

Deliverable 1 of Carbon Lane project (ID 190365)

Report on concept designs for carbon drawdown



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1 Introduction

1.1 Carbon Lane

Carbon Lane (CarLa) is an EIT Climate-KIC funded project which takes place during 2019. The project explores practical concept designs for carbon drawdown in urban green areas. The aim of the project is to develop general practices, science, awareness and sustainable public procurement. The project is organized by the Climate-KIC partners: Aalto University (project lead), University of Helsinki and City of Helsinki. The steering group and partners include central actors of the Finnish green building and gardening sectors. The project aims to facilitate a co-creation process to introduce broadly usable concept designs and implement selected concepts at a demonstration area in the Helsinki region.

1.2 Project background

Helsinki has a goal to reach carbon neutrality by 2035. In order to become carbon neutral, the city has adopted a strategy which contains 143 actions, 30 related to transportation, 56 to construction and the last 57 to procurement, consumption, sharing and circular economy. The Carbon Lane project is dealing with the section "Carbon sinks and emissions compensation", action numbers 130-136 (City of Helsinki 2035, p.104) which includes urban green areas in the city. The Carbon Lane project is premised on the idea that green building and maintenance of urban green areas offer novel opportunities to integrate new and innovative solutions which not only draw down the carbon but also improve the condition and provide an additional social benefit to the residents.

In order to become carbon neutral, the city of Helsinki has adopted an action plan to reduce GHG emissions by at least 80% (the reference year 1990) and compensate for the remaining 20% (outside the city or through increasing carbon sinks). So far the city has made significant progress by reducing emissions by 24% (from 1990) even though the population of the city has increased by 150 000. However, the

ongoing efforts are not enough to reach the desired climate targets and therefore the city is actively implementing new actions in collaboration with residents, businesses and organizations. While the action plan highlights the most polluting sectors such as heating, traffic and electricity, and requires urgent action in terms of energy efficiency, energy production and traffic, there is still a need for further action. (City of Helsinki, 2035 p. 7).

Managing green areas offer great potential for carbon drawdown. According to the study by Rasinmäki & Känkänen (2014) around 1250 kt of carbon is stored in the trees, plants and soil in the Helsinki area. When converted to CO2, the storage corresponds to around 1,5 years of Helsinki GHG emissions(~4600 ktCO2). Moreover, at the time the study was done, carbon storage was increasing at an annual rate of 35 kt (corresponding 26 000 people's emissions (130 ktCO2/y). While some degree of uncertainty remains in the numbers, the results illustrate the importance of climate impacts of soil and flora. However, as the city is rapidly growing, increasing carbon sinks or even preserving them is challenged by the incoming urban construction and for this reason, it has been estimated that the carbon sinks will decrease. (City of Helsinki p. 102-103). The action plan of the City of Helsinki (2035 p. 128) identifies this problem and suggests the following action:

"The impact on carbon storage will be taken into account when designing urban forests and nature and public green zones. Planning and green zone design will be complemented with procedures to compensate for the carbon storage lost during construction."

Planting urban trees or other flora in the city has been seen as one of the key solutions to increase carbon sinks while the potential of soil is rarely recognized. The study by Riikonen et al. (2017) illustrates the importance of soil in urban tree planting. The study explored two case sites located in Helsinki for 10 years. According to the results, the C accumulation of tree woody biomass during the period of 10 years was 18-32 kg per tree. However, the C loss from the growth media (25m3) per tree was at least 170kg. The results indicate that at best the net C

sequestration would begin after 30 years from planting. Therefore, if the aim of urban tree plantation is to sequestrate carbon and create a carbon sink, it is crucial to consider the soil together with a lifespan of the tree already in the planning phase.

Even though the need for Carbon Lane project was triggered by the climate targets, it is just one out of numerous benefits what can be achieved with nature-based solutions. Well-being of soil and plants do not only draw down the carbon but also provide numerous ecosystem services, for instance The Nature Conservancy highlights the following benefits: aesthetic benefits, recreation, physical health, mental health, spiritual value and sense of place, biodiversity, erosion prevention, stormwater mitigation, mitigation flood risk, coastal protection, air purification, shade and heat wave mitigation. Some of these benefits are directly or indirectly economically measurable, for instance, managing stormwater and mitigating impacts caused by flooding and heat waves could alone justify additional costs from investing in nature-based solutions.

This is the first out of three reports produced during this project. The report is based on the work of WP2 which was responsible for engaging key stakeholder groups, including providers of drawdown solutions, green infrastructure planners, the demand side actors, researchers and parties specialised in carbon balance calculations. The report presents concept designs for carbon drawdown. The initial ideas were gathered through workshops with different stakeholders in green building. The aim of the work package was also to establish a market dialogue and to produce generally usable concept designs for carbon drawdown in the urban context. Concept designs are initiated in collaboration with the project partners and the market actors. The process of the dialogue and results of the workshops are presented in this report.

Some of the concepts design will be used in the planning of the demonstration area and presented in more detail in the next deliverable of the project. In the current report we include them but also present a wider range of ideas that came forward in the market dialogue as well as the selection criteria which were collectively developed. These criteria were applied in order to narrow the scope of ideas and fit them into the demonstration area.



2 Market dialogue: interaction with the stakeholders

Image by Sushant Passi: Second advisory board and partners meeting

Carbon Lane project has connected so far with four main stakeholder groups: research organisations, companies, other organisations and authorities. Participants of the workshops have represented in a total of 32 different companies or organisations, which are listed below.

Research organisations (7):

 Aalto University, HÄME University of Applied Sciences, Institute for Atmospheric and Earth System Research, Natural Resource Institute Finland, University of Helsinki, University of Jyväskylä, VTT Technical Research Centre of Finland

Companies (16):

- BiHii Oy, Biolan Oy, Carbofex Oy, Carbons Finland Oy, Puro, Hyvinkään

Tieluiska Oy, Helsieni Oy, Kekkilä Oy, Noireco Oy, Nordic Offset Oy, Novarbo Oy, Ramboll Finland Oy, Sitowise Oy, Stockholm Exergi AB, VSU maisema-arkkitehdit Oy, WSP Finland Oy

Other organizations (7):

 EIT Climate-KIC Nordics, Finnish Biochar Association, Foundation for a Living Baltic Sea, Ithaka Institute, Proagria, Nordic Biochar Network, The Finnish Association of Landscape Industries - Viherympäristöliitto,

Authorities (2):

 City of Helsinki (participants from land use and city structure, climate work, building and public areas, environment and permits, construction services) and Helsinki Region Environmental Services Authority (HSY)

In addition to the face-to-face meeting such as workshops, advisory board and partners meetings the Carbon Lane project members are actively in touch with the stakeholders through emails and phone. In addition to the officials of the City of Helsinki, the project connects with soil and tree experts and scientists, landscape architects, green builders, companies specialized in soil and soil amendments, climate experts, experts specializing in voluntary carbon offsetting projects and parties involved in developing standards and recommendations for the Finnish green building.

The City of Helsinki is actively engaged with the Carbon Lane project and showed great interest in the Carbon Lane project. City representatives are also actively participating in the workshops and provide valuable information and feedback in terms of what types of solutions can realistically be implemented. Based on this feedback several carbon drawdown concepts relevant for the purpose of this project are being recognized. The atmosphere during the ideation process and in the workshops was very open and several concept designs were recognized. One of the main reasons for the successful ideation is that ideas and concepts produced during the workshops are presented anonymously and no commitments are given to

implement the ideas.

In addition to the Helsinki city, the key stakeholder groups of this project include landscape architects, companies and experts specialized in green building. All of these key stakeholder groups are engaged with the project since the beginning as they view that the aim of Carbon Lane - to develop carbon drawdown concepts for urban green areas as a highly important and novel approach to develop the green building.

Process steps during the project: 1) Kick-off meeting with the key partners, 2) Open call - open invitation was sent for all relevant actors , 3) First advisory board and partners meeting, 4) First ideation workshop, 5) Second ideation workshop, 6) Second advisory board and partners meeting, 7) Onsite meeting regarding realization of the demonstration area and 8) Wider engagement with the stakeholders. Each step is described in "Appendix 1. Process steps"

3 Concept designs for urban carbon drawdown

This chapter summarizes all ideas and concepts gathered during the project into four categories: practices, built solutions, vegetation and material choices. The concepts were further analyzed in order to explore their feasibility and relevance for the City of Helsinki. In addition, uncertainties and open questions relating to the concepts were recognized. Based on the summaries a table/matrix was created (Appendix 2.). Together with a fictitious illustrations of the park with some of the concepts based on this project (Appendix 3.).

3.1 Concept designs and ideas summarized

This section summarizes the concept designs of ideation workshops.

1. Practices

a. Avoiding building on currently forested areas

It should be avoided to build on currently forested areas in order to maintain the current carbon sinks. These decisions are made in the regional and city level zoning

process.

b. Increase the number of trees

In addition to the streets and parks, the number of trees could be increased on the outskirts of Helsinki. Citizens could also be engaged to report suitable spots for trees.

c. Extending lifespan of urban trees (e.g. to over 50 years)

The lifespan of urban trees can be extended by providing good growing conditions and choosing the right plants for the habitat. It is also important to allocate additional resources to tree pruning and management, to control the hazards old and declining trees may cause in built environment and to facilitate other management options aside from felling. Favouring largest possible species of trees carbon sequestration can be improved provided there is sufficient space.

d. Increasing co-operation between private and public sector

A significant part of the land is also owned and controlled by private actors, new initiatives could be established to promote cooperation.

e. Leaving plant litter on the ground where possible

In urban green areas maintenance is often intense and plant litter is often removed from the site. It would be more beneficial for the development of soil carbon storage to leave litter on the ground. Stakeholder education and cooperative efforts are needed to modify resident and user attitudes towards the presence of litter however.

f. Less intense maintenance, keeping lawn longer, mowing less often, raising the mower blade

Lawn areas require a lot of resources and generates a relatively large part of the carbon footprint of maintenance. It would be beneficial to biodiversity, habitats and carbon sequestration so that urban parks would not be managed so intensively. In addition, lengthening the cutting intervals can contribute to stronger and deeper root systems. Well-growing roots use nutrients efficiently and prevent the transfer to waterways. Stakeholder education and cooperation is required to make longer vegetation in urban areas acceptable for the public, and areas suited for longer

vegetation must be selected carefully outside foot traffic networks, as long grass may also have unacceptable side effects such as. increased presence of disease-carrying ticks.

g. Leaving trees to decay in the parks as carbon sinks and as a home for insects

Leaving felled park tree trunks in parks or moving them to adjacent, less intensively managed areas is a practice already relatively common in Finland. This practice aims to improve the environment for rare and threatened polypores, other fungi and invertebrates dependent on decaying trees, but it also has benefits for carbon storage.

2. Built solutions

a. Green roofs, building green areas into biological water filters, utilizing stormwater and greywater for irrigation

Bioretention is one option for managing stormwater while improving carbon sequestration through vegetation. As sealed surface area increases hand in hand with construction and land-use intensity, the stormwater loading also increases. In order to maintain balanced water cycle, nature-based stormwater management is needed.

 b. Using biochar and carbon-rich foil to filter nutrients, heavy metals, oils and other impurities from the stormwater before leading them to water bodies

Through vegetated bioretention area stormwater could be filtered from pollutants while creating environments that promote the growth of microorganisms. This could add side benefits in addition to allowing more space for functional soil and vegetation, and consequent C stocks, in urban areas.

c. Use permeable paving

Replacing asphalt or other impervious pavements with pavements that allow stormwater to filter through the surface instead of leading to drainage systems.

d. Using structural soil in parks and grass areas which are intensively

used to avoid compaction of soil

The quality of planting soil is of high importance. The lawn soil is often compacted in areas of high use resulting in bare soil patches and poor grass cover with thin root systems.

e. Adding composting possibilities to the parks

Community-level composting offers benefits such as increasing social inclusion and empowerment. Compost also holds the potential to improve soil health. By improving soil locally, people can be involved in making their own living environment greener and more comfortable.

f. Convert some grass areas into meadows to increase biodiversity and carbon sequestration

Flowering meadows could have only narrow mowed pathways for walking. This prevents compaction of soil, prevents negative impacts of tall vegetation from the stakeholder point of view, and allows for more diverse vegetation with deeper roots.

3. Vegetation

a. Favouring mixtures of different species of grass and other vegetation An interesting approach is to test the impact of different species (deep root systems, slow-growing, height-restricted) on carbon sequestration in lawn and meadow areas. Grass species could be mixed taking into account carbon sequestration, soil microbiota and earthworms well-being.

b. Edible gardens (cherries, apples, plums, berries, tomatoes etc.)
Edible gardens (cherries, apples, plums, berries, tomatoes etc.) were considered a good option to improve carbon sequestration, biodiversity and citizens involvement.

c. Fast-growing trees species

Deep root systems and fast-growing trees, such as willows provide better carbon sequestration. Fast growing trees tend to also need more space and management than slow growing species, so finding suitable sites and resources may be challenging.

d. Use perennials around trees instead of wood chips

Replacing wood chips with vegetation increases carbon sequestration and may improve the well being of green areas; however, it is not known whether organic mulch or perennials are more beneficial to overall site C stock.

e. Use of slow-growing or height-restricted species in lawn areas to reduce GHG emissions from maintenance (e.g. *Poa alpina*)

One idea was to replace commonly used seed mixture for lawn with alpine bluegrass Poa alpina. It is a native perennial grass in the northernmost part of Finland and locally in North Karelia. Its use has also been tested in the South and it has seemed to produce a comparable green cover. Since Poa alpina is slow growing, the GHG emissions of maintenance could be reduced through reduced lawn mowing. To improve biodiversity at the same Poa alpina could be tested as one species among other slow-growing or height-restricted species.

f. Using grass species with deep roots

Roots have an important role in soil health and carbon sequestration. Root systems of different lawn grass species are not well known however.

g. Vegetation species that require less mowing and maintenance

Way to implement this could be tapestry lawn, grass-free lawn or other low-growing ground cover types which tolerate some degree of trampling and require little to no mowing. These currently and relatively rarely used vegetated groundcover types could respond to the solutions needed in the cities for open green areas.

4. Material choices

a. Biochar as a soil additional component in soil and soil products Biochar can be used to directly increase the carbon sink in the soil, in addition, it can be used to improve soil properties, decrease the need for irrigation and ease maintenance

> b. Carbon binding stone (e.g. olivine) to be used as decorative stones or pavement on the roads and roofs to accelerate chemical carbon sequestration

Olivine or other carbon binding stones could be used around street trees instead of gravel. Gabions could also be made from carbon binding stones to replace for example concrete used in park structures.

c. Using solid wood in building park fences, benches

The carbon can be sequestered in urban parks by using solid wood. The impact of this solution if heightened if wood substitutes for materials with high carbon footprint such as concrete and steel.

- d. Recycled soil from nearby building sites
- e. Prioritizing locally available materials
- f. Utilizing waste concrete in structural soil

Reusing and recycling locally available materials from other building sites can provide significant financial savings and environmental benefits.

3.2 Feasibility, evaluation and execution of concepts

The feasibility of solutions for carbon drawdown in urban green areas is conditioned in many ways. In addition to meeting financial and technical criteria, the ideas also need to fit the design and planning process. In this section, we first consider the process-related feasibility and then the bio-physical aspects of the concepts. The assessment is summarized by a table which evaluates the concept ideas against the selection criteria

3.2.1 The fitting of the concepts to the planning process

Most of the decisions concerning the actual building of a green site are done during the planning phase. Therefore, it is important to recognize which actors are involved in the planning and increase their awareness of the carbon drawdown concepts and practices. Usually, the planning phase is rapidly followed by a landscape plan, budget, vegetation and material choices. Once the building plan is ready, the project will be scheduled for building. The timeframe between building plan and actual building might be several years. Since the decision-making process is linear, it is highly challenging to introduce significant changes to building plans once they have passed decision making and budgeting process. On the other hand, carbon drawdown concepts which do not significantly impact the landscape such as changes in maintenance, planting soils or soil amendments can be implemented more easily. In addition, some of the carbon drawdown concepts could be implemented afterwards as a separate project for example during the maintenance stage.

Reusing and recycling locally available materials from other building sites can provide significant financial savings and environmental benefits. This can be achieved by moving from individual project-based thinking into managing a portfolio of projects, where excess materials from one construction side are moved to a nearby site instead of disposing them and buying new virgin materials to the other building site. In addition to publicly owned space, Helsinki accommodates significant parts of privately owned and managed areas. One potential idea would be to increase cooperation between the public and private sector in the building projects.

Protecting current nature was seen as an important aspect which should be taken into consideration in the rapidly developing city. Extending the lifespan of urban trees (e.g. to over 50 years) and avoiding building on e.g. forested areas were highlighted. In order to decrease emissions from traffic, several cities are improving public transport connections such as building new railroads and urban centres. Significant construction process has a major impact on natural processes and can cause a significant decrease in the carbon sinks of the city which should be taken into consideration.

In urban green areas maintenance is often intense and plant litter is mostly removed from the site. It would be more beneficial for the development of soil carbon storage to leave litter on the ground. This topic was seen as important and was considered interesting to study how big the C-leakage is due to litter removal. Using a lawn in the urban park offers benefits such as functionality, durability and safety. However, the maintenance requires a lot of resources and generates a relatively large part of the carbon footprint of maintenance. The lawn area of the demonstration park will, for example, be classified as A2 according to the general classification for maintenance. In the A2 class the grass is kept in between 4 - 12 cm height (VHT '14). Depending on the weather conditions that usually means approximately 15-20 cuts during the season. Ways to lengthen the mowing interval and leave the lawn longer after mowing were discussed. This was seen as an opportunity to improve carbon balance and increase biodiversity benefits. These types of interventions will affect the daily environment and surroundings of the citizens, and changes in management will need to be accepted by the general public. Longer grass and increased presence of leaf litter should be conceived as an overall positive change in the environment, instead of lowered standard of neatness or upkeep of the urban green.

One idea in the workshop was to replace commonly used seed mixture for lawn with alpine bluegrass *Poa alpina*. It is a native perennial grass in the northernmost part of Finland and locally in North Karelia. Its use has also been tested in the South and it seems to produce a comparable green cover. Since *Poa alpina* is slow growing, the GHG emissions of maintenance could be reduced through reduced lawn mowing. To improve biodiversity at the same *Poa alpina* could be tested as one species among other slow-growing or height-restricted species.

Another way to implement this could be tapestry lawn, grass-free lawn or other low-growing ground cover types which tolerate some degree of trampling and require little to no mowing. These currently relatively rarely used vegetated groundcover types could respond to the solutions needed in the cities for open green areas.

3.2.2 Bio-physical considerations

Carbon sinks in urban green areas can be improved by favouring high amount and multi-layered vegetation. Providing good growing conditions, retaining water and choosing the right plants for the habitat can improve carbon drawdown and soil carbon storage. Edible gardens (cherries, apples, plums, berries, tomatoes etc.) were considered a good option to improve carbon sequestration, biodiversity and citizens involvement. The most discussed topic about vegetation was lawn, which

usually dominates urban green spaces. An interesting approach is to test the impact of different species (deep root systems, slow-growing, height-restricted) on carbon sequestration in lawn and meadow areas. Deep root systems and fast-growing trees, such as willows provide better carbon sequestration; however, these may interact with the C stock longevity, as fast growing trees tend to have less durable wood. Furthermore, grass species could be mixed taking into account carbon sequestration, soil flora and fauna well-being.

The quality of planting soil is of high importance. The lawn soil is often compacted in areas of high use resulting in patchy grass cover with thin root systems. It is recommended to use perennials around trees instead of wood chips as they will absorb carbon dioxide; however, also organic mulches have benefits for soil C stock. Lastly, vegetation could be enhanced also on green roofs. The so-called "Golf Model" grass growing conditions include sand, biochar (10%), compost (10%).

Planting soils, which are capable of filtering and storing water are not only an ideal solution for stormwater management but also they significantly reduce and even eliminate the need for irrigation. Such stormwater solutions have additional benefits, for instance, phosphorus emission prevention. Furthermore, the concept could be expanded by connecting green building and stormwater management. For instance, roof water and greywater could be utilised for green roofs.

When planning urban green areas, the focus should be on both the public and private areas, and it should also take into consideration the natural flow of water. Building soil-based water-absorbing surfaces are not only a good stormwater solution, but they also enable soil recovery and recycling. Nutrient-rich soils could be used for other applications. Lawns and grasslands in varying heights could be designed in suitable locations and some of them could be left as meadow type / set up lawns in appropriate locations. Load bearing media, consisting of crushed waste concrete as a substrate, could also be tested on lawn and lawn trees to combat the risk of compaction in highly trampled areas. In case a stormwater system enters into a lawn area, the system maintenance measures should be taken into account, for

instance when to replace the filter or substrate.

The use of any materials also needs to comply with health and safety regulations. Concerning the concept ideas, this is particularly pertaining to the use of biochar, which results from an industrial process of pyrolysis. All novel industrially produced materials or soil products which come from processes with possible contamination, including large scale composting, management of municipal wastewaters, sludge and residues, repurposing of building materials require special attention in the design and building process.

3.2.3 Assessment of concepts: criteria and indicative results

The ideas from the workshops were preliminarily assessed according to the criteria from the perspectives of the City of Helsinki. The following assessment criteria were used:

- 1. Resource requirements
 - a. What type of action or resources are required
- 2. Implementation considerations
 - a. It is important to recognize possible limitations related to the concepts and evaluate their social acceptance
- 3. Potential benefits
 - a. Investing in nature-based solutions can provide multiple benefits, including economically measurable benefits over time.
- 4. Future research requirements
 - a. There is an urgent need for climate action and several actions can be already done based on current knowledge. However, further research, product and process development is required.

The concepts are assessed in the table/matrix (Appendix 2.).

3.3 Uncertainties and open questions relating to the concepts

The ideation process was not data driven. Nevertheless, interesting open questions surfaced in the process. Such gaps undermine the utilizations of some of the concepts or require that they are developed in parallel with appropriate research efforts. Several data gaps and research needs were identified in the process, some of these are described in the following text.

It is not known if organic mulching materials, which are essentially biomass additions to the green areas, might improve soil carbon stocks beneath, or whether mulches may have priming effects on soil C stocks (accelerating or decelerating the breakdown of other C compounds in the soil). In addition, studies comparing the soil C stock effects of mulches and perennial vegetation e.g. around tree plantings are needed. Root system depth or root C stocks and soil C inputs of different lawn grasses and other urban greening plants are poorly known.

New types of C-fixing or C-optimised planting soils may have currently unknown interactions with soil flora and fauna, such as mycorrhizal fungi, N-fixing bacteria, or earthworms, and these may have feedbacks on the site C budgets. It is known that earthworms do not suffer significantly from small biochar additions to the soil (provided the biochar is of good quality), but there are very few studies on other aspects of soil flora and fauna interactions with novel soil components. For example, possible priming effects of biochar on soil C stock development are still poorly known.

The possibility and potential impact of soil C stocks below the currently studied topsoil layers, and whether any construction or management strategies may affect subsoil C, is largely unstudied area. Similarly, fluxes of dissolved organic carbon (DOC) from urban areas are largely unknown, although it is known that e.g. stormwaters carry some amount of carbon outside the urban system.

Some especially construction related methods suggested for improving urban C stock or sequestration, such as green roofs and planting urban trees in the most intensively built downtown areas, require significant amounts of resources and carbon expenses. The net C effects of e.g. green roofs should be studied in detail and if necessary, less C intensive building materials could be tested and developed. There is little information on how much biochar can be added to urban planting soils

without any adverse impacts on soil functioning or vegetation. Similarly, the optimal grain size of biochar is not known aside from the information that dust size particles are very prone to erosion and thus should be avoided. Biochar can be produced from many biomasses; however, there is little information on which feedstock, pyrolysis process or pre-processing is the most appropriate for planting soil biochars.

Urban green areas such as the demonstration area of this project is located close to the sea and it should be taken into consideration how these green areas impact the water e.g. nutrient leakages during heavy rains.

4 Citizen involvement interaction and art

One of the CarLa premises was that experimentation in urban green areas allows for the engagement of wide sectors of the society. The methods of and ideas for engagement presented below do not draw heavily on the workshops. Rather, the project members have engaged in a study of existing alternatives of engagement some of which were already in place in Helsinki (e.g. soil art by Teemu Lehmusruusu) and some which are taking place in other cities. Citizen involvement and interaction can be can broadly be categorised as

- Sharing a long-term vision of the park and enabling the follow up of developments by citizens through either on site devices or internet sites that are dedicated to the demonstration area
- Creating interactive art pieces which engage with park visitors or local residents through means of art.
- A portfolio of activities which take place in the urban green areas and engage with the carbon cycle.

During the workshops, the visual observability of soil was discussed, in particular how to increase awareness of citizens about life in soil. It was suggested that clear planting pots and boxes for display could be used in the park area. They could present different layers of soil, in addition, vegetation could be grown and roots could be visible. Different components such as biochar could also be presented in the display boxes together with brief description and QR codes for more information. In addition, transparent narrow tubes could be installed around the root system of trees and enable visual presentation of roots with small cameras.

A question of perception - we cannot perceive the ground under us like we can the surface. This dimension below us is close, yet so far. It is dark and unseen. Yet incredibly vital to our existence. All these movements, and especially the movement of carbon from the surface to the soil is inconceivable but significant. Can we in some way bring it to the surface? Perceive it, comprehend it and celebrate it. It is often the case that the ground under us is not recognised as a living, breathing entity. The ground is alive. It is just beyond human perception.

The demonstration of carbon sequestration, call for new ideas on how to visualise the fact that our carbon capturer, the soil and, in the case of the Jätkäsaari demonstration area also biochar, in fact has a significant amount of important movement and activity.

There is an array of sensors that can measure different forms of soil activity. Some of these sensors measure data in real time and can be a valuable source to visualize and represent this activity under the ground. Data like CO2, CO2 Flux, N2O, Temperature and Moisture are datasets that can be measured in realtime and can be perceived as breathing, body heat and water content of the ground, presenting it as a living being.

Tree Savoka site Marolaona Precipitation, soil moisture and temperature



An example of what the data looks like. Source : <u>http://p4ges.org/news/bobsblog2015.php.en</u>

The project has identified three aspects that highly impact the design of the interactive installation - The data being collected, the senses that we are evoking and the form of the installation. The project has further pinpointed at following opportunities relating to these aspects:

- Data: Soil activity, the carbon storage
- Senses: Sound/hearing, vibration/touch, lights/visual, mixed
- Form: Segmented/inspired by organisms, inspired by roots, monolith/inspired by human interaction, a new organic life form

These ideas provide a starting point starting point for designing interaction and engagement relating to urban carbon drawdown. In the CarLa project, they will be used to generate ideas that are evocative, educative and robust on an implementation and material level. The four ideas of interaction produced during this project are presented in the Appendix 4. Ideas for interaction.

5 Conclusions

This deliverable covers the ideation and concept development phase of the CarLa-project, which proceeded from establishing a market dialogue and raising interest in the opportunities of carbon drawdown in urban green areas to to ideation processes. To support novelty, creative problem solving and association, these processes used a double phase of first generating ideas and only later evaluating them against explicit criteria. The second stage of the project, reported in deliverable 2, will fit selected ideas to the planning context in Jätkäsaari Helsinki.

The project invited all interested parties such as companies providing carbon drawdown solutions to participate in ideation workshop to learn more about the Carbon Lane project and to ideate concepts related to carbon drawdown solutions in urban green areas. The invitation letter was sent to various companies, organizations and influencers in the green building and gardening sector. The project organized two of both advisory board and partner meetings and ideation workshops. In addition, onsite meeting regarding the realization of demonstration area was organized.

During the workshops with different experts, several concepts designs for carbon drawdown solutions were created. The concepts were categorized into four categories: changes in practices (behavioural changes), built solutions, vegetation and material choices. In addition, citizen involvement and interaction e.g. through graphical material or artwork was viewed as novel opportunity to increase awareness and interest towards urban carbon drawdown solutions among nearby residents.

The evaluation criteria for the feasibility of the concepts comprises of issues relating to resource requirements, implementation, benefits and future research requirements. The criteria serve as a proxy for evaluating the applicability of the concept ideas and understanding how the local contextual factors impact the design of urban carbon solutions. They also form the backbone of the further work in the project in moving towards planning a real demonstration area in Helsinki.

6 Sources

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Appendix 1. Process steps



Image by Sushant Passi: Working in the groups

The market dialogue proceeded along with the following steps:

1. Kick-off meeting

The carbon Lane project started with a kick-off meeting on 28 March 2019, where we scheduled workshops, advisory board meetings and a closing event/dissemination event. In addition, we drafted an invitation letter for engaging stakeholders and a communication plan.

2. Open call

The project invited all interested parties such as companies providing carbon drawdown solutions to participate in ideation workshop to learn more about the Carbon Lane project and to ideate concepts related to carbon drawdown solutions in urban green areas. The invitation letter was sent to various companies, organizations and influencers in the green building and gardening sector. For instance, The Finnish Association of Landscape Industries (Viherympäristöliitto ry.)

assisted in communicating the open call through their 10 sub-organizations which are dealing with specialized areas related to landscape planning, construction and management. It can be said that the open call reached all central actors of Finnish green building sector.

3. First advisory board and partners meeting

The first advisory board and partner meeting were organized on the 6th of May 2019. For the meeting, we had 14 participants representing 8 organizations or companies. In this meeting, we concentrated on introducing the project plan, work packages, deliverables and dissemination of the results. The advisory board provided valuable opinions and comments which were marked down. The advisory board highlighted the need of taking the circular economy into consideration, life cycle impacts of biochar. The evaluation of cost and benefits of urban carbon drawdown solutions were also highlighted

4. First ideation workshop

The first advisory board and partner meeting were followed by the ideation workshop. First ideation workshop had 19 participants, representing 12 different organizations or companies. The following stakeholder groups were represented: Businesses which are producing and supplying cities with different soil products and soil amendments, architectures, green builders and the customer of the services City of Helsinki. During the day we heard the Carbon Lane project's presentation, the individual introduction of each participant, Helsinki's perspective to the project, different solutions provided by the companies and methods to validate and demonstrate urban carbon drawdown concepts. In addition, we had a table discussion in 4 groups and 3 rounds.

In the first round, we discussed how to improve the growth and well-being of soil, how green areas can be used for sequestering carbon, how to involve citizens into action. In the second round, we discussed the boundaries of different solutions, what type of concepts could be applied in Helsinki. In the third round, we concentrating on discussing what types of concepts would be appropriate for the Helsinki Jätkäsaari demonstration area, what aspects should be taken into consideration by different actors. Based on the conversations, we created a comprehensive summary which will be presented later in this document.

5. Second ideation workshop

The second ideation workshop was organized on the 14th of June 2019. In a total of 21 participants from 16 different organizations and companies participated. In this workshop the current progress of the Carbon lane project was presented, in addition, we had a presentation from puro.earth which is a marketplace for CO2 removal. The demonstration area in Jätkäsaari Hyväntoivonpuisto was also presented. In the table discussions, we were ideating carbon drawdown concepts, for example, what types of materials should be used and what would be the criteria for assessing different concepts and materials. In addition, we were ideating what type of information we can and should produce from the demonstration area. Furthermore, we discussed what types of concepts would be the most applicable for the demonstration location and how we can best support the innovative solutions and disseminate the knowledge.

6. Second advisory board and partners meeting

Second advisory board and partner meeting were organized on the 3rd of September 2019. In a total of 17 participants from 8 companies or organizations participated in the meeting. In this meeting, we discussed the state of the project, presented a proposal of concepts which could be implemented in the demonstration, what type of data could be collected and initial ideas for interaction and engagement of citizens. In addition, we concentrated to discuss the proposed concepts and what the obstacles for wider use of the solutions can be.

7. Onsite meeting

The onsite meeting between all parties involved in the actual building of the demonstration area was organized on the 15th of October 2019. In this meeting, all practicalities were planned and agreed regarding the realization of the demonstration area.

8. Wider engagement of stakeholders

In order to gain wider ideas and engage new market actors, the Carla project team has been active in presenting the project aims and inviting new participants in different venues. For instance, Carbon Lane was presented and assisted in organizing a Biochar Study Tour 2019 event in Finland on the 4th-6th of September. In a total of 121 participants from 18 countries attended the 3-day event. In addition, the Carbon Lane project hosted an interactive workshop session at the Nordic Biochar Conference 2019 in KTH Royal Institute of Technology in Stockholm, with around 70 participants, mostly from Nordic countries. Carbon Lane is also invited to give a presentation to the international seminar - Beyond Alliance for Knowledge Seminar BAK2019 on 26th - 27th of November 2019.

Appendix 2.Table/matrix of evaluation

IDEAS FROM THE ASSESSMENT CRITERIA WORKSHOPS

I Workshop 6.5.2019 II Workshop 14.6.2019 III Workshop 3.9.2019	Resource requirements	Implementation considerations	Potential benefits	Future research	
Avoiding building on currently forested areas	Challenging in limited land areas of urban centres	Requires consideration at the early zoning/ planning phase	Maintaining current carbon stocks and sinks	Verifying and validating the impacts requires more research	PRACTICES
Increase the number of trees	costly but outer parts of the city can offer feasible opportunities	At the planning stage of a building project or later stage	Potential to reduce costs and increase the efficiency of heating and cooling buildings	While scientific literature is available on the topic, verifying and validating the impacts requires more research	
Extending lifespan of urban trees (e.g. to over 50 years)	Additional budget for tree pruning and management, planting soils and soil amendments	The life span of urban trees should be maximized	increasing net negative carbon sequestration of trees, improved biodiversity		
Increasing co-operation between private and public sector	Requires new approach and ways of cooperation	Requires new initiatives and approaches	Can provide significant environmental and financial benefits	Requires more knowledge on the possible impacts and co-operation strategies	
Leaving plant litter on the ground where possible	Changes in resident / user attitudes and maintenance plans	Could be experimented on appropriate locations	Less maintenance, increased biodiversity	Requires more studies on validating and estimating the impacts	
Less intense maintenance, keeping lawn longer, mowing less often	Changes in resident / user attitudes and maintenance plans	Currently in limited use	Less maintenance, increased biodiversity		
Leaving trees to decay in the parks or as a home for insects	Changes in maintenance plans	Currently in limited use	Limited impacts, increased biodiversity		

IDEAS FROM THE ASSESSMENT CRITERIA WORKSHOPS

I Workshop 6.5.2019 II Workshop 14.6.2019 III Workshop 3.9.2019	Resource requirements	Implementation considerations	Potential benefits	Future research	
Green roofs, building green areas into biological water filters, utilizing stormwater and greywater for irrigation Filter nutrients, heavy metals, oils and other impurities from the stormwater before leading them to water	Might require significant C inputs and resources in budget and planning Requires additional budget, may require additional land area for ponds, streams	Utilizing greywater might cause issues in social acceptance Best results if considered at the planning stage	Significant savings due to local management of water, savings from the sewer system Significant environmental benefits can be achieved	Available but a further product and process development and research is highly requested Available but a further product and process development and research is highly requested	BUILT SOLUTIONS
bodies Use permeable paving	Requires separate assessment	Currently in limited use; oftentimes limited durability	Decreasing the need of handling stormwater	Requires separate assessment	
Using structural soil in parks and grass areas	Requires additional financial budget	Should be considered at the planning stage	Compaction of soil can be avoided, longer lifespan and easier maintenance	Available but requires separate experimenting	
Adding composting possibilities to the parks	Requires changes in resident/user attitudes, additional financial budget	Can be added separately	Requires separate assessment	Available but requires further investigations, can be a source of GHG emissions	
Convert some grass areas into meadows	Requires separate assessment, changes in resident/user attitudes	Currently in limited use	increase biodiversity and carbon sequestration	Requires separate assessment	

IDEAS FROM THE WORKSHOPS

IDEAS FROM THE ASSESSMENT CRITERIA

I Workshop 6.5.2019 II Workshop 14.6.2019 III Workshop 3.9.2019	Resource requirements	Implementation considerations	Potential benefits	Future research requirements	
Favouring mixtures of different species of grass and other vegetation	Requires additional maintenance resources	Could be experimented on appropriate locations	Can provide to increase biodiversity and carbon sequestration	Requires further research on validating and verifying the climate benefits	VEGETATION
Edible gardens	Requires additional space and maintenance resources	In limited use currently, could be used on appropriate locations	Can provide to increase biodiversity and decrease CO2 emissions of food	Available but requires further investigations, decaying fruits can be a source of GHG emissions	
Fast-growing tree species	Requires additional space and tree maintenance resources	Could be experimented on appropriate locations	Can accelerate CO2 sequestration	Requires separate assessment	
Use perennials around trees instead of wood chips	Requires separate assessment	Currently in limited use	Can accelerate CO2 sequestration	Requires separate assessment	
Use of slow-growing or height-restricted species in lawn areas	Requires separate assessment	Could be experimented on appropriate locations	Reduction of GHG emissions from the maintenance	Requires separate assessment	
Using grass species with deep roots	Requires separate assessment	Could be experimented on appropriate locations	Roots have an important role in soil health and carbon sequestration	Requires separate assessment	
Vegetation species that require less mowing and maintenance	Requires separate assessment	Could be experimented on appropriate locations	Reduction of GHG emissions from the maintenance	Requires separate assessment	
Biochar as a soil additional component in soil and soil products	Requires financial investments	Could be experimented on appropriate locations	Increasing carbon sink, improving soil properties, decrease the need for irrigation and ease maintenance	Available but requires further product and process development and research is highly requested	
Carbon binding stone (e.g. olivine) to be used as decorative stones or pavement on the roads and roofs	Requires financial investments	Could be experimented on appropriate locations	Can accelerate chemical carbon sequestration	Minerals are available in Finland, requires further research	MATERIAL CHOICES
Using solid wood in building park fences, benches	Requires financial investments	Can be implemented	Storing carbon in wood-based products	Requires separate assessment	
Recycled soil from nearby building sites	Requires separate assessment	ls currently experimented	Can provide significant financial and environmental benefits	Requires separate assessment	
Utilizing waste concrete in structural soil	Requires environmental permit	Requires separate assessment	Can provide significant financial and environmental benefits	Requires separate assessment	

Appendix 3. Illustrations of concept designs



Image: illustration of the concept designs by Minja Koivunen

The map and pictures in this section are for illustration purposes, the map above is based on the real demonstration area of this project.

The solutions described in this section increase carbon sinks through wood based building materials such as fences, pathways, benches and biochar based planting soils. Carbon sequestration and biodiversity is improved through improved soil conditions and mixture of different species of vegetation. In addition, this area considers citizen involvement and interaction.



Image: illustrations by Minja Koivunen



Image: illustrations by Minja Koivunen

Community-level composting increases social inclusion and empowerment. Organic waste is always generated, so why not use it locally to make our living environments greener by improving soil conditions.



Image: illustrations by Minja Koivunen

Wooden fence. In addition to environmental benefits of increasing the use of solid wood include creating pleasant acoustics for urban green spaces.

Appendix 4. Ideas for interaction and art

Idea 1 - Visualising the data through light

This idea involves visualising the data in realtime through light & colour that stems from the ground or under trees. Colour would represent different types of data being mapped and the light intensity would represent the highs and lows in the data.



Reference image - Light pillar. Image by Adam Kraft, 2013



Reference image - Luxform Solar Power LED Land Lamps (left) Forest lighting (right). Image by Geir Pettersen

The lights could also pulsate to represent and amalgam of data activity. Highs in the overall data would be represented by high frequency of pulsation while lower frequencies would present the overall lows.

Idea 2 - The Network

Visualizing the data online through an interactive website.

Linking data from demonstration sites in the world in an interactive visualization of the process and significance of carbon sequestration as a network. This would involve communicating the real time data along with key aspects of the project and the research.



Reference image - data visualization of EU cities as corals. Image by Ito world design lab, 2018

The visualization can draw data about soil activity, plant growth, SOC levels, etc from various sites, and can be a platform for visualizing data on carbon sequestration for public access. It can be used as a tool to explore the concept of carbon sequestration, the data being gathered and the different activities at the demonstration site.



Reference image - Carbon Tree - Hyytiälä http://www.carbontree.fi/

An example of a data visualization is the carbon tree based in Hyytiäla where a tree is visualised by a point cloud that represents carbon movement. The carbon content and movement is linked to the environment and soil conditions around it, in real time. This visualization can also be used as a tool that represents what the carbon flow and activity would be like in different conditions by allowing the viewer to manipulate the different environment parameters interactively.

A visualization of carbon sequestration sites across the world can also be represented by an interactive sculpture at the demonstration site. The sculpture would serve as a beacon for carbon sequestration and could also present real time data of carbon capture and soil activity in different parts of the world. The form of this sculpture can be inspired by the ideas that follow.

Idea 3 - A Translator

An object by nature or inspired from nature that communicates with the visitors.

This idea revolves around having a human sized object, like a monolith, that is inspired by the ground and nature. This entity can be perceived as a translator that provides information about the health and activity under the ground through creative and interactive mediums.



Reference Images - Conceptual Monoliths. Images by Jordan Habrin, 2015 (left) & Rene Aigner, 2012 (right)



Reference image - Monolith in Tähtitorninmäki Park. image by Teemu Lehmusruusu

An example of a monolith is a sculpture in Tähtitorninmäki park with a height of about 150cm, comparable to human height.



Reference Image - Sibelius Monument by Eila Hiltunen. image by Brian Cohen, 2017

An example of an abstracted monolithic form is the Sibelius monument. The monument is much larger in comparison to human height and works as spatial and tactile experience, and as an attraction. Visitors can interact with the sculpture by walking around it, sitting under it and through activities in the surrounding space.

An approach to creative and interactive mediums for the monolith that could represent data and soil activity in the form of light, sound, vibration or a mix of them are :

- The monolith can be formed to have cavities that produce light that represents different forms of data and activity under the ground.
- The surface of the monolith can be formed to have textures and relief work

that represents organisms and roots that live and thrive in the soil.'

- Sounds, like a low frequency hum, could represent highs and lows in the overall soil activity.
- The monolith can have a conductive vibration that is also based on overall highs and lows in the soil activity. Having a tactile and relief surface can make the monolith inviting to touch and feel the vibration as a representation of the ground underneath being alive.



Reference image - 2066 by Hans Rosenström, 2016

An example of an audio interactive public art piece is the work of Hans Rosenström in his installation called 2066, that presents boulders in an intimate setting. These boulders are embedded with a transducer speaker that can be heard through bone conduction by laying down on it. This audio heard are thoughts vocalised by various professionals on what the world would be like in 50 years

Form and material

Since we are exploring an interactive & abstracted sculpture that represents the natural activity under the ground, it is important to consider the living organisms in the soil and their form. Organisms like roots, earthworms, millipedes, casts (fossils) and other such forms of life are rather underrepresented. Public art pieces rarely celebrate it. These forms can be a great source and inspiration to compliment our representations through the interactive sculpture. Roots are a fundamental form to the concept of carbon sequestration as they are the link between the world about and below the ground, and can be a great source of inspiration for the form and structure of the monolith.

Materials like glass and metals can be considered for use to create the structure. Materials like cob could be used as a building material. Granite can be used for foundation and surface textures. These materials are robust and yet complementary to the idea.



Reference Images - A cast fossil (left). Image by Budimir Jevtic. An earthworm (right). Image by J. Fieber.



Reference images - Alma Heikkilä, Warm and moist | decaying wood (Left) & In a Good Mood (right), 2016

Works of Alma Heikkilä provide inspiration towards how this natural and organic relief work can be represented that evoke a feeling of interaction of material and tactile surfaces.



Illustrations by Sushant Passi

Sketches of how the monolithic structure could look with organic and tactile relief forms on the surface. The forms are inspired by organisms underground.

Idea 4 - Favourable and unfavourable

This idea considers the data received from the sensors in relation to what conditions are favourable or unfavourable for plant growth. The data received from the sensors can be analysed to reveal the environment under the ground and then represented through an interactive and segmented scale.



Illustration by Sushant Passi

happy/sad worm. Representing soil conditions as favourable or unfavourable through a kinetic sculpture.



Illustration by Sushant Passi

Representing the data through the segmentation of the organism. Individual segments light up to visualize the data, soil activity and favourability. Materials can be glass blown balls for each segment and embedded with a wire frame structure.