



Toward More Sustainable Infrastructure: Project Evaluation for Planners and Engineers

Los Angeles, CA

Course Objectives

- Provide a framework for understanding and evaluating projects
 - Financial, economic, social, and environmental perspectives
- Demonstrate how to apply the basic methods of engineering economics in project evaluation
- Promote an approach to project evaluation based upon the needs of society and the potential for sustainable development

What is Your Role as an Engineer?

- Build projects
- Design projects
- Evaluate projects
- Propose projects
- Define problems



- Increasing complexity
- Decreasing certainty
- More possibilities
- Greater need for imagination and leadership

Key Concepts

- Justification of large investments
- Engineering-based performance functions
- Probabilistic analysis
- Critical factors
- Cost-effectiveness
- Sustainability
- System Evolution

Chapter 1 Introduction

“Focus first on those aspects of infrastructure that provide essential services, that is, those involving drinking water, wastewater, transportation, energy, and communications. ... Business and population growth have already outpaced the capacity of existing systems. To meet user’s expectations, planners should first determine the public’s expectations with respect to the levels and resiliency of such services and the amount of money that should be spent to maintain them and then determine what alternatives exist and what actions need to be taken to meet those expectations.” [\[1\]](#)

[\[1\]](#) National Research Council, *Sustainable Critical Infrastructure – A Framework for Meeting 21st Century Imperatives* (“Report Urges New Framework for Planning Critical Infrastructure.” *Civil Engineering*. June 2009. p. 20.)

Characteristics of Infrastructure Systems

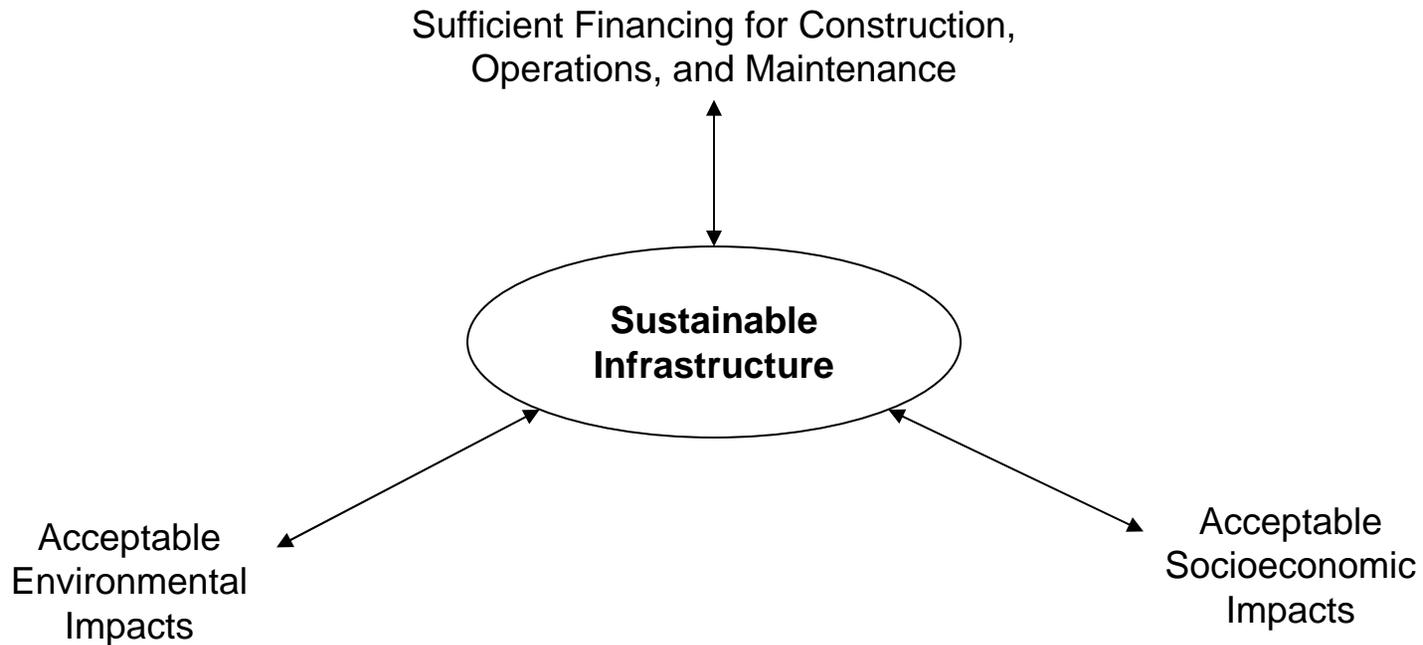
- **Long lives:** will future benefits justify high initial costs?
- **Land use:** how will investments in infrastructure affect urban, regional, and national development?
- **Networks:** how to balance needs of systems vs. local environmental impacts?
- **Difficulty in Measuring Benefits:** mobility, safety, air quality, etc
- **Multiple perspectives:** developers, users, abutters, public officials, and the general public

	Grade	Estimated 5-year Investment Needs	Investment Shortfall
Transportation			
Roads & Bridges	A. (roads) C (bridges)	\$930 billion	\$550 billion
Mass Transit	D	\$265 billion	\$190 billion
Aviation	D	\$87 billion	\$41 billion
Rail	C-	\$63 billion	\$12 billion
Inland Waterways	D-	\$50 billion	\$21 billion
Water and Environment			
Drinking Water & Waste Water	D-	\$265 billion	\$109 billion
Hazardous & Solid Waste	D & C+	\$77 billion	\$43 billion
Levees	D-	\$50 billion	\$49 billion
Dams	D	\$13 billion	\$8 billion
Public Facilities			
Schools	D	\$160 billion	\$35 billion
Public Parks & Recreation	C-	\$85 billion	\$48 billion
Energy			
National Power Grid	D+	\$75 billion	\$30 billion
Total	D	\$2.2 trillion	\$1.2 trillion

Sustainable Infrastructure

- Financing is available for construction, operation, maintenance, expansion, and renewal
- Social and economic benefits are sufficient for society to support continued operations and expansion
- Environmental impacts are limited, and the necessary resources are available

Three Requirements for Sustainable Infrastructure



Sustainability Issues Related to Infrastructure

- Excessive reliance on fossil fuels
- Green house gases, global warming, and climate change
- Risks related to natural disasters – earthquakes, hurricanes, tsunamis, floods, droughts
- Congestion
- Excessive costs
- Deterioration of poorly maintained systems

Projects Can Promote Sustainability

- New & better systems (wind power and solar power)
- Rehabilitation & expansion of existing systems (highway construction programs)
- Restructuring existing systems (new windows and insulation for buildings)
- Better management of existing systems (peak period pricing for water and electricity)

What is a Successful Project?

- It is built
 - ▶ Engineering feasibility
 - ▶ Financial feasibility
 - ▶ Social feasibility
- The benefits are indeed greater than the costs
- This was an effective way to achieve those benefits
- The project was built in an efficient and effective manner
 - ▶ No clearly better options
 - ▶ No significant externalities
- Building this project did not foreclose other, even better projects

How Do We Justify a Project?

- Is this project worthwhile?
 - ▶ *Are the benefits greater than the costs?*
- Is this the best way to achieve these benefits?
 - ▶ *Can similar benefits be achieved more efficiently by some other approach?*
- Is this the best place to allocate resources?
 - ▶ *Do other projects have greater payoff?*
 - ▶ *Are other types of benefits more important?*

Elements of Project Evaluation

- Create a "story" for the project
- Estimate the time, resources, and other costs of building the project
- Determine how the project can be financed
- Support a comparison of costs and benefits
 - ▶ Financial
 - ▶ Non-financial
- Provide a process for dealing with controversies

What Does it Take to Sustain a Project?

- Financing
 - ▶ Sufficient income to cover expenses
 - User fees, subsidies, contractual payments
- Government approvals (inspections, licensing, etc)
- Engineering
 - ▶ Sufficient maintenance and renewal to perform at an acceptable level of service
- Resources
 - ▶ People and materials as required for maintenance and operations of infrastructure
 - ▶ As required by users of the project
- Public support (or tolerable opposition and interference)

Financial & Economic Issues

■ Financing

- ▶ Where does the money come from to cover the costs that are incurred?
- ▶ What returns are necessary to attract capital?
- ▶ How can we reduce life cycle costs?
- ▶ How much money can we make?

■ Economic

- ▶ How will the project affect jobs, personal income, gross regional product, ... ?
- ▶ How can we value non-monetary costs & benefits?

Finances Are Important, but They Aren't Everything

- Environmental Impact Assessment
 - ▶ Understand the expected impacts of the major alternatives on the environment
- Sustainability
 - ▶ Can (or should?) this project (or this program) be sustained indefinitely?
 - ▶ Three sets of concerns
 - Financial/economic
 - Social
 - Environmental

Common Steps in Project Evaluation

- Identification of problems and establishing objectives
- Identification of major options
- Design
- Financial analysis
- Economic analysis
- Environmental impact assessment
- Public hearings
- Agency approvals

Five Phases of Project Evaluation

- I – Project Identification
- II – Analysis of Alternatives
- III – Assessing and Comparing Alternatives
- IV – Implementation
- V – On-Going Evaluation

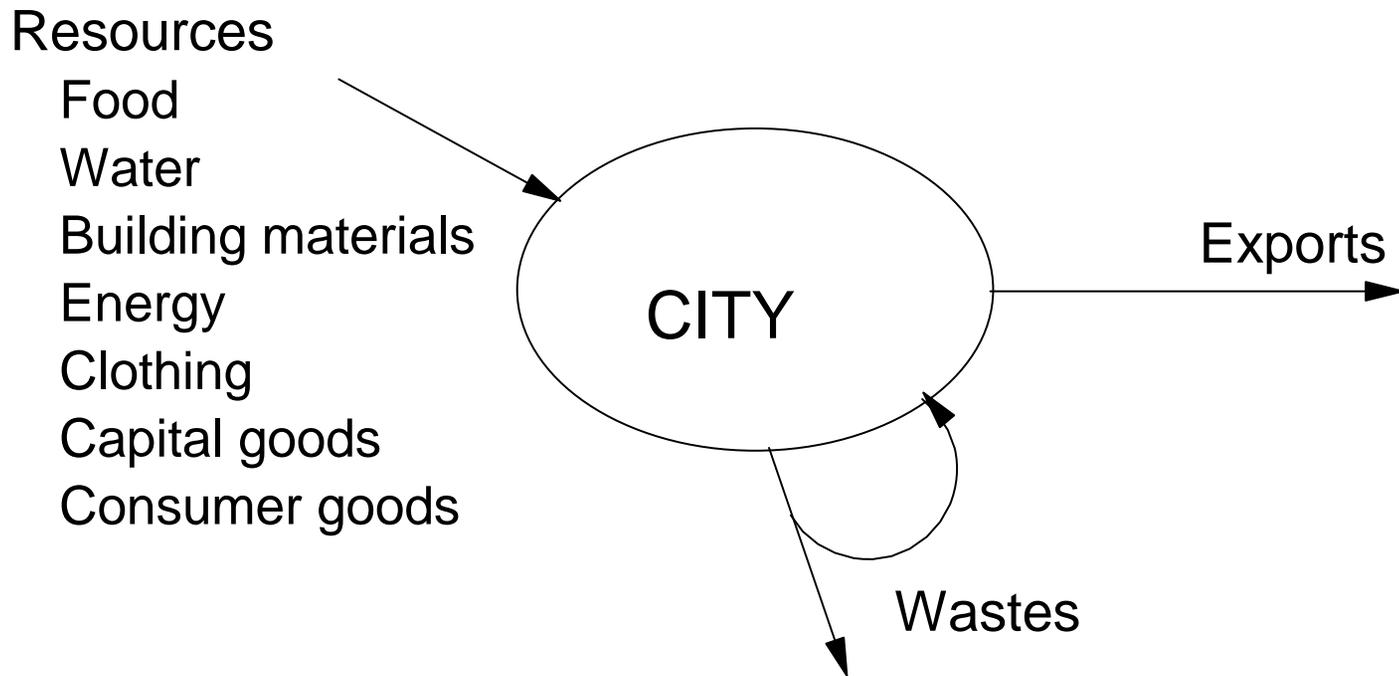
“Our society will never be great until our cities are great.”

Lyndon Baines Johnson



San Antonio, Texas

Civil & Environmental Projects are the Key to Civilization



Benefits of Urbanization

- For people:
 - ▶ Diversity of lifestyles, opportunities, people
 - ▶ Frequency & quality of social events
 - ▶ Employment opportunities
 - ▶ Creation of enough time to enjoy the fruits of civilization
- For the system:
 - ▶ More efficient use of resources
 - Roads, buildings, water sources, etc.
 - ▶ Proximity of complementary activities
 - ▶ Efficiency in distribution of goods
 - ▶ Safety

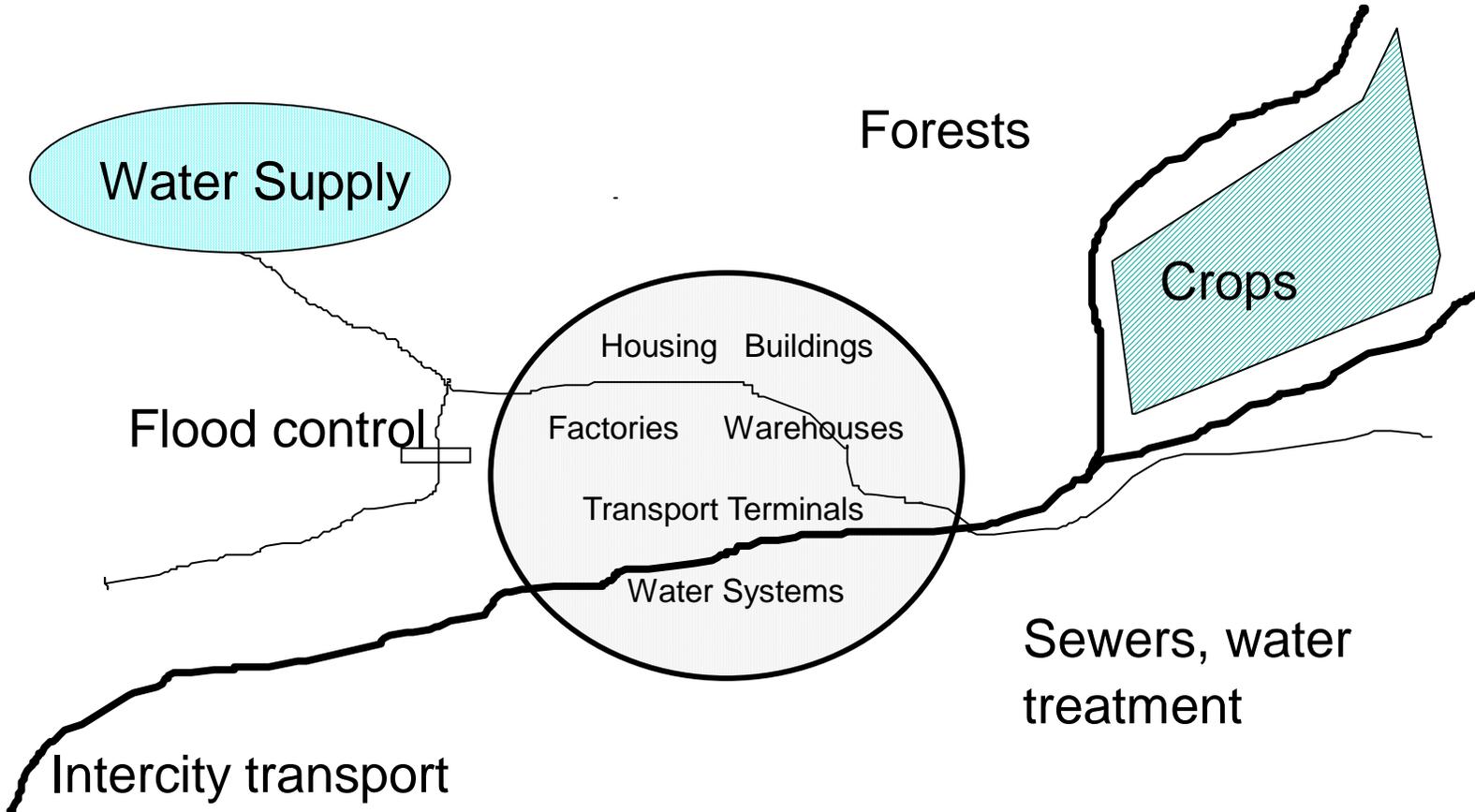
CEE Capabilities Limit the Growth and Quality of Urban Life

Water supply Amount & quality	Dams, aqueducts, treatment systems
Food supply	Transportation & warehousing Land use near city
Density of living	Floor area ratio (FAR) Floor area per person
Local Transportation - Commuting; freight	Limits on time and money for commuting Capacity & performance of local freight
Land available for development	Bridges & transport capabilities Flood control
Quality of life (& options for moving)	Parks & open space Public facilities Air & water quality

Disbenefits of Urbanization

- Loss of self-sufficiency
 - ▶ Possibility of extreme poverty
- Dependency upon transport system for resources
- Susceptibility to disease (physical and mental)
- Congestion
- Pollution - inability to absorb wastes

CEE Projects Make Cities Possible and More Livable



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