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2.1.5 Measured soil carbon content

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Total carbon storage and sequestration in soil per unit area per unit time	**Climate Resilience Green Space Management**
Description and justification	Accounting for C stored in soil and vegetation in an urban area can provide an indication of the condition of natural green spaces, total free surface area and total quantity of vegetation in the area examined. Measures of C storage and sequestration also provide a tangible connection to climate change mitigation, and the impacts of local land use, planning and management decision-making. It is important to note the substantial variation in C sequestration and storage capacity of different types of NBS.
Definition	Total amount of carbon (tonnes) stored in soil per unit area and unit time
Strengths and weaknesses	+ Physical sampling and laboratory analysis of soil C yields accurate information, with improved accuracy of estimated C storage in soil with increasing sampling intensity

	+ Combustion-based analytical methods are relatively simple and widely applicable - Small changes in soil C may be difficult to quantify in carbonate-rich soils, in which case multiple analytical steps may be required to obtain reliable measurements - Soil sample collection is relatively labour-intensive; analyses typically require an external laboratory (rather than analysed in-house)
Measurement procedure and tool	The most reliable and accurate method of determining soil C content is field sampling followed by laboratory analysis. Combustion is an accurate, commonly used analytical technique to quantify total C in soil – including both organic and inorganic soil C. Combustion analysis involves converting all forms of C in the soil to CO_2 by wet or dry combustion, then measuring evolved CO_2. Change in soil C content occurs most readily in the SOC fraction, so observed changes in total soil C content with time are most likely to represent changes to SOC content. Sampling is performed using a measuring tape (for establishment of sampling transect or grid), soil corer, and plastic bags. It may be challenging to detect small changes in soil C content in soils that contain substantial inorganic (mineral) C. A rapid field test of the soil's reactivity to acid can indicate whether it may be necessary to undertake more intensive analyses of soil samples to quantify both the organic and inorganic C fractions, rather than total (inorganic + organic) C by combustion. Rapid assessment of soil carbonate content involves reacting a small sample (ca. 1 g) of soil with 1-2 drops of 1 M hydrochloric acid (HCl) in a glass or porcelain container and observing the reaction for ~5 min. The reaction between soil carbonate minerals and HCl is visible as bubbles/effervescence as bubbles of CO_2 are produced. If the HCl 'field test' indicates the presence of inorganic C then the soil sample should be pre-treated to remove inorganic C prior to determination of organic C content by wet digestion. A sample of the carbonate-containing soil should be treated at room with a mixture of dilute sulphuric acid (H_2SO_4) and ferrous sulphate ($FeSO_4$) for at least 20 min or until effervescence appears to cease. The flask containing the soil and H_2SO_4/$FeSO_4$ mixture should then be heated over a flame and boiled slowly for 1.5 min to destroy any remaining carbonate. Finally, pulverised

	potassium dichromate ($K_2Cr_2O_7$) should be added to the mixture and organic C determined by chromic acid digestion (wet combustion) (Nelson & Sommers, 1996).
Scale of measurement	Plot scale; it is possible to extrapolate results from small number of field samples based on soil maps to approximate soil C storage at landscape (regional) scale
Data source	
Required data	Site characteristics, including maps of soil type, topography, and vegetative cover. Average soil bulk density (in kg/m^3; can be measured or estimated based on soil type). Obtainable from local municipality, department of environment, geological survey.
Data input type	Quantitative
Data collection frequency	Annually, including at a minimum measurement before and after NBS implementation
Level of expertise required	Low to Moderate – field sampling Moderate – combustion analysis in laboratory conditions High – soil sample pre-treatment for determination of organic C content
Synergies with other indicators	Used for evaluating C storage necessary for *Carbon removed or stored per unit area per unit time* indicator
Connection with SDGs	SDG 11 Sustainable cities and communities, SDG 13 Climate action, SDG 15 Life on land
Opportunities for participatory data collection	Participatory data collection is feasible through soil sample collection
Additional information	
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