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Towards Sustainable Cycling: Life Cycle Assessment of bicycle road pavement

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INTRODUCTION

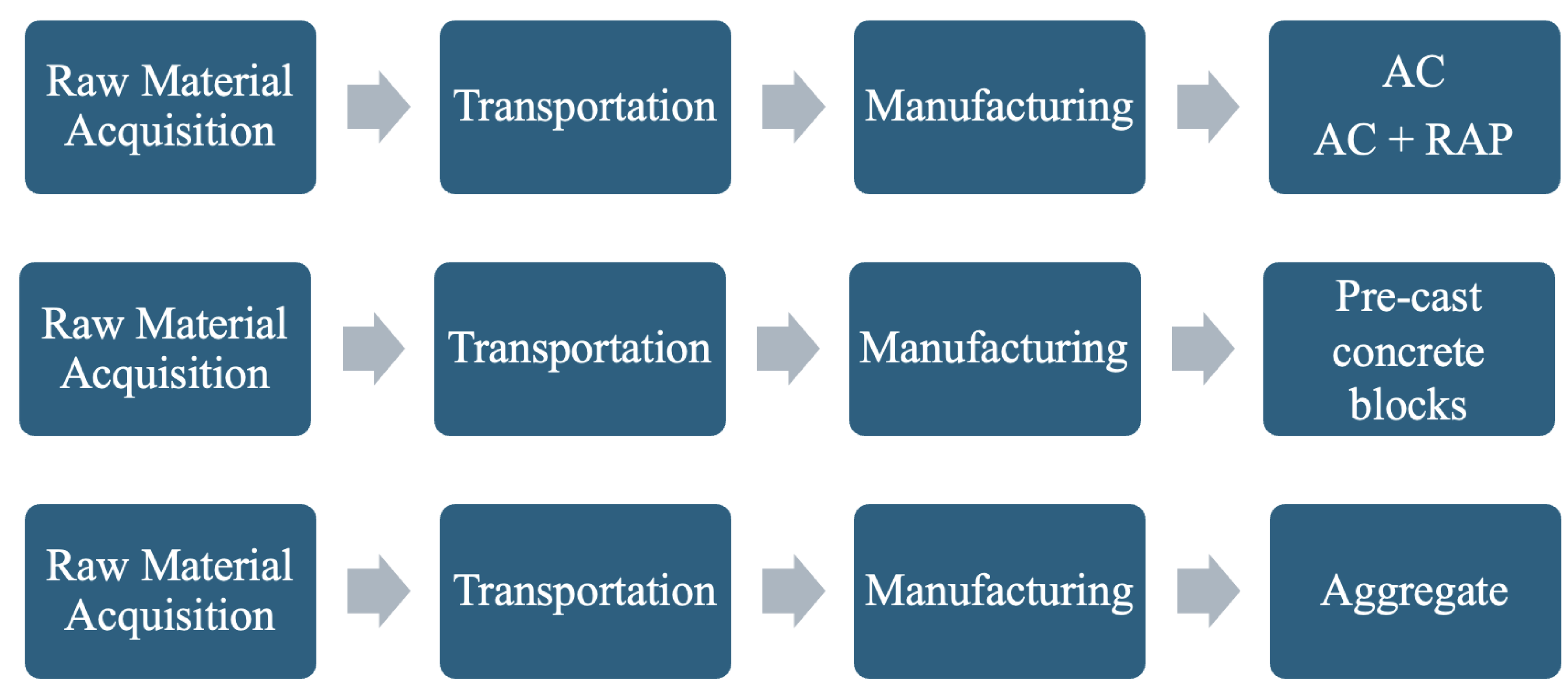
Bicycle roads rely on asphalt, a key contributor to global warming potential (GWP). Road traffic and construction produce 74% of transportation emissions (IEA, 2019), with demand expected to rise by 50% by 2050 (Alonso Raposo et al., 2019). Using reclaimed asphalt pavement (RAP) can reduce emissions and resource use.

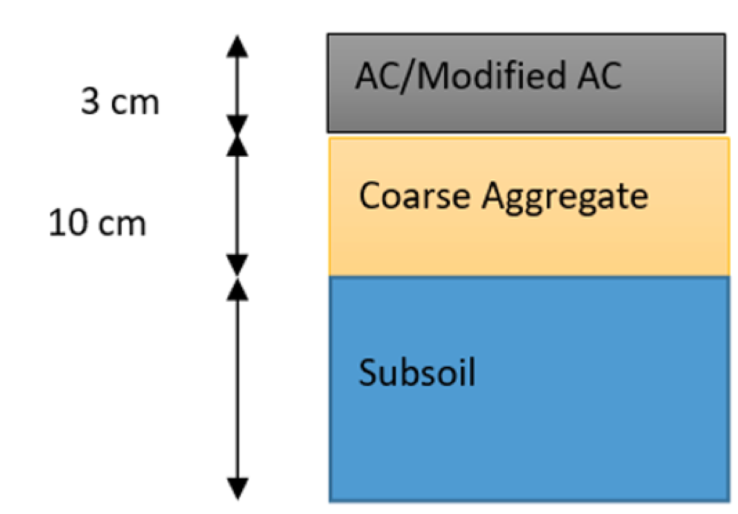
Asphalt's impact in bike lanes is understudied. The EU "Transport White Paper" (2011) supports sustainable transport, and cities like Amsterdam and Copenhagen promote cycling. Studies show bike lanes cut CO_2 emissions (Prasara-A & Bridhikitti, 2022). RAP reduces emissions and costs, but feasibility must be evaluated.

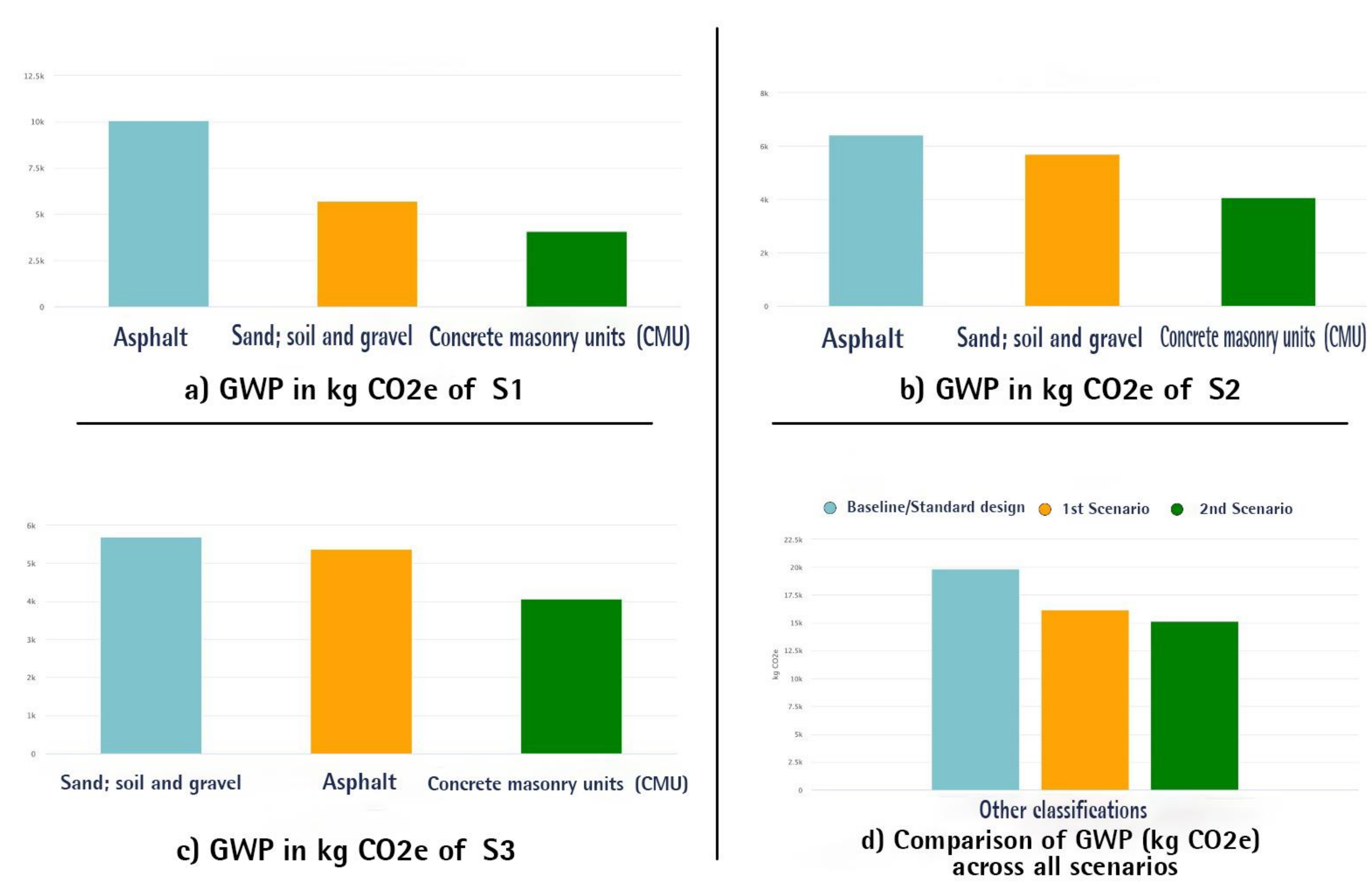
This study assesses the GWP of asphalt with 20% and 40% RAP. A life cycle assessment (LCA) found 40% RAP had the lowest GWP. Bike lanes can support higher RAP use due to lower traffic loads, improving sustainability. LCA integration aids eco-friendly infrastructure decisions (Plati et al., 2023).

MATERIALS, METHODS & IMPLEMENTATION

Study Objective: Assess the environmental impact of using RAP in bicycle road construction through LCA.
Scenarios Analyzed: Standard asphalt concrete (AC) vs. AC with 20% and 40% RAP.
Software & Standards: OneClick-LCA software, EN 15804 standards.
Data Source: Laboratory data and pavement density calculations (AASHTO T-209).
Functional Unit: 1 km of a 2.0 m-wide bicycle pavement, 10-year analysis period, no maintenance.
System Boundary: Cradle-to-gate, focusing on material production only (excluding construction, use, and end-of-life).
Impact Assessment: Environmental Product Declarations (EPDs) for material impact quantification.
CML Baseline method used.
Global Warming Potential (GWP) as the primary indicator.
Key Outcome: RAP reduces emissions while maintaining performance, promoting sustainable pavement design.







a) GWP in kg CO2e of S1

b) GWP in kg CO2e of S2

c) GWP in kg CO2e of S3

d) Comparison of GWP (kg CO2e) across all scenarios

RESULTS

Impact of RAP on Global Warming Potential (GWP)
Key Finding: Increasing RAP content in asphalt significantly reduces GWP, supporting sustainable pavement construction.
Scenario Analysis & Results:
- Scenario 1 (0% RAP - Conventional AC):
- GWP: 1.9334E+04 kg CO2e
- High environmental impact due to reliance on virgin materials (aggregates and bitumen).

- Scenario 2 (20% RAP):
- GWP: 1.5655E+04 kg CO2e
- Reduced emissions due to decreased raw material extraction, transportation, and processing.

- Scenario 3 (40% RAP):
- GWP: 1.4594E+04 kg CO2e
- Further reduction in carbon footprint, reinforcing the benefits of RAP for sustainability.

Overall trend:
- Higher RAP content consistently lowers GWP.
- Using recycled materials in asphalt pavements is an effective strategy to cut CO2 emissions.
- Promotes sustainable road infrastructure by reducing dependence on virgin materials.

CONCLUSION & IMPLEMENTATION PATH

This study highlights key findings:
- RAP lowers GWP, especially in the product stage.
- Higher RAP yields diminishing returns in GWP reduction.
- Enhances sustainability, replacing raw materials in asphalt.
- Supports eco-friendly bicycle roads.
- Limited scope: Only material production was analyzed.
- Further research needed on full pavement lifecycle impacts.

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