahl method.

3.2. Results

3.2.1. Site 1. Schützenhofstraße, Jena 50°57'02.4"N 11°36'05.4"E

Site description

As part of the research field Green Urban Labs, the project "Green climate oases in urban space Jenas" is being developed in Jena. At the heart of this strategy is a coherent, comprehensive network of climate comfort islands that help mitigate the effects of climate change.

The northern district of Jena was identified as an area with high heat load for humans. The so-called “Grünzug Schützenhofstraße” is secured in the long term as a green corridor in the land use plan of the city of Jena.

The general view of the area of investment is presented in Figure 1.

Fig. 1. General view of the investment area in Jena

Soil characteristics

Soil texture on the site was the classified as clay what indicate heavy soil structure (Table 5). The pH was neutral. Interestingly, electrical conductivity of soil was at the higher appropriate range for different agricultural soils, with relatively low concentrations of P and K. Total Nitrogen content is in the sufficient amount, even for agricultural purposes. The organic matter content was also high comparing to values commonly found in agricultural soil.

Table 5. Soil characteristics for Site 1.

Parameters	Values
Soil texture	clay
pH (H_2O)	7.77 ± 0.07
pH (KCl)	7.57 ± 0.05
EC (µS cm^{-1})	208 ± 15
OM (%)	8.1 ± 0.8
N (%)	0.27 ± 0.04
P (mg $100g^{-1}$)	1.00 ± 0.81
K (mg $100g^{-1}$)	12.7 ± 2.5

Values are mean ± SE (n=5)

3.2.2. Site 2. Körnerstraße, Erfurt 50°57'40.6"N 11°03'39.2"

Site description

The area is located on a football field (hard court) with surrounding lawn area (Figure 2). The goal is to expand the possibilities of use (recreation, barbecue, etc.) in order to increase the

quality of stay. The previously pure sports field will be made more attractive for the local community.

Fig. 2. General view of the investment area at Körnerstraße

Soil characteristics

Soil on the site was characterized as Sandy Clay which is light structure soil with low water retention due to high sand fraction content in the soil (50-60%) (Table 6). Moreover soil was characterized as neutral what was confirmed by analysis using two method of pH measurements in H_2O and KCl. Electrical conductivity of soil was at the higher appropriate range detected in different agricultural sites what might refer to higher ion contents such us Na^+, K^+, Mg^{+2}, Ca^{+2}, Cl^-, HCO_3^-, NO_3^-, SO_4^{-2} and CO_3^{-2}. Also organic matter content was very high, even greater than in good quality agricultural soil. Value of this parameter is about 11%. The same was also true for primary macronutrients concentration (N_{total}, $P_{available}$, $K_{available}$) which were in range detecting in agricultural soils.

Table 6. Soil characteristics for Site 2.

Parameters	Values
Soil texture	Sandy clay
pH (H_2O)	7.48 ± 0.03
pH (KCl)	7.26 ± 0.06
EC (µS cm^{-1})	248 ± 6
OM (%)	10.7 ± 0.5
N (%)	0.37 ± 0.02
P (mg $100g^{-1}$)	2.64 ± 1.13
K (mg $100g^{-1}$)	51.6 ± 8.5

Values are mean ± SE (n=5)

3.2.3. Site 3. Postgarten, Apolda 51°01'39.3"N 11°31'18.7"E, Bahnhofstraße

Site description

The general view of the area of investment is presented in Figure 3. A special focus of Apolda's urban development lies on the quarter of the northern Bahnhofsstraße. The structural change of recent years has posed new challenges for the city. With the reconstruction and renovation of the former post office building as well as the redesign and revitalization of the inner city green area "historic post office garden", the area is to be upgraded. In addition, the intergenerational living together should be promoted.

Fig. 3. General view of the investment area at Postgarten in the Bahnhofstraße

Soil characteristics

Soil samples at the site showed different characteristic compare to the other sites. The soil texture was characterized as sand and it was only fraction detected during aerometric analysis (Table 7). The pH value was also neutral but close to pH=8. The concerns might arise very high electrical conductivity which might indicate high soil salinity. Also unexpected is very high organic matter content (13%) which is unusual for such light soil texture. The concentration of primary macronutrient (N, P, K) were in the range detecting in agricultural soils.

Table 7. Soil characteristics for Site 3.

Parameters	Values
Soil texture	sand
pH (H_2O)	7.96 ± 0.11
pH (KCl)	7.72 ± 0.15
EC (µS cm^{-1})	418 ± 59
OM (%)	13.6 ± 5.8
N (%)	0.24 ± 0.09
P (mg $100g^{-1}$)	1.60 ± 0.90
K (mg $100g^{-1}$)	40.2 ± 15.0

Values are mean ± SE (n=5)

3.2.4. Site 4. Insektenweide, Weimar 50°59'43.0"N 11°18'57.7"E, Bonhoefferstraße

Site description

The area was considered as part of a planning for a kindergarten, but was not processed at the time. It is a wild fallow land with wild growth next to the kindergarten (Figure 4). The visual enhancement with a natural green area would be desirable. The city of Weimar wants to transform the urban green space to promote biodiversity in order to create an additional food supply for insects.

Fig. 4. General view of the investment area at Bonhoefferstraße.

Soil characteristics

Soil texture on the site was classified as clay (Table 8). The pH was neutral however balance from neutral was slightly shifted towards alkali. Soil was characterised by the relatively high electrical conductivity and OM content. Concentration of P and K available forms was at low levels, while total nitrogen content was at the level commonly found in agricultural soils.

Table 8. Soil characteristics for Site 4.

Parameters	Values
Soil texture	clay
pH (H_2O)	7.67 ± 0.09
pH (KCl)	7.32 ± 0.12
EC (µS cm^{-1})	180 ± 9
OM (%)	7.8 ± 0.6
N (%)	0.25 ± 0.01
P (mg $100g^{-1}$)	1.06 ± 0.50
K (mg $100g^{-1}$)	17.5 ± 3.8

Values are mean ± SE (n=5)

4. Proposed plant species to be potentially used during the Pilot action.

Selection took into account results of soil characteristics, climatic conditions as well as final proposed land use type.

Site 1. Schützenhofstraße, 50°57'02.4"N 11°36'05.4"E

Flower species:

Achillea millefolium, Agrimonia eupatoria, Anthriscus sylvestris, Betonica officinalis, Campanula glomerate, Campanula patula, Campanula rotundifolia, Carum carvi, Centaurea cyanus, Centaurea jacea, Centaurea scabiosa, Crepis biennis, Daucus carota, Galium album, Galium verum, Galium wirtgenii, Geranium pratense, Heracleum sphondylium, Hypericum perforatum, Hypochoeris radicata, Knautia arvensis, Lathyrus pratensis, Leontodon autumnalis, Leontodon hispidus, Leucanthemum ircutianum/vulgare, Lotus corniculatus, Lychnis flos-cuculi, Malva moschata, Medicago lupulina, Papaver dubium, Papaver rhoeas, Pimpinella major, Pimpinella saxifrage, Plantago lanceolate, Plantago media, Primula veris, Prunella vulgaris, Ranunculus acris, Ranunculus bulbosus, Rhinanthus alectorolophus, Rhinanthus minor, Rumex acetosa, Rumex thyrsiflorus, Salvia pratensis, Sanguisorba minor, Sanguisorba officinalis, Silene dioica, Silene vulgaris, Stellaria graminea, Tragopogon pratensis, Vicia cracca, Vicia sepium,

Grass species:

Agrostis capillaris, Alopecurus pratensis, Anthoxanthum odoratum, Arrhenatherum elatius, Briza media, Bromus erectus, Bromus hordeaceus, Cynosurus cristatus, Festuca brevipila, Festuca guestphalica, Festuca pratensis, Festuca rubra, Helictotrichon pubescens, Poa angustifolia, Poa pratensis, Trisetum flavescens,

Site 2. Körnerstraße, 50°57'40.6"N 11°03'39.2"E

Flower species:

Achillea millefolium, Anthriscus Sylvestris, Campanula patula, Campanula rotundifolia, Carum carvi, Centaurea cyanus, Centaurea jacea, Crepis biennis, Daucus carota, Galium album, Galium verum, Galium wirtgenii, Heracleum sphondylium, Knautia arvensis, Leontodon autumnalis, Leontodon hispidus, Leucanthemum ircutianum/vulgare, Lotus corniculatus, Lychnis flos-cuculi, Malva moschata, Papaver dubium, Papaver rhoeas, Pimpinella major, Plantago lanceolate, Prunella vulgaris, Ranunculus acris, Rumex acetosa, Salvia pratensis, Sanguisorba minor, Sanguisorba officinalis, Silaum silaus, Silene dioica, Silene vulgaris, Tragopogon pratensis, Trifolium pratense

Grass species:

Agrostis capillaris, Alopecurus pratensis, Anthoxanthum odoratum, Arrhenatherum elatius, Bromus hordeaceus, Cynosurus cristatus, Dactylis glomerate, Festuca guestphalica, Festuca pratensis, Festuca rubra, Helictotrichon pubescens, Lolium perenne, Poa angustifolia, Poa pratensis, Trisetum flavescens,

Site 3. Postgarten 51°01'39.3"N 11°31'18.7"E, Bahnhofstraße

Creeper species:

Actinidia sp., Ampelopsis brevipedunculata, Clematis sp., Humulus lupulus, Vitis coignetiae

Site 4. Insektenweide, 50°59'43.0"N 11°18'57.7"E, Bonhoefferstraße

Flower species:

Achillea millefolium, Agrimonia eupatoria, Barbarea vulgaris, Betonica officinalis, Campanula patula, Campanula rotundifolia, Centaurea cyanus, Centaurea jacea, Centaurea scabiosa, Cichorium intybus, Clinopodium vulgare, Daucus carota, Echium vulgare, Galium album, Galium verum, Hypericum perforatum, Hypochoeris radicata, Knautia arvensis, Leontodon autumnalis, Leontodon hispidus, Leucanthemum ircutianum/vulgare, Linaria vulgaris, Lotus corniculatus, Medicago lupulina, Origanum vulgare, Papaver dubium, Papaver rhoeas, Pastinaca sativa, Picris hieracioides, Plantago lanceolata, Plantago media, Prunella vulgaris, Ranunculus acris, Rumex acetosa, Rumex acetosella, Rumex thyrsiflorus, Salvia pratensis, Sanguisorba minor, Silene dioica, Silene latifolia ssp. Alba, Silene nutans, Silene vulgaris, Stachys sylvatica, Triforium arvense, Trifolium campestre, Trifolium medium, Verbascum densiflorum, Verbascum lychnitis, Verbascum nigrum, Verbascum thapsus, Veronica officinalis,

Grass species:

Agrostis capillaris, Anthoxanthum odoratum, Briza media, Bromus erectus, Bromus hordeaceus, Cynosurus cristatus, Festuca brevipila, Festuca guestphalica, Festuca rubra, Lolium perenne, Poa angustifolia, Poa compressa, Poa pratensis, Puccinellia distans,

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