Elements of Sustainable Infrastructure

INTERNATIONAL CENTRE FOR
SUSTAINABILITY ENGINEERING & RESEARCH

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Infrastructure

The technical structures that support a society, such as:

- Roads
- Water supply
- Wastewater
- Power generation and grids
- Flood and stormwater management systems
- Telecommunications (Internet, telephone lines, broadcasting)

New Orleans

"The tragedy of the I-35W bridge was, unfortunately, a symptom of how age, overuse and other stresses are impacting the American transportation system“

Stephen E. Sandherr, CEO, Associated General Contractors of America.

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Wivanhoe Dam, Australia

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Megacities

- More than half the world's population now live in cities – 3.3 billion people
- Megacities > 5 million people
- Over 50 cities qualify as magacities
- There are currently 20 cities with populations > 20million people
- We have little knowledge of how to deal with the complexities of cities of that magnitude

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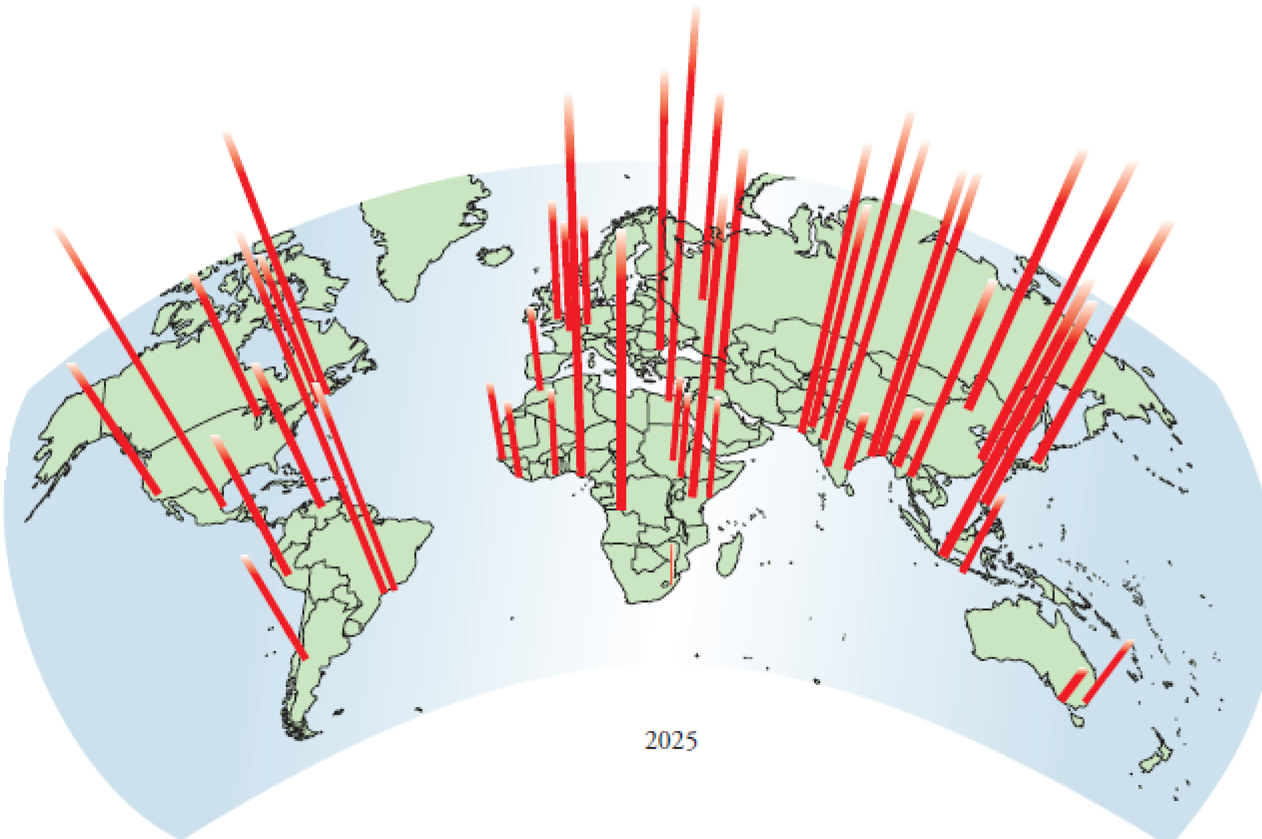
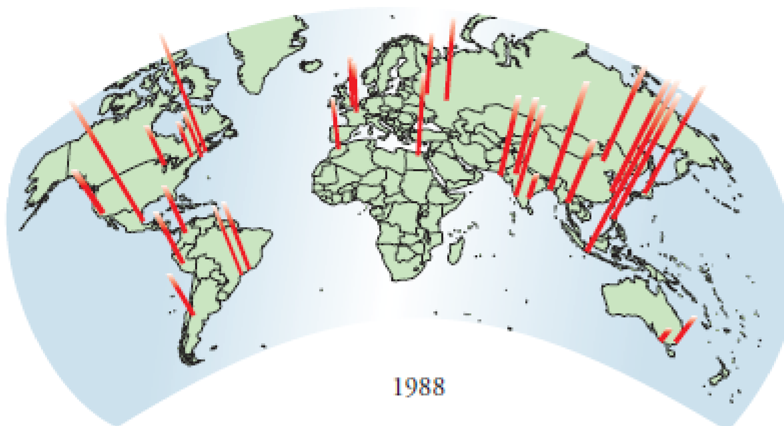
Megacities and population growth, 1988 - 2025



2025



1988

Current Infrastructure in the Developed World

- Centralised
- Highly engineered
- Highly technical
- Energy intensive
- Issues with funding, particularly for maintenance
- Often highly regulated
- Politicised – local/national
- Based on society’s demands

North America blackout, 2003

Cause:
Tree felled in storm, shorting out 1 line

Affected 40 million people in the US, 10 million in Canada

Current Infrastructure in the Developing World

Limited or non-existent

Poorly maintained

Old technology

Erratic function

Labour intensive

Issues with funding

Often poorly regulated

Based on financial drivers

Politicised – local/national/international

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Financing and Management

Increasing privatisation of infrastructure

- Provision of essential needs based on financial imperatives
- Cost/benefit analysis
- Increasing requirements for massive profits
- Increasing focus on wealthy communities
- Focus on ‘sexy’ projects
- Lack of maintenance and capacity building
- Lack of vision

Long Term Consequences

Influence of decisions made today on future generations

- Operation/Maintenance
  - Cost
  - Resources
- Upgrading
  - Competition for resources
  - Degradation/loss of ecosystems
- Increasing complexity
  - Increasing probability of failure
  - Increasing consequences of failure
- Technology lock-in
  - Decreasing resilience

6th century Chinese bridge, Anji

Roman Aqueduct
Segovia Spain

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Timeframe Years	**Water**	**Soil**	**Land**	**Food**
1	Annual rainfall, flooding, runoff, pollution	Erosion, nutrient level, organic content, pollution	Management of existing land use	Annual production, cash/food crop, pest prevention
5-10	Storage, ground water contamination	Heavy metal accumulation, soil health	Residential/commercial /industrial development	Crop rotations, disease and pest management
10-50	Climate changes; flooding, storm surge	Salinisation, compaction, desertification, soil health	Urban/rural development	Climate suitability for crops, production energy requirements
50-100	Climate changes; recharge of underground storage systems	Gradual soil loss, soil health	Floodplain development, volcanic/seismic activity	Long term crop management
100-500	Major climate changes	Soil loss, soil health	Infrastructure	Species diversity, social stability
1000	Local supply for drinking, sanitation, food production, ecosystem support	Soil abundance, health	Transportation corridors, development areas	Long term local production of minimum supply for local population

return

Sustainability Priorities

Marshall and Toffel (2005)

4.
Actions that reduce quality of life or are inconsistent with other values, beliefs, or aesthetic preferences.

Sustainability

3. Actions that may cause species extinction or that violate human rights.

2. Actions that significantly reduce life expectancy or other basic health indicators.

1. Actions that, if continued at the current or forecasted rate, endanger the survival of humans.

		Action	Risk	Need
Sustainability	**1**	Endanger human survival; loss of ecosystem services	Risk to provision of basic human needs; risk of social conflict; risk to environment	Water, air, food, shelter, clothing, light, removal of waste, cooperation, reproduction, medical care, ecosystem protection and maintenance, security
	2	Reduce life expectancy	Risk to human health (chronic and acute); risk of social breakdown; risk to large scale ecosystem function; employment	Higher quality and optimum quantity of needs; strengthening of community links; employment and education
	3	Species extinction, violation of human rights	Risk to species survival; risk to human rights	Maintenance of species habitat and numbers; freedom, provision of fair and equal justice and treatment
	4	Reduce quality of life, reduce ecosystem viability	Risk to quality of life; long term risk to ecosystems	Quality of life including employment, social inclusion, security; preservation and rehabilitation of important ecosystems

Meeting Human Needs

Basic physical needs

- Water
- Shelter
- Energy
- Food
- Transportation
- Communication
- Waste disposal
- Clean air

Secondary needs

- Governance
- Community
- Employment
- Education
- Security
- Health services

Tertiary needs

- Biodiversity
- Ecosystem integrity
- Justice
- Equality

Risk Analysis – Current

Probability of failure

- Increased understanding of system limits
  - How much water can we take?
- Increased understanding of complex system interactions and feedback mechanisms
  - How will taking water from the system affect ecosystem function and downstream use?
- Increased understanding of complex system failure
  - What happens if the water system fails?

Risk Analysis

Consequences of failure

- Feedback mechanisms
  - How will water failure affect other systems – food, energy production, manufacturing?
- Time and spatial consequences
  - What would be the long term consequences of loss of a water source?
  - How will this affect surrounding communities and ecosystems?

System Limits

Capacity of the system to provide resources

Capacity fluctuates as the system changes

Difficult to distinguish between trends and blips

Climate change vs drought

Precautionary principle critical

Often system dynamics poorly understood

Risks to Future Generations

- Capacity to meet future needs
- Financial burdens
- Technological burdens
- Resource burdens
- Flexibility
- Resilience
- Decreasing complexity

Needs Analysis

- Assessing the need for a resource
  - Quantity
  - Quality
  - Consumption patterns/need patterns
  - Supply availabilities and limits
  - Competing requirements and demands
- Assessing service requirements
- Available technologies
- Appropriate technologies
- Downstream implications – energy, waste, other resources, community cohesion, justice, security

Visions for Sustainable Infrastructure

- As populations increase, we will have to make difficult decisions
- We will have to determine how to support larger populations with dwindling resources
- Increasing resilience will be important
  - Decentralisation
  - Less ‘sexy’; appropriate technology
  - Potentially increasing manual input or user awareness or interaction
  - Cooperation rather than competition
  - Increasing community involvement in decision-making
  - Increasing awareness of future generations

Challenges for Engineers

- Leadership
- Difficult choices must be made clear
  - Infrastructure maintenance
  - Needs vs demands – what do we actually need?
  - System limits – how many people can the system support?
- Visionary
  - Appropriate technologies which will do the job
  - Infrastructure systems which are needed
- Engaged
  - Working with communities

Communications in India