Life cycle assessment and other demands on streets

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Traditional requirements for pavements

- Public
  - Safety
  - Functionality
    - Smooth
    - Not distorted or cracked
- Owner
  - Lowest initial cost
  - Contractor and owner expertise sufficient to bid and adequately manage

New requirements for pavement

- State agencies
  - Safety, functionality, low initial cost, contractor and owner expertise
  - Low life cycle cost
  - Noise
- State and local agencies
  - Maintainability
  - Traffic control and congestion
  - Right of way for stormwater handling
  - Environmental impact considerations

Pavement Life Cycle Assessment

Comparisons between permeable pavement vs conventional pavement + other stormwater handling

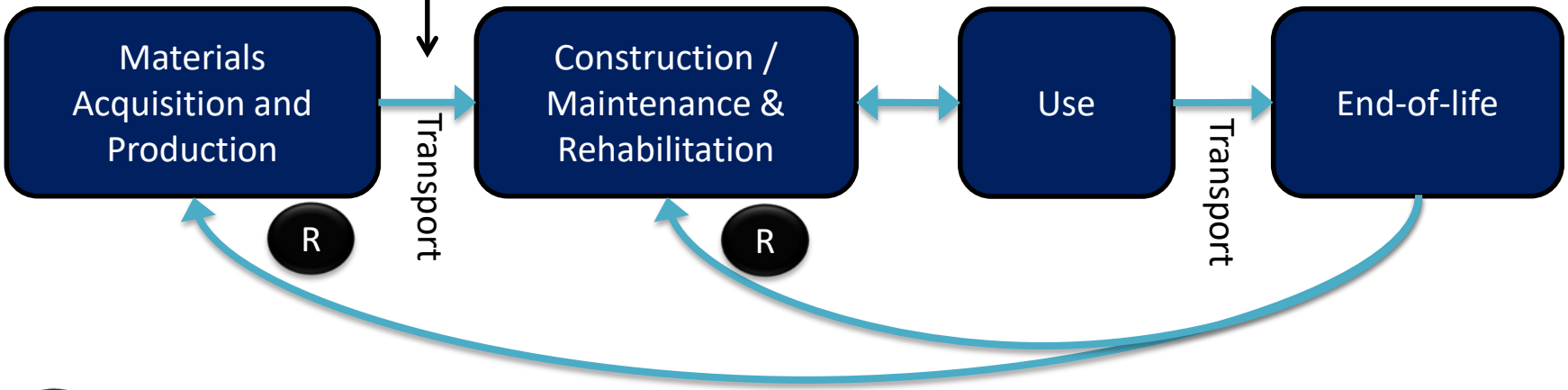
- Design of materials and pavement

- Pavement performance
- Rolling resistance
- Safety
- Stormwater
- Noise
- Thermal

- Material extraction and production

- Equipment Use
- Transport
- Traffic delay

- Recycle
- Landfill



From: Kendall et al., *2010*

Four Key Life Steps of Life Cycle Assessment

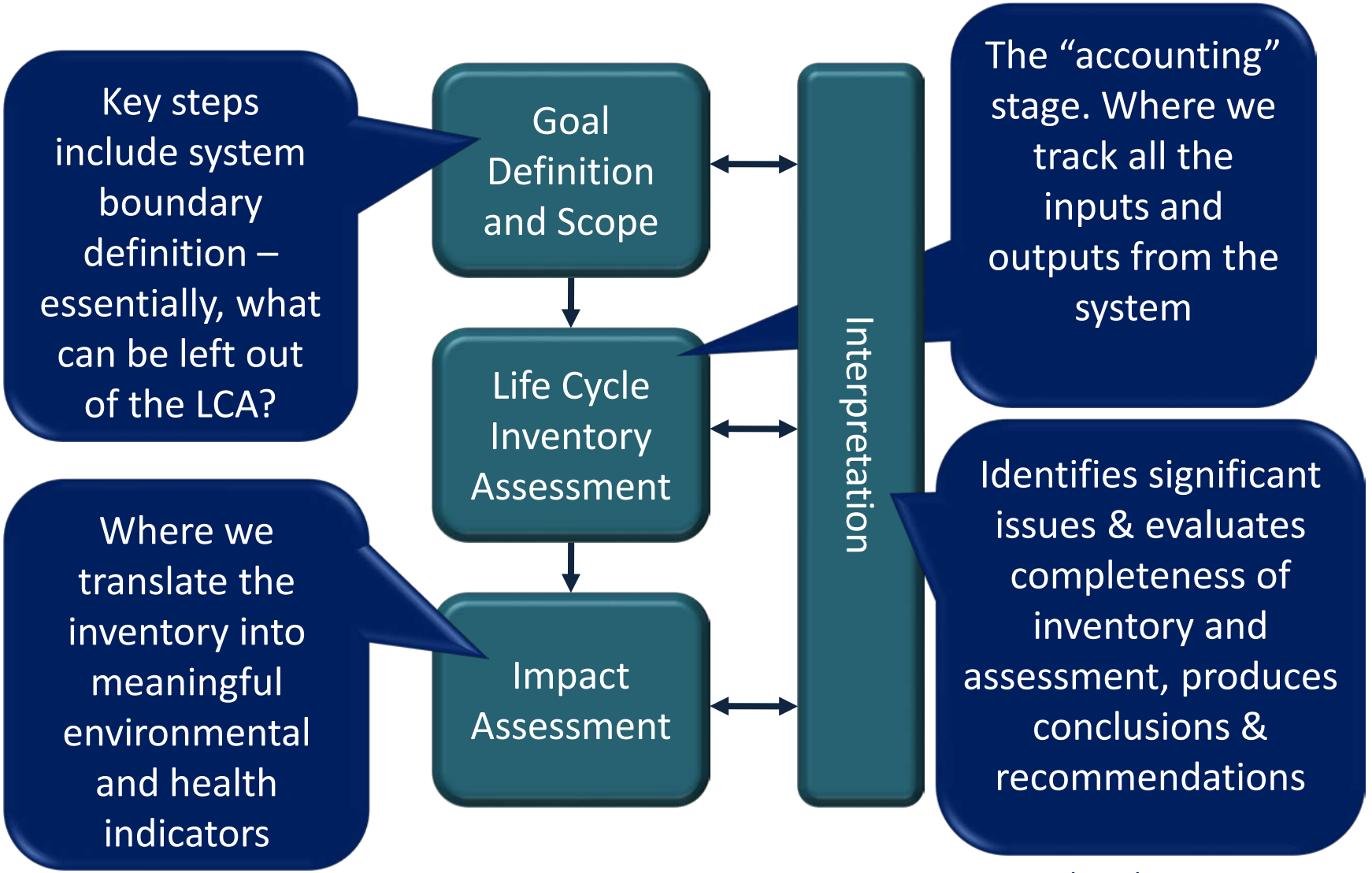
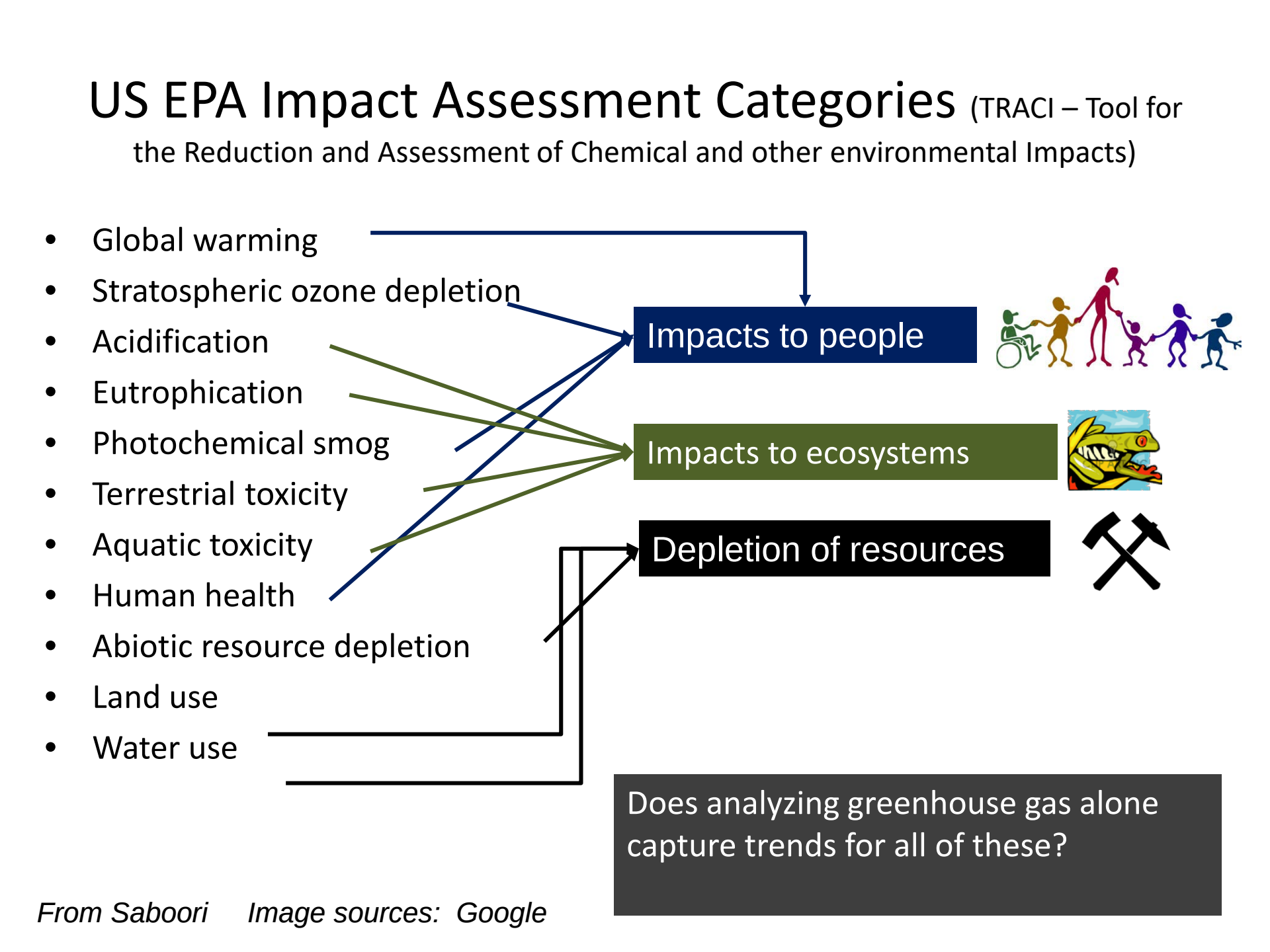


Figure based on ISO 14040

US EPA Impact Assessment Categories (TRACI – Tool for the Reduction and Assessment of Chemical and other environmental Impacts)

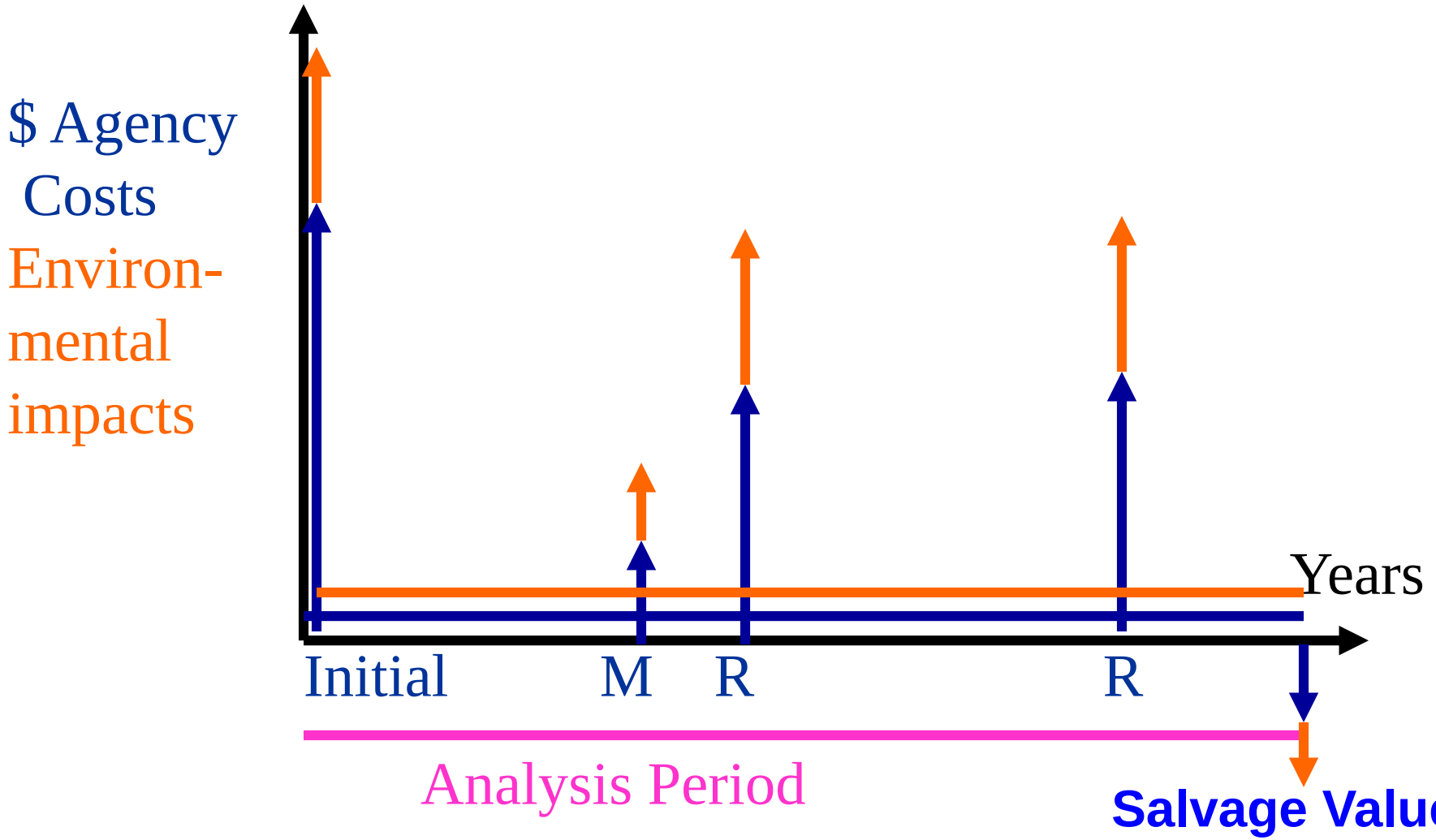
- Global warming
- Stratospheric ozone depletion
- Acidification
- Eutrophication
- Photochemical smog
- Terrestrial toxicity
- Aquatic toxicity
- Human health
- Abiotic resource depletion
- Land use
- Water use



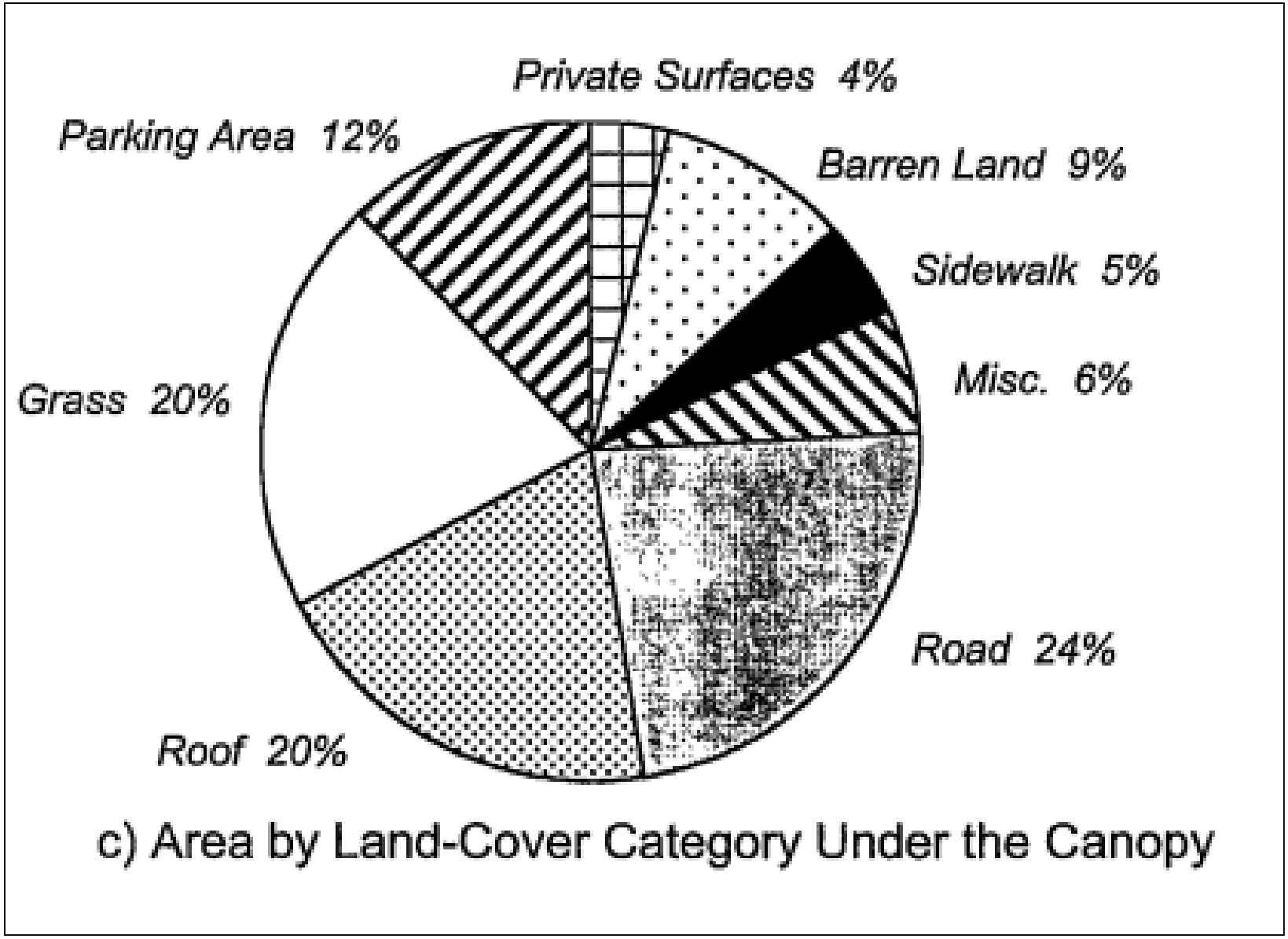
Does analyzing greenhouse gas alone capture trends for all of these?

From Saboori Image sources: Google

Need life cycles for permeable pavement to compare with conventional pavement + stormwater handling for both Life Cycle Cost Analysis and Life Cycle Assessment



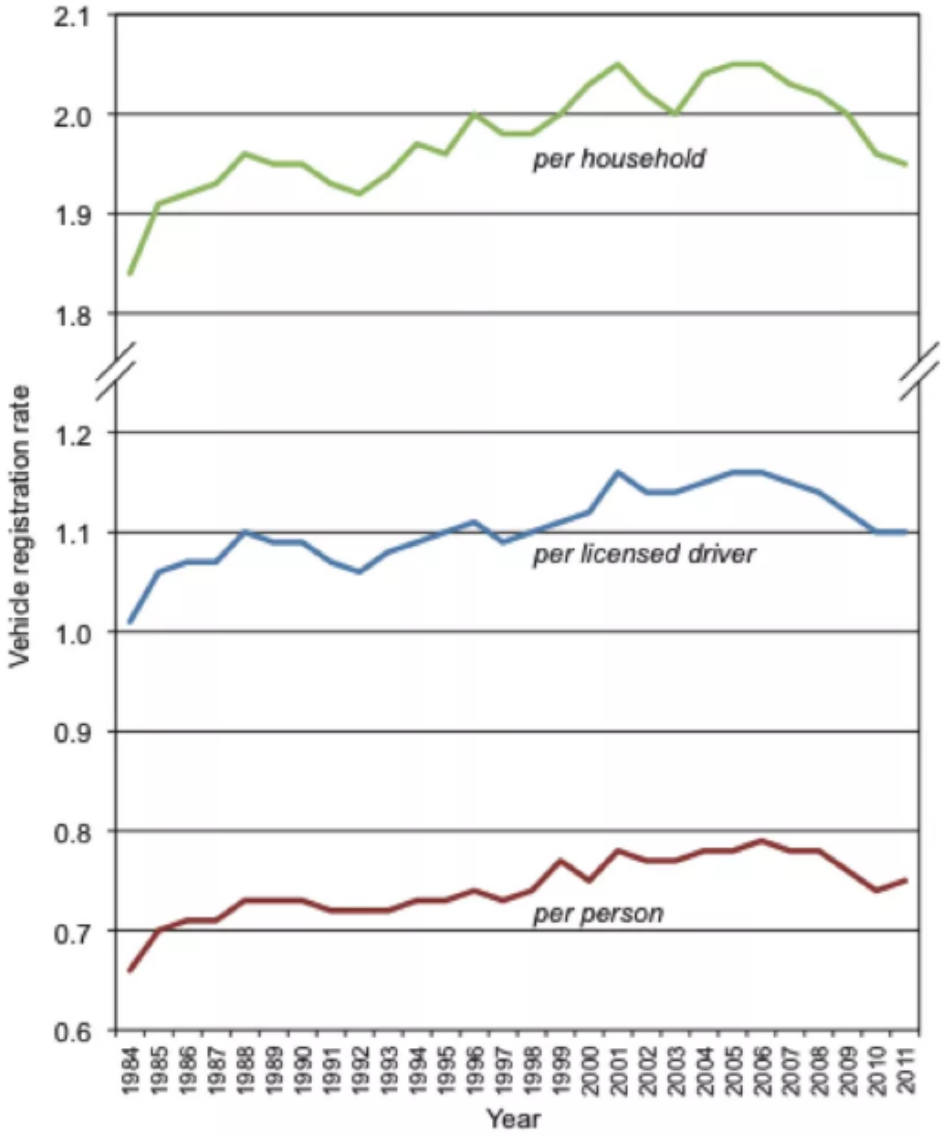
And a little further in the future?



Sacramento (Akbari, Rose, Taha, 1999)

Shared vehicles and pavement for parking

- What percentage of time are vehicles moving vs parked?
- What percentage of land area is paved for parking?
- Will number of vehicles be reduced with shared vehicles and more active transportation?



Any way you cut it, Americans have fewer cars than they used to. Image: Michael Sivak, ##http://deepblue.lib.umich.edu/bitstream/handle/2027.42/98098/102947.pdf##UMTRI##

Issues with current approach to urban pavement

- Active transportation
  - Street geometric and surface designs generally don't consider it
  - Bike path and trails are scaled down highway pavement designs
- Urban forests
  - Impermeability
  - Pavement and root growth
- Noise
  - Tire pavement noise at higher speeds
  - Non-absorptive for noise

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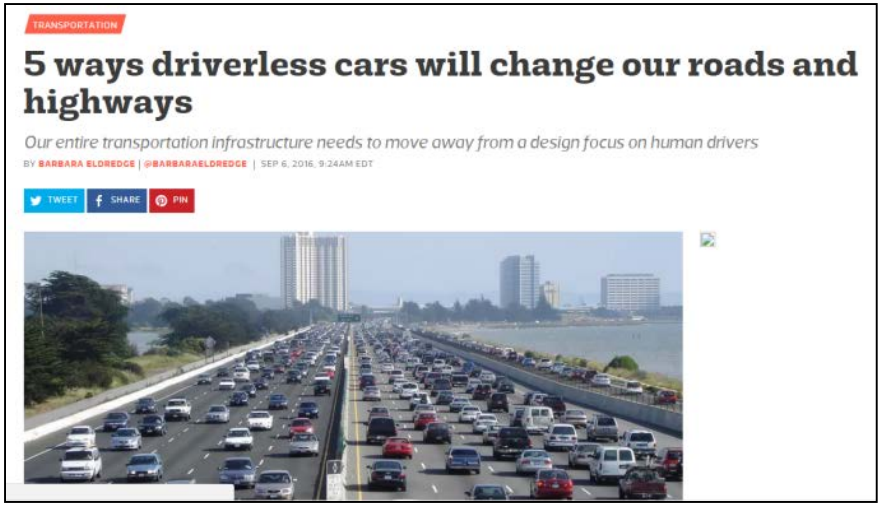
Autonomous Vehicle Technology

- Automated Vehicles Symposium2017
  - One presentation that mentions infrastructure
- Infrastructure focus on detection and guidance, not pavement condition
- Will cause increase in car travel?

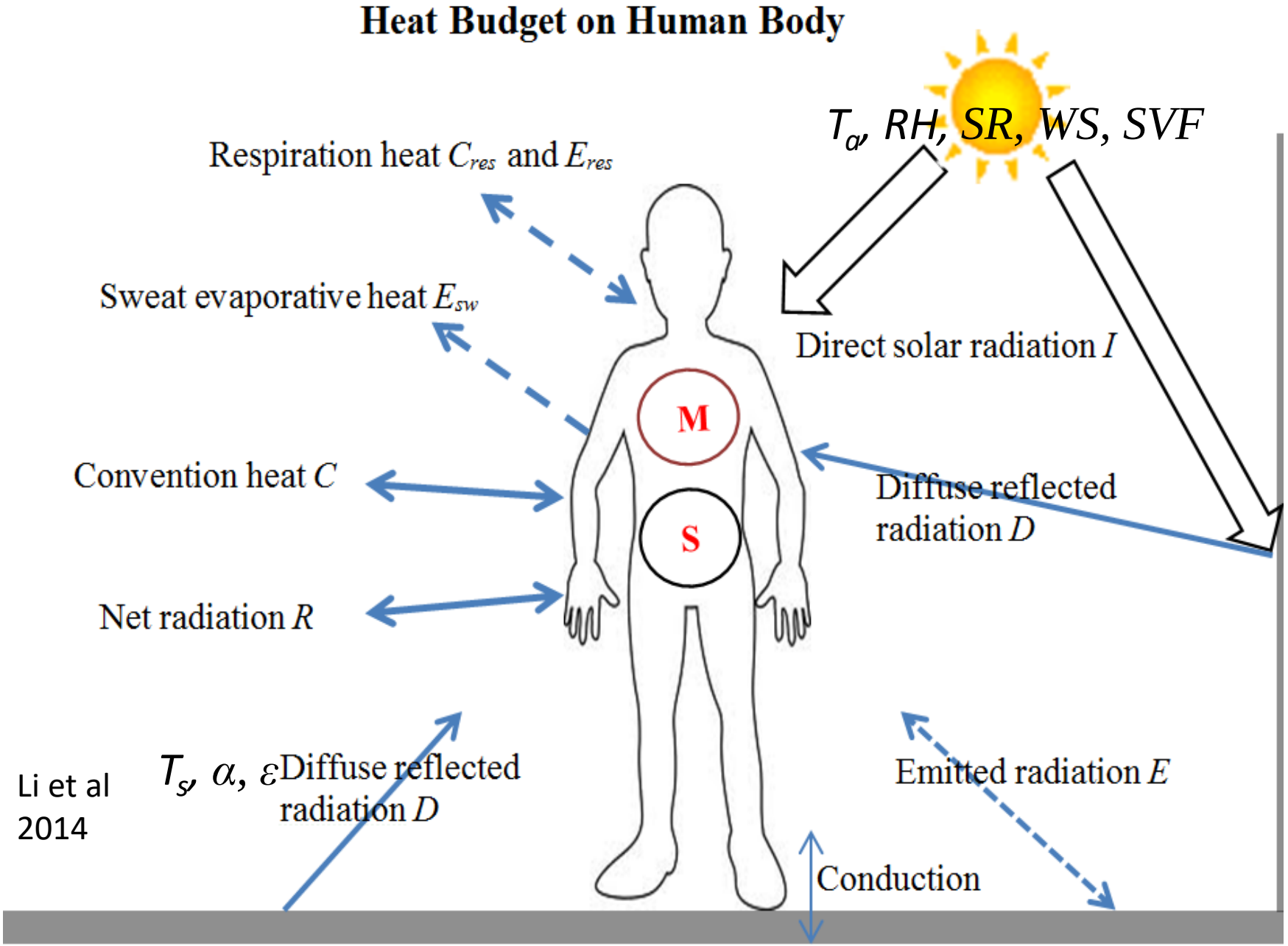


Climate change effects on precipitation events

- California (http://www.water.ca.gov/climatechange/docs/dwr_extremes_wkshop_jan2012-MikeDettinger131.pdf)
  - General increase in rainfall, less snow
  - Potentially more atmospheric river events, same intensity
- National
  - Increases in rainfall (particularly northeast US)
  - More extreme rainfall events

Climate change effects on urban heat

- California
  (http://www.water.ca.gov/climatechange/docs/CA_Climate_Science_and_Data_Final_Release_June_2015.pdf)
  - Future projections of temperatures across California by Scripps Institution of Oceanography indicate that by 2060-2069 mean temperatures will be 3.4 to 4.9 °F higher across the state than they were in the period 1985-94. Seasonal trends indicate a greater increase in the summer months (4.1 to 6.5 °F) than in winter months (2.7 to 3.6 °F) by 2060-2069.



Li et al 2014

M is the metabolic rate (W/m^2). *W* is the rate of mechanical work (W/m^2). *S* (W/m^2) is the total storage heat flow in the body.

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