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CARBON FOOTPRINT ASSESSMENT IN ROAD CONSTRUCTION PROJECTS: METHODS FOR REDUCING EMISSIONS

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Abstract – Road construction represents a significant contributor to global greenhouse gas (GHG) emissions, yet standardised methodologies for quantifying and reducing these impacts remain underdeveloped in developing-country contexts, particularly in South Asia. This study aims to quantify the carbon footprint of road construction and identify technically and economically feasible emission reduction strategies through a comparative Life Cycle Assessment (LCA) of two infrastructure projects — the Outer Circular Highway (E02) in Sri Lanka and the A3 Motorway (Salerno–Reggio Calabria) in Italy — conducted using SimaPro software with the Ecoinvent v3 database, strictly following the four mandatory phases prescribed by ISO 14044. In the goal and scope definition phase, the functional unit is established as one kilometre of a standard two-lane road, and the system boundary is defined as cradle-to-gate, encompassing raw material extraction (A1), transport to manufacturer (A2), material production (A3), transport to construction site (A4), and on-site construction activities (A5). In the life cycle inventory (LCI) phase, material quantities, transport distances, and construction equipment fuel consumption data are compiled from project documentation, published LCA studies, and semi-structured stakeholder interviews; where Ecoinvent v3 datasets do not adequately represent Sri Lankan conditions, process-level adaptations are applied to reflect the local electricity grid composition, cement production characteristics, and regional supply chain distances. In the life cycle impact assessment (LCIA) phase, the IPCC 2021 GWP 100-year characterisation method is applied, expressing results in kg CO_2-equivalent per kilometre, complemented by the ReCiPe 2016 midpoint approach for additional impact categories. In the interpretation phase, Monte Carlo simulation and one-at-a-time sensitivity analysis quantify result uncertainty and identify the most influential parameters, while scenario analysis systematically evaluates emission reduction interventions including warm mix asphalt adoption, increased Reclaimed Asphalt Pavement (RAP) incorporation, local material sourcing optimisation, and construction equipment modernisation. Preliminary SimaPro modelling indicates significantly higher carbon intensity in the Sri Lankan case, attributable principally to near-absent RAP use (below 5 % versus 20–40 % in Italy), greater reliance on virgin construction materials, and a more carbon-intensive electricity grid. The study delivers a reproducible, ISO 14044-compliant methodological framework for carbon footprint assessment in tropical road construction, providing evidence-based guidance for Sri Lanka's Road Development Authority and analogous institutions across South Asia in meeting national climate commitments under the Paris Agreement.

Keywords – Ecoinvent database; greenhouse gas mitigation; ISO 14044; life cycle inventory; reclaimed asphalt pavement; SimaPro; Sri Lanka; warm mix asphalt