# Measuring Transport Sustainability and Resilience


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CRICOS No. 00213J

# Research Motivation

How can we achieve Transport Sustainability and Resilience if we don't know what it is?

We can only monitor what we can measure.

What things do we need to measure?

Can we combine them into a single metric?

# Presentation aims

- Current definitions of sustainability/resilience
- Identify major factors that may serve as indicators of sustainability/resilience
- Discuss some key challenges
- Propose how a single metric might be applied

# Current Definitions

# Sustainability/resilience

# Sustainability definitions are ‘all over the map’ (In US especially)

Some excerpts..

- “...ensuing a fast, safe, efficient, accessible and convenient transportation” (USDOT)
- “...safe, efficient, balanced and environmentally sound transportation system” (New York DOT)
- “...improve the environmental performance of Australian Government departments and agencies, by providing advice, communication networks, and access to best practice environmental management techniques from around the world.” (Australian Government, SEWPC)

# Definitions elsewhere are becoming more advanced.....or ‘state of the practice’

Canada (STPI Project)..

- “The impacts [of transport] are so low they no longer provide reason for concern about people’s health or any part of the natural environment, in the present or the future. In particular, emissions of carbon dioxide and other greenhouse gases from transportation are less than one fifth of the total of such emissions in the 1990s.”

# The Canadian STPI further stipulates:

A sustainable transportation system is one that:

- Allows the basic access needs of individuals to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources*, limits consumption of renewable resources* to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise

# Major Sustainability Factors

# There are numerous categories of indicators used in Sustainability Metrics:

- Economic
- Transport related
- Environmental
- Safety Oriented
- Social/Cultural Equity

# Economic Metrics.... (from Amekudzi et al.)

| | US DOT | US EPA | Trans Canada | EC[2] | NRTEE[4] | ORTEE[5] | TAC[6] | VTPI[7] | CST[8] | OECD | World Bank | PROS PECTS[9] | EEA[10] | Baltic | UK | New Zealand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Economic* | | | | | | | | | | | | | | | | |
| Population density (persons/ha) | | | | | | ■ | ■ | | | | | | | | | ■ |
| Economic efficiency | | | | | | ■ | | | | | | ■ | | | | |
| Employment | | | | | | ■ | ■ | | | | | | | | | |
| Accessibility measures | | | | | | | | | | | | ■ | | | | |
| Public expenditure | | | | | | | | | | | | ■ | | | | |
| Growth potential | | | | | | | | | | | | ■ | | | | |
| Green GDP | | | | | | ■ | | | | | | | | | | |
| GDP per unit of energy use | | | | | | | | | | | ■ | | | | | |
| Tax revenues | | | | | | ■ | | | | | | | | | | |
| Implementation of internalisation instruments | | | | | | | | | | | | | ■ | | | |
| Employment-to-population ratio in Central area | | | | | | | ■ | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

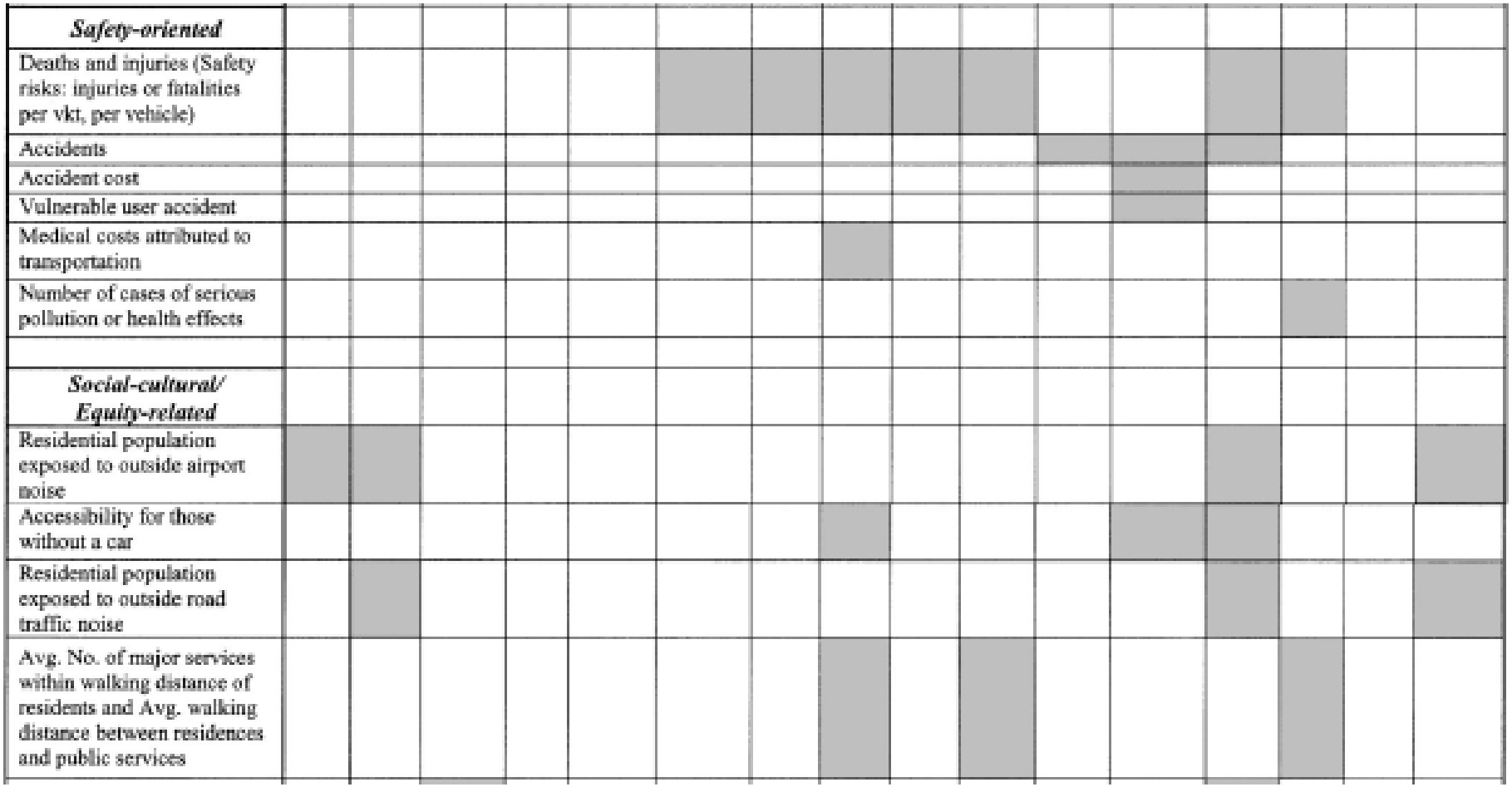
# Transport Related Metrics (continued)

| *Transportation-related* | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length of railways and main roads, Parking facility | | | | | | | | ■ | ■ | ■ | | | | ■ | ■ | ■ |
| Passenger-kilometres (by mode, purpose) | | | | ■ | | | | | ■ | | ■ | | ■ | | ■ | ■ |
| Freight tonne-kilometres (by mode, purpose) | | | | | | | | | ■ | | ■ | | ■ | | ■ | ■ |
| Total kilometres driven(VMT) | | | | ■ | ■ | | ■ | | ■ | | | | | | | ■ |
| Unit sales of cars/trucks (Auto Use per capita) | | | | | ■ | | | | | ■ | ■ | | | ■ | | |
| ∑ Traffic volumes of road, rail, air, sea (vehicle-kilometres) | | | | | | | | | ■ | | ■ | | | ■ | | |
| Public transit and automobile use | | | | ■ | | | ■ | ■ | | | | | | | | |
| Avg. home-work trip distance/time (by purpose) | | | | | | | ■ | | | ■ | | | ■ | | | |
| Portion of transportation-related costs paid by public funding (Subsidy) | | | | | | | | ■ | | ■ | | | ■ | | | |
| ∑ Total passenger and cargo turnover by air, ship, road, rail; mode shifts | | | | | | | | | | | ■ | | | ■ | | |
| Per-capita gas consumption vs. urban density | | | | | ■ | | ■ | | | | | | | | | |
| Mixed land use | | | | | | ■ | | ■ | | | | | | | | |
| Average. portion of Household transportation expenditures | | | | | | | | ■ | ■ | | | | | | | |
| Length of public transport network | | | | | | | | | | ■ | | | | ■ | | |
| Extent and density of transport Infrastructure | | | | | | | | | | ■ | ■ | | | | | |
| Land Area Occupied by Roadways/Transportation Infrastructure | | ■ | | | | | | | | | | | ■ | | | |
| (Morning peak) Auto occupancy to/from CBD | | | | | | | ■ | | | | | | ■ | | | |

# Environmental Metrics (continued)

| *Environmental* | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO2 emissions (by mode) | | | | | | | | | | | | | | | | |
| Greenhouse gas emissions | | | | | | | | | | | | | | | | |
| Fossil fuel consumption | | | | | | | | | | | | | | | | |
| Per-capita use of transportation energy | | | | | | | | | | | | | | | | |
| Emissions of air pollutants (from Transportation Vehicle and Equipment Manufacturing) | | | | | | | | | | | | | | | | |
| NOX emissions (by mode) | | | | | | | | | | | | | | | | |
| VOCs emissions | | | | | | | | | | | | | | | | |
| Main land use/Urban land use | | | | | | | | | | | | | | | | |
| Fossil fuel use by auto | | | | | | | | | | | | | | | | |
| Waste/Recycling | | | | | | | | | | | | | | | | |
| CO emissions | | | | | | | | | | | | | | | | |
| Emission intensity | | | | | | | | | | | | | | | | |
| Noise level/cost | | | | | | | | | | | | | | | | |
| Green area | | | | | | | | | | | | | | | | |
| Toxic substances in urban air: benzene/ozone | | | | | | | | | | | | | | | | |
| Fuel efficiency of new auto | | | | | | | | | | | | | | | | |
| E-index (Per capita energy consumption) | | | | | | | | | | | | | | | | |
| Non-fossil fuel use (Alternative fuel) | | | | | | | | | | | | | | | | |
| Wetland losses and creation | | | | | | | | | | | | | | | | |
| Hazardous materials incidents | | | | | | | | | | | | | | | | |
| Maritime Oil spills | | | | | | | | | | | | | | | | |
| Overall energy efficiency for passenger and freight transport | | | | | | | | | | | | | | | | |
| CO2 cost[11] | | | | | | | | | | | | | | | | |
| SO2 emissions | | | | | | | | | | | | | | | | |
| CH4 emissions | | | | | | | | | | | | | | | | |
| Black smoke emissions | | | | | | | | | | | | | | | | |
| Lead emissions | | | | | | | | | | | | | | | | |
| Air pollution cost | | | | | | | | | | | | | | | | |
| Chlorofluorocarbons and stratospheric ozone depletion | | | | | | | | | | | | | | | | |

# Safety and Social Metrics



# Key challenges

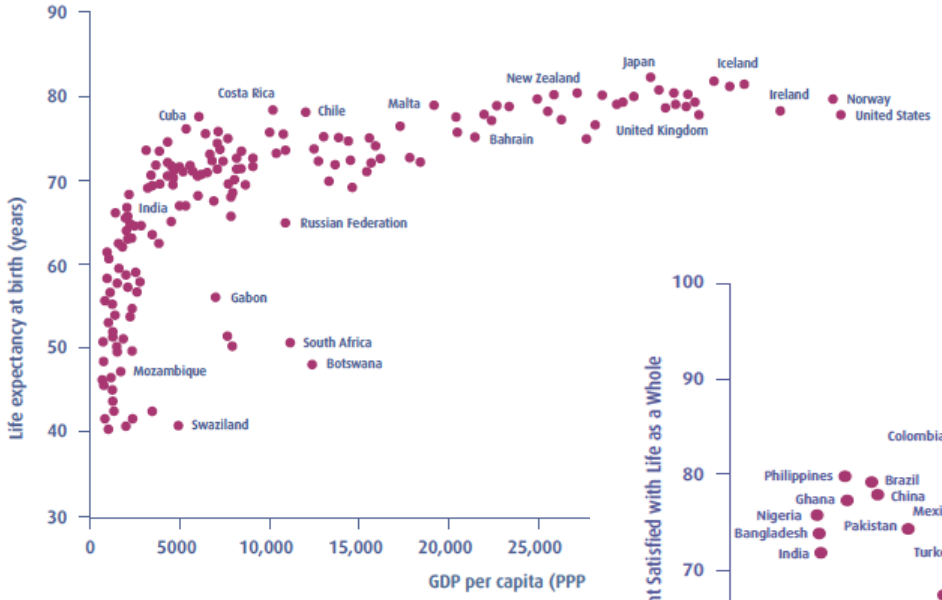
# Key challenges we must face.....

- Transport demand is a function of generalized cost of alternatives facing a traveller
- It is unclear if ANY economic model based on growth can be consistent with sustainability principles (one is expansion the other static)
- Some externalities are regional while others are global

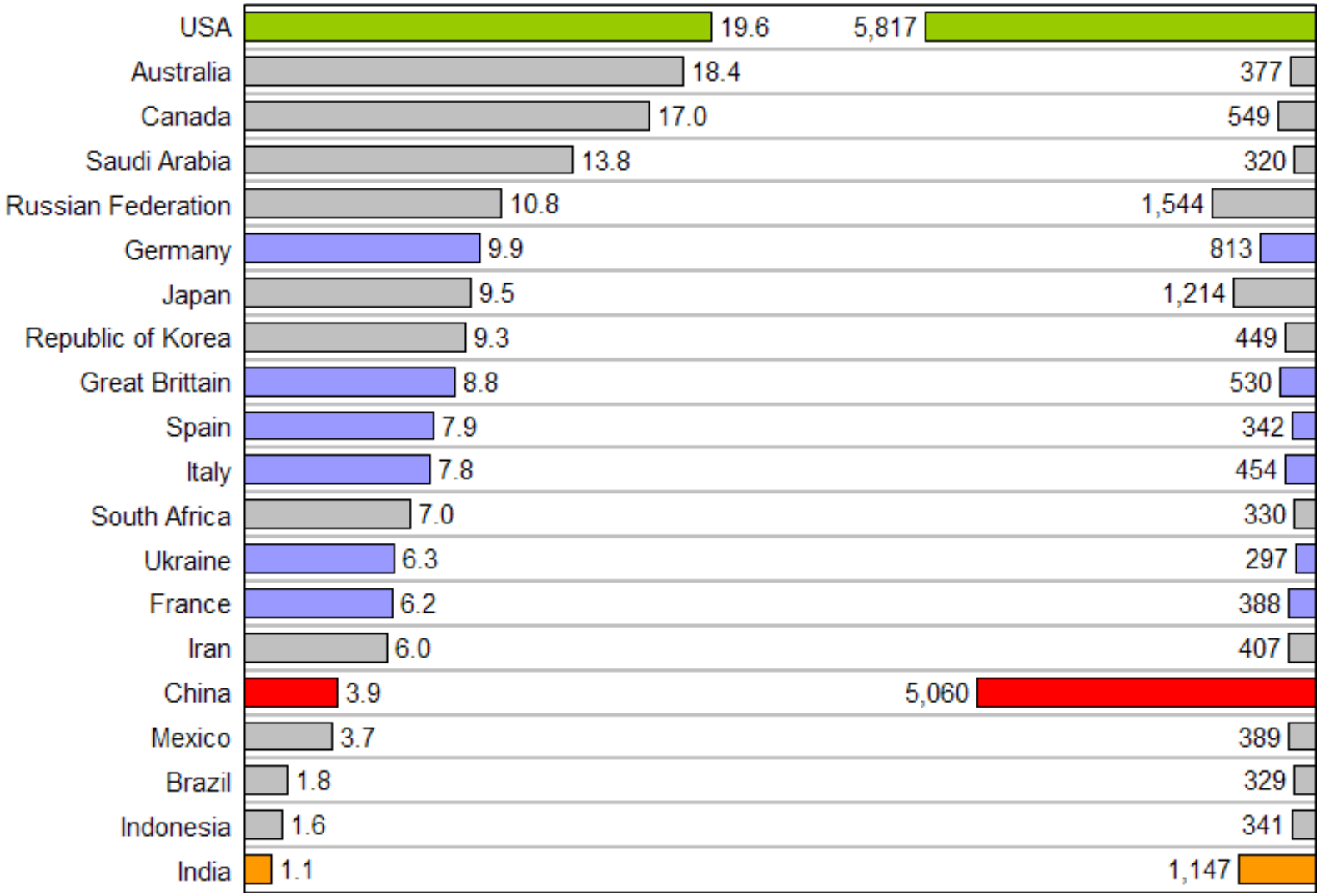
# Economic Models

- Economic models based on growth (most/all are) are inconsistent with sustainability principles
- Growth is geometric; Sustainability is static
- The US is on the “verge of economic collapse” because growth is near to zero.....
- We can’t manage the existing human load on the planet, let alone growth
- Much work is needed understanding a steady state economy

# Consider quality of life metrics




# Per capita and total CO2 emissions in Mtons



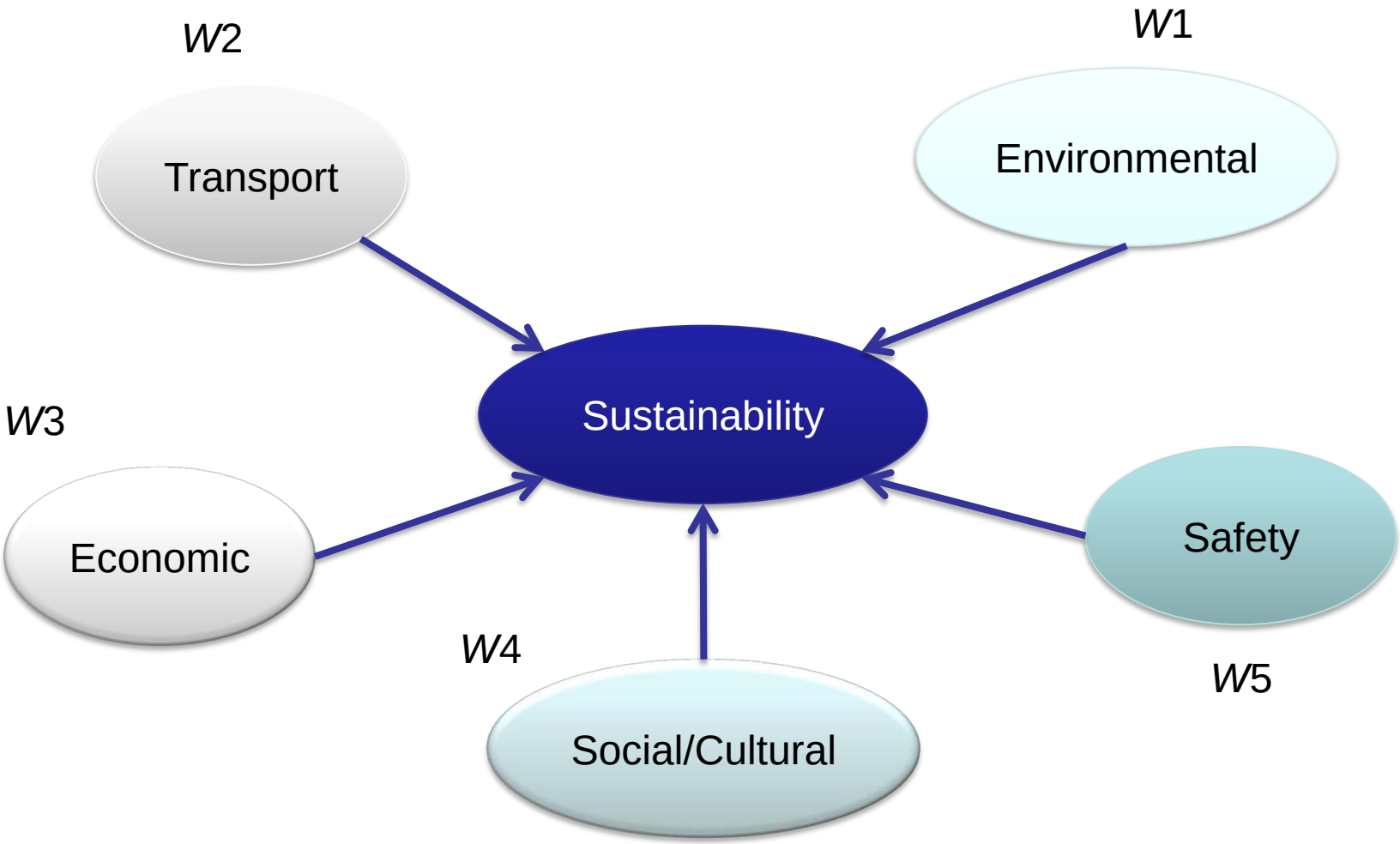
# Sustainability: Is a single metric possible?

# With so many potential metrics, how can “we” measure Sustainability—a singular and static concept?

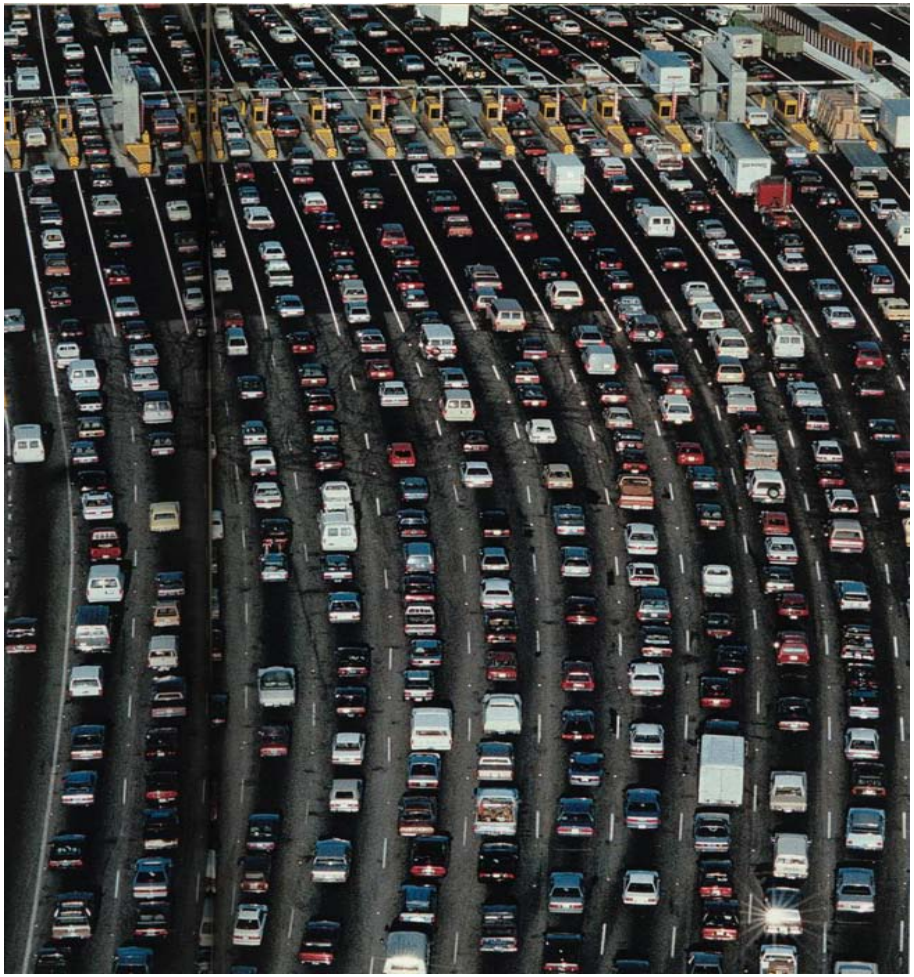
- We need to ‘widow’ down the list to a set of ‘core’ metrics
- We can do this by recognizing the latent construct underlying many of the metrics (a powerful statistical construct)
- We can implement a weighting equation calibrated to reflect regional/national priorities and challenges

$\Sigma W = 1$

# How is this done?



# Conclusions

# Conclusions

- The way forward is muddied by the lack of a single metric and vague sustainability policies
- Growing economies and sustainability are at direct odds with one another
- Viable economic models of “no growth” are needed
- Some metrics, particular air quality and global warming, will require global metrics that put downward pressures on developed countries
- A single metric is possible and desirable

# Next steps.....

- Develop and test a single Sustainability metric across urban regions, and benchmark
- Engage the broader community and research on important links between economies and sustainability
- Understand the role of (generalized) transport costs and fee structures in sustainability


# Thank You