

CLIMATE RESILIENCE

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1. RECOMMENDED INDICATORS OF CLIMATE RESILIENCE

1.1. Carbon removed or stored in vegetation and soil

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Total carbon removed or stored in vegetation and soil per unit area per unit time	Climate Resilience
Description and justification	Accounting for C stored in soil and vegetation in an urban area can indicate 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 carbon removed or stored (tonnes/ha/y or similar units)
Strengths and weaknesses	+ Quantifying removal and sequestration can give the opportunity to mitigate GHG effects - Requires other metrics to evaluate the indicator
Measurement procedure and tool	<p>To evaluate C removal or storage per unit area per unit time:</p> <ul style="list-style-type: none"> • Determine C storage in vegetation or soil as described in <i>Carbon storage and sequestration in vegetation</i> or <i>Carbon storage and sequestration in soil</i> indicators, respectively, for the same area at two different points in time • Divide each C storage value obtained by the area assessed to determine C storage per unit area • Subtract the earlier value obtained for C storage and sequestration/unit area from the more recent value, then divide by the length of time between measures to obtain an estimate of C removal or storage per unit area per unit time. <p>The growth rate of a forest has significant impact on its C storage potential. Forest C sequestration (FCS) is usually estimated as a function of forest area, forest type, and forest age:</p> $FCS = (FIA_{rate} / FOREST_{mean-pct}) \times NONF_{mean-pct,i} \times NONF_{area,i}$ <p>where FIA_{rate} is net forest growth rate for the most common type group in county i, $FOREST_{mean-pct}$ is mean canopy cover percentage for all forested pixels in the county i, $NONF_{mean-pct}$ is mean canopy cover percentage for all non-forest pixels in county i, and $NONF_{area}$ is area sum of all non-forest pixels in county i. The sum of FCS in both forested and non-forest pixels is the total net FCS by urban and community trees in county i (Zheng, Ducey, & Heath, 2013). Studies have shown that more accurate estimates of FCS are obtained by classifying forests as recently afforested or mature/remnant forest as tree growth rates vary substantially between these forest types (Smith, Heath, Skog & Birdsey, 2006; Zheng, Heath, Ducey & Smith, 2011).</p>
Scale of measurement	Plot scale to regional scale
Data source	
Required data	Requires C storage to be determined from either <i>Carbon storage and sequestration in soil</i> or <i>Carbon storage and sequestration in vegetation</i> indicators
Data input type	Quantitative

Data collection frequency	Annually
Level of expertise required	Low – requires the ability to determine C storage from other metrics and follow the calculation procedure
Synergies with other indicators	Requires C storage to be determined from either <i>Carbon storage and sequestration in soil</i> or <i>Carbon storage and sequestration in vegetation</i> indicators
Connection with SDGs	SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	<p>Smith, J.E., Heath, L.S., Skog, K.E., & Birdsey, R.A. (2006). Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States. USDA Forest Service Report GTR-NE-343. Newtown Square, PA: Northeastern Research Station, United States Department of Agriculture, Forest Service.</p> <p>Zheng, D., Ducey, M.J. & Heath, L.S. (2013). Assessing net carbon sequestration on urban and community forests of northern New England, USA. <i>Urban Forestry & Urban Greening</i>, 12, 61-68.</p> <p>Zheng, D., Heath, L.S., Ducey, M.J. & Smith, J.E. (2011). Carbon changes in conterminous US forests associated with growth and major disturbances: 1992–2001. <i>Environmental Research Letters</i>, 6, 014012.</p>