



Urban CDR Pathway Fact Sheet

Soil Organic Carbon (SOC) Enhancement from Urban Land Regeneration Practices

LEGEND

Application: Forestry; agriculture and landscaping; ecosystem restoration; botanical gardens

Permanence:

- 20–100+y in soils for composting, urban tree planting, no-till and reduced-till methods, cover cropping, and semi-persistent carbon in biochar.
- 100–1000+y in soils for polycyclic aromatic carbon in biochar (see Biochar in Construction and Road Infrastructure Fact Sheet for more biochar use cases)

Infrastructure: Soil carbon testing; Remote sensing; GIS; Kon Tiki kiln or industrial scale pyrolysis machine; Biochar processing equipment; Analytical testing equipment; Life-cycle analysis; Toxicity analysis; Digital Monitoring, Reporting and Verification software (dMRV).

Guidance: Identify the relevant pathway steps, inputs, and outputs. Calculate the carbon sequestration impact. Report emissions impacts in the city's emissions inventory in accordance with the [GHG Protocol for Cities](#).

PATHWAY

Soil Organic Carbon (SOC) enhancement focuses on increasing the amount of carbon stored in the soil as organic matter. Regenerative practices that enhance SOC in urban and peri-urban areas can take different forms. Nature-based Solutions (NbS) that incorporate regenerative practices aim to restore and strengthen ecosystems while addressing societal challenges such as climate change and food security.

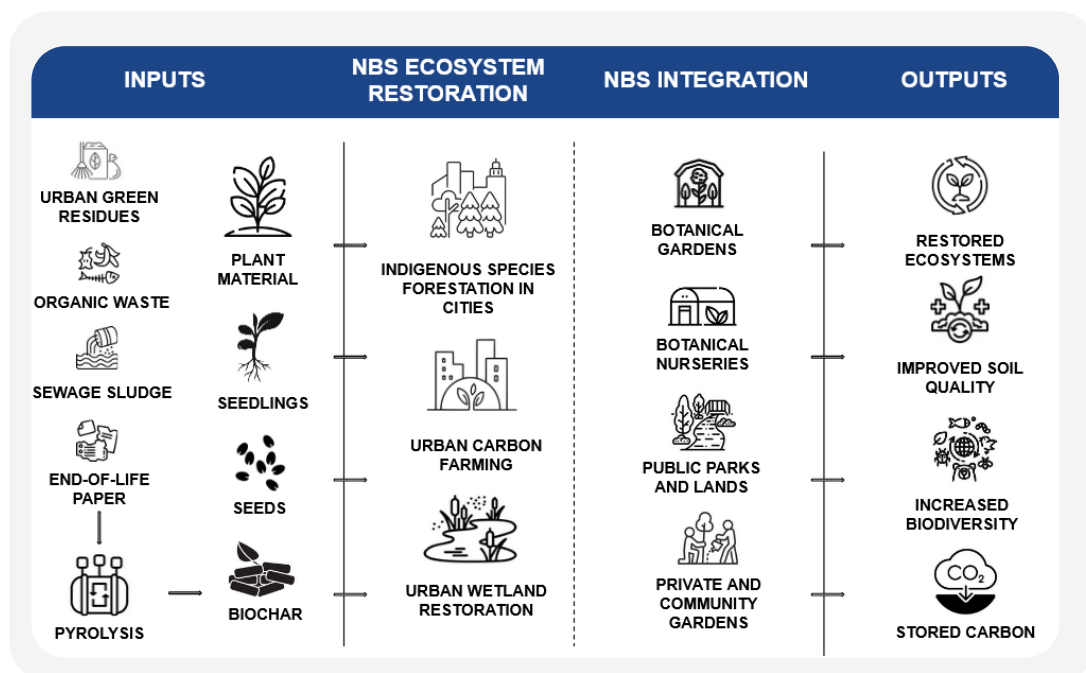


Figure 1: Simplified pathway overview

This may include interventions such as indigenous species forestation, rewilding in cities, ecosystem restoration, and urban carbon farming, as well as the application of biochar. Land regeneration as an urban CDR pathway focuses on a range of SOC enhancement interventions on public parks and lands, private and community gardens, botanical gardens, botanical nurseries. Outputs extend beyond the climate impact.

ACCOUNTING

Emission risks: Accounting for embodied emissions of regenerative practices associated with SOC enhancement inputs, and restoration and integration activities, is complex. Another risk is the use case for the removals. If the removals are generated from solutions with low permanence (<100y), they should not be used to compensate for long-lived fossil emissions.

Emission sources to account for:

- Embodied carbon in nursery infrastructure and tools.
- Embodied carbon in farming and landscaping infrastructure and tools.
- Embodied carbon associated with pyrolysis reactor.
- Logistics (transport of seeds, inputs, biomass and materials).
- Production and use of fertilizers and agrochemicals (N₂O release).
- Displacement of pre-existing biomass use incentivizing emitting replacement activities.
- Dewatering and grinding the biomass materials used to produce biochar.
- Pyrolysis process used to produce biochar.
- Water pumping energy, if not renewable.
- Electricity use in labs for plant tissue culture / micropropagation (can be high).
- Heating, lighting, and plastic items for sterile use in controlled environments.
- Management of non-biodegradable waste from growth media.

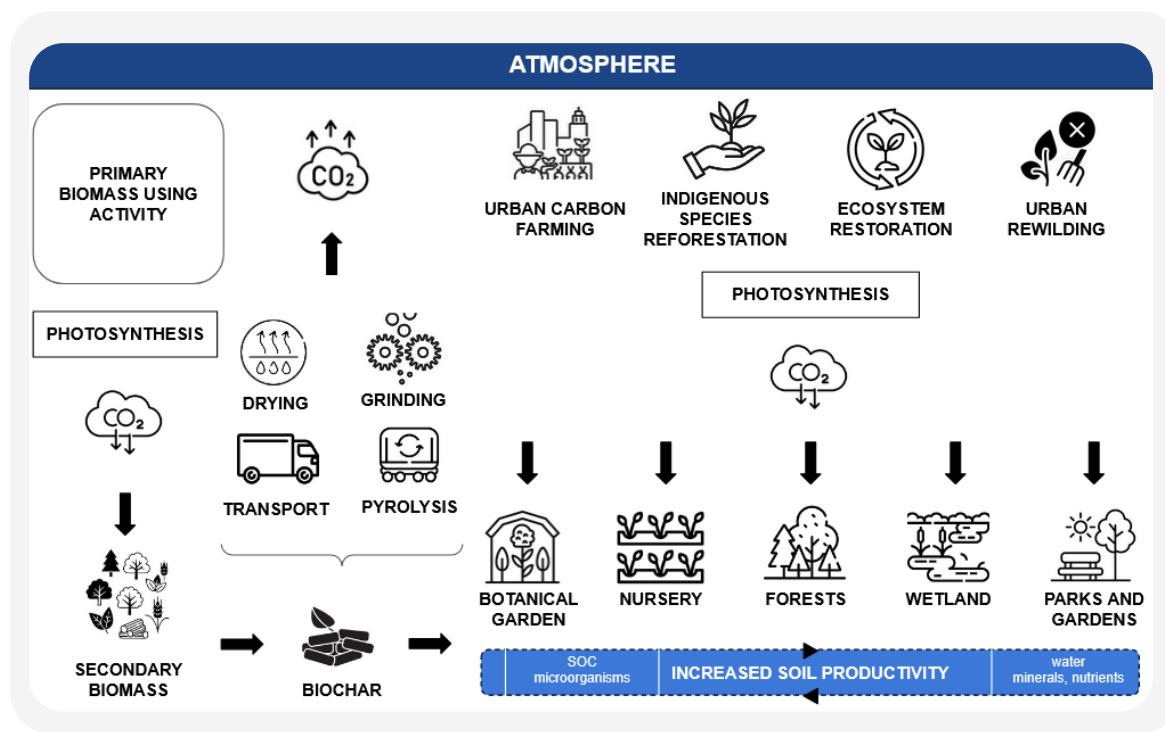


Figure 2: Simplified carbon flow diagram

Mitigation Strategies:

- ☐ Use renewable energy for propagation and local sourcing to cut transport emissions.
- ☐ Deploy energy-efficient tissue culture systems and biodegradable growth media.
- ☐ Use a mobile pyrolysis reactor to cut biomass transportation emissions.

(Part) Value Chains	Emissions	Removal Potential	Net Carbon Impact*
Inputs and Nurseries	Medium	Low	Slightly positive
Biochar Pellets	Low to Medium**	High	Strongly negative
Ecosystem Restoration	Low	High	Strongly negative
Urban Farming	Medium	Low to medium	Positive to to neutral
Botanical Gardens	Medium	Indirect	Neutral to negative
Monitoring/Verification	Low	Enabling	Critical for credibility

* Indicates whether the activity releases more carbon into the atmosphere than it removes (positive) or removes more carbon than it releases into the atmosphere (negative).

** Emissions associated with the production of biochar pellets vary depending on the pyrolysis system that is used. Slow pyrolysis (Kon Tiki kiln) tends to have a higher footprint than fast pyrolysis and hydrothermal carbonization (industrial scale pyrolysis machine).

Accounting protocols:

- **Land regeneration:** [Gold Standard Soil Organic Carbon Framework Methodology](#), [Verra Improved Agricultural Land Management methodology](#), [Forest Footprint for Cities](#), [Climate Action Reserve U.S. Organic Waste Composting Protocol](#).
- **Biochar production:** [Global Biochar C-Sink Standard](#), [Puro.earth](#), [Isometric Biochar Protocol](#), [VCS Biochar Methodology](#), [Climate Action Reserve U.S. and Canada Biochar Protocol](#), [Rainbow Biomass Carbon Removal and Storage Methodology](#).

ALTERNATIVE DESIGNS

Urban land regeneration as an urban CDR pathway recognizes that urban and peri-urban systems and infrastructure leveraged for CDR may vary across cities due to differences in geography, governance, existing assets, and local development capacities and priorities. The presented pathway design reflects one of several viable configurations.

Possible variations:

- Substitute constructed wetlands with blue-green corridors in high-density areas.
- Substitute urban forests with green walls or green roofs in vertical cities.
- Adapt nursery propagation to mobile/container-based systems in informal settlements.
- Integrate biochar production within waste-to-energy plants or industrial zones.
- Integrate biochar pellets into construction materials (see “Biochar in construction” fact sheet).
- Use modular botanical gardens as mobile educational units in underserved zones.
- Use modular botanical gardens as mobile living labs for urban CDR education.

OPPORTUNITIES AND GAPS

Acceleration:

- Co-deployment with urban heat mitigation projects and disaster risk reduction.
- Inclusion in **green building codes**, e.g. UN Habitat 9m² green space per capita.
- **Co-Benefit 1: Stormwater management and filtration** via restored wetlands and urban forestry.
- **Co-Benefit 2: Soil rehabilitation** using biochar to reduce fertilizer dependency.
- **Co-Benefit 3: Urban cooling** through forest canopy and wetland microclimates.
- **Co-Benefit 4: Air and soil quality improvements** with phytoremediation landscapes.

Gaps:

- **Research:** High uncertainty and large variance of carbon impact measurement in the limited available research data on urban SOC.
- **MRV Complexity:** Limited access to standardized carbon measurement tools for urban land regeneration and biochar pathways.
- **Infrastructure Readiness:** Gaps in pyrolysis capacity, water management systems, and decentralized nursery networks.
- **Policy and Finance Misalignment:** Few mechanisms connect urban land regeneration and ecosystem restoration projects to overcome cost barriers and unlock long-term CDR revenue streams.
- **Feedstock Variability:** Biomass availability, diversity and quality for biochar production may fluctuate seasonally or as a result of competing uses.
- **Workforce Capacity:** Insufficient skilled labor in urban forestry, tissue culture, ecological monitoring, and carbon accounting.

CORE RECOMMENDATIONS

- Evaluate project economics beyond carbon impact, including ecosystem and the broader benefits to be realized as a city.
- Make side by side comparisons of common city biomass waste stream use cases.
- Establish collaborative research programs to measure and re-measure the impacts of urban SOC interventions.
- Develop hybrid MRV systems using mobile phone apps, low-cost sensors, satellite data, and community science.
- Aggregate urban forest projects and urban carbon farming projects and account their carbon impact as single groups.
- Launch pilots with modular pyrolysis and nurseries embedded in public utilities.
- Evaluate the availability of residual and waste feedstocks suitable for sustainable biochar production and matchmake opportunities with project developers.
- Map the complete materials management requirements, such as logistics, preexisting uses, and departmental priorities and procedures, for projects to work.
- Evaluate toxicity levels of biomass feedstocks such as sewage sludge for their use as biochar input for agricultural and regenerative land management.
- Incentivize interim benefits via municipal carbon budgeting and ESG-linked bonds.
- Build public-private skills partnerships for CDR jobs in urban ecological infrastructure.
- Phase in full CDR protocols by first deploying co-benefit-focused green infrastructure.

INNOVATION LANDSCAPE

There are important innovation needs, such as integrated platforms for CDR and biodiversity co-benefit reporting to enable a valuation of the co-benefits, urban zoning incentives for wetland and carbon farm overlays, modular, replicable tissue culture and nursery units for underserved communities, and scalable models for biomass sourcing and biochar production.

LEADING CITIES

- **Nairobi, Kenya** – Piloting community-led botanical corridors and wetlands ([Maarifa Park](#)).
- **Quito, Ecuador** – Embedding participatory urban agriculture in resilience strategy ([AGRUPAR](#)).
- **Kigali, Rwanda** – Embedding indigenous reforestation in urban planning ([IISD/WRI](#)).
- **Singapore** – Urban carbon farming integrated with stormwater gardens ([Bishan-Ang Mo Kio Park](#)).
- **San Francisco, USA** – Wood chip biochar for stormwater management ([Ashoori, et al, 2019](#)).
- **Freetown, Sierra Leone** – [Urban tree tracking](#) via [TreeTracker](#) for carbon and flood control.
- **Grevesmühlen, Germany** – Biochar carbon removal and green heat generation ([Carbon Removal Park Baltic Sea](#)).
- **Minneapolis, USA** – City-owned biochar unit to build resilience, reduce food waste and improve soils ([city biochar](#)).
- **Helsinki, Finland** – Piloting local production and use of biochars ([city biochar](#)).
- **Stockholm, Sweden** – Biochar-urban forestry strategy ([city biochar](#)).

Acknowledgment: This fact sheet is part of a series. The development of the fact sheet was led by the Centre for Science and Technology Innovations (CSTI), a partner in the City CDR Initiative, and received input from partners, cities, and developers associated with the Initiative. The following individuals in particular contributed, either in their organizational or personal capacity: Sue Doward, Francisco Koch, Grant Faber, Aidan Preston, Simone Mangili (CNCA), Lucia Dora Simonelli (CRSI), Kyle Clark Sutton (RMI), and Dylan Marks (South Pole).