Can A City Be Sustainable?

STATE OF THE WORLD
GARY GARDNER
WORLDWATCH INSTITUTE
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Today’s Agenda

- An Urban World
- The Historic Perspective: What Does it Teach Us?
- The City: A System of Systems
- Toward a Vision of a Sustainable City
An Urban World

- The World: 54 percent urban today

- Urban Population has grown 5-fold:
  - From 0.7 billion in 1950
  - To 3.9 billion in 2014

- In 2050, the urban share of global population is expected to be 60 percent
Urban Share of Population, by Region

- Africa
- Asia
- WORLD
- Oceania
- Europe
- Latin Am.
- Northern Am.
Megacities

- Greater than 10 million population
- Rapid growth in megacities
  - 1950: 2 megacities
  - 2016: 29
  - 2030: 41
- But ...
  - Almost half of urbanites live in cities of less than 500,000 persons
Many Cities are Decreasing in Density

<table>
<thead>
<tr>
<th></th>
<th>Projected Increase by 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Built-up Area (%)</td>
</tr>
<tr>
<td>Developing country cities</td>
<td>200</td>
</tr>
<tr>
<td>Industrial country cities</td>
<td>150</td>
</tr>
</tbody>
</table>
Cities as Economic Engines

- 80 percent of the global gross domestic product (GDP) is produced in cities.

- 60 percent is produced in the 600 most productive cities, where one-fifth of the world’s population now lives.

- Urban economic activity accounts for
  - up to 55 percent of gross national product (GNP) in low-income countries,
  - 73 percent in middle-income countries, and
  - 85 percent in high-income countries.

- Cities generate a disproportionate amount of revenue for governments.
Urban Consumption and Waste

- Cities account for
  - 60–80 percent of energy consumption
  - more than 75 percent of natural resource consumption, and
  - 75 percent of the world’s carbon emissions

- 1.3 billion tons of Municipal Solid Waste (MSW) is generated globally each year

- MSW is the third largest source of human-caused methane emissions
Consumption in Cities

- Consumption in the lowest- and highest-consuming megacities differs by a factor of:
  - 28 in energy per capita
  - 23 in water per capita
  - 19 in waste production per capita
  - 35 in total steel consumption,
  - 6 in total cement consumption.
The Poor in Cities

- 1 in 7 urban dwellers live in poverty
- Slum residents:
  - 863 million in 2012
  - 650 million in 1990
- But the share living in slums fell, from 46 percent to 33 percent.
- 10 percent of urban population of developing countries lacks access to electricity
- 18 percent uses wood, dung, or charcoal for cooking
Summary

- We are now an urban species
- Big cities are growing fast, but most urbanites are in small cities
- Many cities are becoming less dense—a real challenge for sustainability
- Cities are economic engines
- Cities are centers of consumption, another challenge for sustainability
- Inequality and poverty remain key problems—yet another challenge for sustainability
Cities in the Arc of Human History
Sociometabolic regimes in human history

Homo sapiens sapiens
- use of fire
- language

agriculture, pastoralism
- CITIES
- scripture

fossil fuel use
- steam engine

hunter gatherers

agrarian mode

Industrial mode

log years BP
- 100,000
- 10,000
- 1,000
- 100
- 10
## Materials Appetite of Hunter-Gatherers

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Hunter-Gatherers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use per person (gigajoules per person per year)</td>
<td>10-20</td>
</tr>
<tr>
<td>Materials use per person (tons per person per year)</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Population Density (people per km²)</td>
<td>0.025 – 0.115</td>
</tr>
<tr>
<td>Agricultural Population (percent)</td>
<td>--</td>
</tr>
<tr>
<td>Biomass share of energy use (percent)</td>
<td>More than 99</td>
</tr>
</tbody>
</table>
# Materials Appetite of Agrarian Society

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Hunter-Gatherers</th>
<th>Agrarian Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use per person (gigajoules per person per year)</td>
<td>10-20</td>
<td>40-70</td>
</tr>
<tr>
<td>Materials use per person (tons per person per year)</td>
<td>0.5-1</td>
<td>3-6</td>
</tr>
<tr>
<td>Population Density (people per km²)</td>
<td>0.025 – 0.115</td>
<td>Up to 40</td>
</tr>
<tr>
<td>Agricultural Population (percent)</td>
<td>--</td>
<td>More than 80</td>
</tr>
<tr>
<td>Biomass share of energy use (percent)</td>
<td>More than 99</td>
<td>More than 95</td>
</tr>
</tbody>
</table>
## Materials Appetite of Industrial Society

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Hunter-Gatherers</th>
<th>Agrarian Society</th>
<th>Industrial Society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy use per person</td>
<td>10-20</td>
<td>40-70</td>
<td>150-400</td>
</tr>
<tr>
<td>(gigajoules per person per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials use per person</td>
<td>0.5-1</td>
<td>3-6</td>
<td>15-25</td>
</tr>
<tr>
<td>(tons per person per year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population Density</td>
<td>0.025 – 0.115</td>
<td>Up to 40</td>
<td>Up to 400</td>
</tr>
<tr>
<td>(people per km2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Population</td>
<td>--</td>
<td>More than 80</td>
<td>Less than 10</td>
</tr>
<tr>
<td>(percent)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass share of energy use</td>
<td>More than 99</td>
<td>More than 95</td>
<td>10-30</td>
</tr>
<tr>
<td>(percent)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Maximum City Size By Regime

<table>
<thead>
<tr>
<th>Mode of Subsistence</th>
<th>Maximum City Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Agrarian State</td>
<td>10,000</td>
</tr>
<tr>
<td>Agrarian State</td>
<td>100,000</td>
</tr>
<tr>
<td>Agrarian Empire</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Industrial Societies</td>
<td>25,000,000 or more?</td>
</tr>
</tbody>
</table>
## Population, Affluence, Technology Over History

<table>
<thead>
<tr>
<th>Period</th>
<th>Increase in Environmental Impact</th>
<th>Of Which</th>
</tr>
</thead>
<tbody>
<tr>
<td>1AD to 1500AD</td>
<td>5-fold</td>
<td>Population and Affluence were roughly equally responsible</td>
</tr>
<tr>
<td>1500AD to present</td>
<td>10-fold</td>
<td>Affluence is responsible for about 3 times more impact than population growth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology increased impact by a factor of 1.5</td>
</tr>
</tbody>
</table>
The City: A System of Systems
Land Use and Transportation

- Huge shaper of the look, feel, and sustainability of a city
- Density matters
- Sprawl a problem
- Car-centric planning is a major problem
Land Use: Smart and Not-so-Smart

ATLANTA
- Urban area: 7,692 km²
- Population: 5.3 million
- Transport carbon emissions p.c: 6.9 tonnes

BARCELONA
- Urban area: 648 km²
- Population: 5 million
- Transport carbon emissions p.c: 1.16 tonnes
“Loops and Lollipops”
Sprawl: $1 trillion per year in U.S.
Transport-related energy consumption
Gigajoules per capita per year

Urban density and transport-related energy consumption

Source: Newman et Kenworthy, 1989;

North American cities
Australian cities
European cities
Asian cities
## Material Use Patterns in Urban Development

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Examples</th>
<th>Increase with doubling of population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>sewer lines, power lines, roads</td>
<td>85</td>
</tr>
<tr>
<td>Human Needs</td>
<td>employment, water consumption, electricity consumption, and housing</td>
<td>100</td>
</tr>
<tr>
<td>Socioeconomic measures</td>
<td>information, innovation, and wealth, but also serious crime and disease</td>
<td>115</td>
</tr>
</tbody>
</table>
# Cities Stimulate Energy Use

<table>
<thead>
<tr>
<th>Region</th>
<th>GDP per Capita</th>
<th>Urban Share of Population</th>
<th>Estimated Urban Energy Use per Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>42,893</td>
<td>80</td>
<td>235</td>
</tr>
<tr>
<td>Pacific OECD</td>
<td>35,480</td>
<td>86</td>
<td>107</td>
</tr>
<tr>
<td>Western Europe</td>
<td>31,217</td>
<td>74</td>
<td>114</td>
</tr>
<tr>
<td>Latin America</td>
<td>4,973</td>
<td>77</td>
<td>40</td>
</tr>
<tr>
<td>North Af. &amp; Middle East</td>
<td>4,384</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>3,566</td>
<td>64</td>
<td>112</td>
</tr>
<tr>
<td>China &amp; Centrally Planned Asia</td>
<td>1,738</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>907</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>South Asia</td>
<td>703</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>WORLD</td>
<td></td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>
Energy Use by Urban Sector

- Transportation
- Industrial
- Commercial
- Residential
## Domestic Material Consumption per Person

<table>
<thead>
<tr>
<th>Region</th>
<th>1980</th>
<th>2009</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tons per person</td>
<td>percent</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>5.0</td>
<td>4.8</td>
<td>-4.5</td>
</tr>
<tr>
<td>Asia</td>
<td>4.9</td>
<td>9.2</td>
<td>87.2</td>
</tr>
<tr>
<td>Europe</td>
<td>16.3</td>
<td>13.0</td>
<td>-19.8</td>
</tr>
<tr>
<td>Latin America</td>
<td>10.6</td>
<td>13.1</td>
<td>23.4</td>
</tr>
<tr>
<td>North America</td>
<td>24.8</td>
<td>20.1</td>
<td>-18.9</td>
</tr>
<tr>
<td>Oceania</td>
<td>34.6</td>
<td>35.6</td>
<td>-2.9</td>
</tr>
<tr>
<td><strong>WORLD</strong></td>
<td><strong>7.9</strong></td>
<td><strong>9.9</strong></td>
<td><strong>25.4</strong></td>
</tr>
</tbody>
</table>
Varying Levels of Consumption

- But global averages obscure:
  - per capita consumption is 60 times higher in the highest-consuming country than in the lowest-consuming one

  - Taipei: 30 kilos of copper per person
    - consumption growing at 26 percent per year,
  - Vienna: 180 kilos per person,
    - Growing at 2 percent per year.
<table>
<thead>
<tr>
<th>Region</th>
<th>Waste generation per person (kilos / person / day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Asia</td>
<td>0.45</td>
</tr>
<tr>
<td>Africa</td>
<td>0.65</td>
</tr>
<tr>
<td>East Asia and Pacific</td>
<td>0.95</td>
</tr>
<tr>
<td>Europe and Central Asia</td>
<td>1.1</td>
</tr>
<tr>
<td>Latin America and Caribbean</td>
<td>1.1</td>
</tr>
<tr>
<td>Middle East and North Africa</td>
<td>1.1</td>
</tr>
<tr>
<td>OECD</td>
<td>2.2</td>
</tr>
</tbody>
</table>
More Waste to Come

- World Bank: waste levels will increase 69 percent by 2025 over 2012 levels.
- Peak in global waste:
  - under BAU conditions, not before 2100.
  - with more aggressive policies, around 2075.
- Wild card: how waste generation unfolds in sub-Saharan Africa, where population growth rates are high
Insufficient Recycling

- 2011 UNEP study of 60 metals
  - only 18 had a recycling rate greater than 50 percent.

- Recovery rates from MSW streams:
  - Eastern and southeastern Europe, less than 30 percent
  - United States, about a third
  - Austria, Belgium, Germany, 50 percent

- Lack of legal, institutional, and market infrastructure keeps recycling rates low
Increasingly Complex Food Systems

- In Argentina, Brazil, Chile, South Korea and Taiwan, supermarkets’ share of food sales have grown:
  - from 10–20 percent in 1990
  - to 50–60 percent in the early 2000s.
- Food travel to supermarkets can be long:
  - 70 percent of Chilean grapes are produced for export to Europe, the United States, and China
Vision of a Sustainable City
Principles of a Sustainable City

1. Reduced and Cleaner Consumption of Materials and Energy
2. A Prominent Place for Nature
3. Compact and Connected Patterns of Development
4. Creative Placemaking
5. Centers of Well-being
6. People-Centered Development
7. Participatory Governance
Principle 1: Reduced and Cleaner Consumption of Materials and Energy

- Scientists: the needed increase in resource productivity are huge in wealthy countries—on the order of 80 percent. How?
  - Circular economy, with essentially 100 percent zero waste to landfills
  - Absolute reductions in the use of materials and energy is an essential materials policy metric
  - Commitment to major reductions—on the order of 4- to 10-fold—in materials use
  - Emphasis on enhanced wellbeing, which may involve a reduction in consumption levels
  - Consumption is increasingly public, often in civic places, and consisting of services
## Renewable Electricity Targets

<table>
<thead>
<tr>
<th>City</th>
<th>Target Share for Renewable Electricity (%)</th>
<th>Target Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspen, U.S.</td>
<td>100</td>
<td>2015</td>
</tr>
<tr>
<td>San Francisco, U.S.; Malmö, Sweden</td>
<td>100</td>
<td>2020</td>
</tr>
<tr>
<td>San Jose, U.S.</td>
<td>100</td>
<td>2022</td>
</tr>
<tr>
<td>Munich and Ulm, Germany</td>
<td>100</td>
<td>2025</td>
</tr>
<tr>
<td>Wellington, New Zealand</td>
<td>78-90</td>
<td>2020</td>
</tr>
<tr>
<td>Austin, U.S.</td>
<td>35</td>
<td>2020</td>
</tr>
<tr>
<td>Amsterdam, Netherlands</td>
<td>25</td>
<td>2025</td>
</tr>
<tr>
<td>Tokyo</td>
<td>20</td>
<td>2024</td>
</tr>
<tr>
<td>Cape Town, South Africa</td>
<td>15</td>
<td>2020</td>
</tr>
</tbody>
</table>
LED Street Lighting, Los Angeles
Dezhou, China’s Solar Emphasis

- Million Roof Project
  - new residential buildings must have solar water heating
- Solar thermal or PV technology in 95 percent of new buildings
- Strong local economic base
  - over 120 solar energy firms and 30,000 jobs.
Materials Use Hierarchy

Most favoured option

Reduce: lowering the amount of waste produced

Reuse: using materials repeatedly

Recycle: using materials to make new products

Recovery: recovering energy from waste

Landfill: safe disposal of waste to landfill

Least favoured option
<table>
<thead>
<tr>
<th>Material</th>
<th>Share of Scrap in Global Supply (%)</th>
<th>Energy Savings, relative to virgin production (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>25</td>
<td>95</td>
</tr>
<tr>
<td>Copper</td>
<td>&gt; 40</td>
<td>85</td>
</tr>
<tr>
<td>Plastic</td>
<td>n.a.</td>
<td>80</td>
</tr>
<tr>
<td>Steel</td>
<td>44</td>
<td>74</td>
</tr>
<tr>
<td>Paper</td>
<td>n.a.</td>
<td>65</td>
</tr>
<tr>
<td>Lead</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>Zinc</td>
<td>30</td>
<td>60</td>
</tr>
</tbody>
</table>
Waste Policies Matter

- New Yorker MSW: 1.49 tons per year
- Londoner MSW: 0.32 tons per year
- Why? UK has a landfill tax
- Reduced the share of waste landfilled
  - 80 percent in 2001
  - 49 percent in 2010.
Principle 2. A Prominent Place for Nature

- An ecologically vibrant city is one in which
  - nature is more integrated and less segregated
  - nature is a neighbor, not an artifact
  - ecological services are valued and protected
  - natural functions are given proper attention in city planning
Beatley’s Indicators of Biophilic Infrastructure

- 100% of city population lives within 100 meters of a park or green space.
- Continuous green corridors from the city center to the periphery
- 10% of the urban area in a wild or semiwild state
- 40 percent forest cover (less in the core, more near the periphery)
- 1 Green feature (green roof, gardens, trees, etc.) per 1000 inhabitants (minimum of one per block)
- 1.6 km of trails for every 1000 personas
- 1 community garden for every 2,500 inhabitants
“Green Infrastructure”

- Using nature to manage water flow and other city functions
Principle 3. Compact and Connected Patterns of Development

- Connection is critical to urban life
  - In transportation
  - In cultural and political affairs
  - For innovative and efficient business operations
- Density is important for connection
<table>
<thead>
<tr>
<th>City</th>
<th>Density (people per km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta</td>
<td>636</td>
</tr>
<tr>
<td>London</td>
<td>5,900</td>
</tr>
<tr>
<td>Tokyo, Singapore</td>
<td>9,000+</td>
</tr>
<tr>
<td>Shanghai, Seoul</td>
<td>20,000+</td>
</tr>
<tr>
<td>Hong Kong, Mumbai, Ho Chi Minh City</td>
<td>30,000+</td>
</tr>
</tbody>
</table>
Taming the Automobile in Milan

- “Ecopass” -- charge on the most polluting vehicles
- “Area C” -- congestion charge in city center

Results:
- Area C reduced traffic by 30 percent.
- Public transit system, could finance upgrades to subway cars, trams, and buses
- “BikeMi,” the city’s bike sharing system, expanded
- 2005 -- 2013, share of private motorized transport fell from 44% to 37%.
Other Policies to Restrict Cars

- Vehicle quotas through auctions or lottery systems (in Chinese cities such as Beijing)
- License plate restrictions (such as Mexico City’s Hoy No Circula program and initiatives in other Latin American and Chinese cities)
- Low-emission zones (adopted in 226 European cities as of 2013)
- Parking restrictions (in Singapore as well as cities in Europe, Japan, and the United States)
- More than 100 big cities, many in Latin America and Europe, close some roads on weekends.
Car-Sharing Taking Off

- More than 1,000 cities in over 30 countries.
- 1995—15,000 car sharers globally
- 2014—4.9 million
- 2020: Navigant Research projects 12 million car sharers.
Greater Access to Public Transit

Metro Openings by Decade, 1863-2015

- By Decade
- Cumulative
Growth in Bus Rapid Transit

Cities with BRT Systems, per Year and Cumulative, 1968-2015

- New Cities
- Cumulative
Bus Rapid Transit
## BRT by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of cities</th>
<th>Passengers per day (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latin America</td>
<td>63</td>
<td>20.04</td>
</tr>
<tr>
<td>Asia</td>
<td>40</td>
<td>8.74</td>
</tr>
<tr>
<td>Europe</td>
<td>56</td>
<td>1.98</td>
</tr>
<tr>
<td>North America</td>
<td>27</td>
<td>1.05</td>
</tr>
<tr>
<td>Oceania</td>
<td>6</td>
<td>0.43</td>
</tr>
<tr>
<td>Asia</td>
<td>3</td>
<td>0.26</td>
</tr>
<tr>
<td>WORLD</td>
<td>195</td>
<td>32.49</td>
</tr>
</tbody>
</table>
Walking and Biking

- Clean, healthful
- Modal share growing
  - Copenhagen: 1 of 3 trips made by bike
  - Munster: 2/3 of trips made by bike, walking, transit
- Bike sharing:
  - 2000: 6 cities and 4,000 bikes
  - 2014: 712 cities, 806,000 bikes
Principle 4. Creative Placemaking

- **Placemaking**
  - Adds beauty and civic stimulus to a city
  - Can be large or small
  - Should be done all over a city
  - Promotes civic pride
  - Stimulates public consumption in place of private consumption
Metrocable, Medellin, Colombia
High Line, NYC
Sardana at La Seu Cathedral, Barcelona
Principle 5. Centers of Well-being

- Health
  - Accessibility to medical care
  - Opportunities and stimulus for exercise in daily life

- Income
  - “Decent Work Agenda (ILO)—creating jobs; guaranteeing rights at work; extending social protection; and promoting social dialogue
  - Cities can set wage and benefit minimums for city contracts
  - “Bolsa Verde” (Brazil)—$150 each trimester to poor families for environmental conservation actions. Women account for 93 percent of program debit card holders.
  - Self-Employed Women’s Association—informal sector workers in India. Establishes minimum rates for piecework.
Principle 6. People-Centered Development

- Strategic plans based on citizen needs
- People’s interests drive the planning process; economic interests build around people’s interests
- Broad access to basic services, increasing equity across a city
# Water Policy Based on Needs

<table>
<thead>
<tr>
<th>Need Type</th>
<th>Relevance to Water</th>
<th>Affect on Water Policy</th>
</tr>
</thead>
</table>
| **Existence**
  meeting basic survival needs    | water for domestic use; sanitation to prevent disease; stormwater drainage          | Water largely supplied through conventional water management infrastructure                |
| **Relatedness**
  facilitating interactions among people, and with nature | Parks, sports fields, open spaces, where people socialize and enjoy nature           | Recycled stormwater and wastewater were used during droughts to augment water supply and keep parks green? |
| **Growth**
  promoting equity, justice, beauty | Greater control over water management to citizens, which often translates to diversity of offerings and decentralized management | Rainwater harvesting options can cut household water costs. Beautification created by exposing stormwater in garden-like drainage systems |
Principle 7. Participatory Governance

- ✓ Power is distributed and devolved, with districts and neighborhoods having strong voices
- ✓ Decision-making processes are public, including posting of progress on mass communications media, including a website
- ✓ Citizens of all kinds are encouraged and recruited to participate
- ✓ Meeting calendars of civic officials are made public
Thank You!