

COMPREHENDING INFRASTRUCTURE

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INTRODUCTION

- **Word Infra. is a combination of the Latin prefix "infra" and the French word "structure" (derived from the Latin word "structura") "infra" means "below" as many of the constructions are underground, for example, tunnels, water & gas systems, and railways**
- **Word 'Infrastructure' has been used in French since 1875 & in English since 1887, originally meaning "installations that form the basis for any operation or system"**
- **Its use in Military gained popularity after formation of NATO in 1940s**
- **Infrastructure's original and simplest meaning is "The installations that form the basis for any operation or system".**

INTRODUCTION

- UN report of 1955 introduced infra. into the development discussions, as it was concerned with the viability of proposals to create a fund for financing economic development.
- In 1970 the term was adopted in its modern civilian sense.
- US National Research Council panel in 1987 adopted "public works infrastructure", referring to 6 sectors:
 - functional modes – streets, roads, highways & bridges; mass transit; airports & airways;
 - water supply & water resources;
 - wastewater management; solid waste treatment & disposal;
 - electric power generation & transmission;
 - telecommunications; &
 - hazardous waste management

INFRASTRUCTURE DEFINITION

- Webster's Dictionary defines it as the basic equipment & structures that are needed for a country/region/organization to function properly
- Business dictionary broadens it to include public utility, telecommunications, transportation, and waste removal facilities.
- Its broad definition : The basic structure, the framework, the system which supports the operation of an organization, which makes economic development possible of a country/enterprise (Clark, 2004)
- Its concise definition : The physical components of interrelated systems providing commodities & services essential to enable, sustain, or enhance societal living conditions.(JE Fulmer, 2009),
- Can be summarized that Infrastructure refers to structures, systems, including services & facilities necessary for economy of a country, city, or area to function.

INFRASTRUCTURE DEFINITION

- **McKinsey Global Institute in their research on “Bridging global infrastructure gaps” 2016**
- **Initiate the discussion with the broadest definition of infrastructure as including real estate, social infrastructure, & backbone systems for the oil, gas, mining, and processing industries. The world spent USD 9.6 trillion, or 14 % of global GDP on infrastructure in 2013.**
- **Then focuses on a narrower subset, namely networked economic infrastructure. This consists of transport (roads, railways, airports, and ports), water, power, and telecom systems (which include digital infrastructure such as broadband). Together these asset classes accounted for USD 2.5 trillion of global investment in 2013. Over the past two decades, investment has averaged 3.5 % of global GDP.**

INFRASTRUCTURE AS COMPREHENDED

- Infrastructure in hindi - aadharik sanrachna आधारिक संरचना
पूर्वावश्यकता भूमिकारूप व्यवस्था
- Infrastructure can be comprehended as:
 - operating procedures,
 - management practices, and
 - development policies that interact with societal demand & physical world :
 - to facilitate the transport of people & goods,
 - for provision of water for drinking &
 - a variety of other uses - safe disposal of society's waste products, provision of energy where it is needed, & transmission of information within & between communities.

INFRASTRUCTURE AS COMPREHENDED

- Myriad Infrastructure definitions with sector-specific biases, but with commonalities have been made by national & international agencies, and states, municipalities, professional & trade organisations, the financial community, academia & dictionaries.
- Nearly all involve the following characteristics of interrelated systems, physical components & societal needs
- Infrastructure can be put into different overlapping types namely :

TYPES OF INFRASTRUCTURE

- **“Hard” infra.** refers to large physical networks necessary for the functioning of a country/settlement. Ex.- roads, highways, vehicles, refineries
- **“Soft” infra.** refers to all the institutions which are required to maintain the economy, health, cultural & social standards of a country. Ex. Systems – financial, education, health care, govt., law enforcement, emergency, etc.
- **“Urban” / “Municipal” Infra.** refers to hard / physical infra. generally owned & operated by municipalities, such as network of - streets, water distribution, sewers, drains.
- **It also include some of the facilities associated with soft / social infra.** such as parks, play grounds, securities, schools, hospitals & libraries.
- **Rural infra.** refers to hard infra. like rural roads, major dams & canal works for irrigation & drainage, mandis, rural water supply, rural electrification & rural telecommunication connectivity.

TYPES OF INFRASTRUCTURE

- Environmental infra. is an interconnected system of public & private lands that contains significant areas of woodlands, wetlands, wildlife habitats, & other sensitive areas with minimal intrusions from land development & light & noise pollution
- The Clean Water Act (CWA) is the primary federal law in the United States governing water pollution. Its Section 502 defines green infrastructure as "...the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspire stormwater and reduce flows to sewer systems or to surface waters."

TYPES OF INFRASTRUCTURE

- **Green infrastructure** is an approach to water management that protects, restores, or mimics the natural water cycle. It is effective, economical, & enhances community safety & QoL. It means planting trees & restoring wetlands
- **Blue infrastructure** refers to water elements, like rivers, canals, ponds, wetlands, floodplains, water treatment facilities, etc
- **Blue-Green Infrastructure (BGI)** offers a feasible & valuable solution for urban areas facing the challenges of climate change such as cloudbursts & droughts. BGI connects urban hydrological functions with nature, landscape design & planning. Thereby using the blue & green to protect against flooding & other effects of climate change. 10

TYPES OF INFRASTRUCTURE

- **Grey Infrastructure:** in context of Natural Water Retention Measures (NWRM), Grey Infra. usually refers to the traditional methods of managing water, using man-made, constructed assets, most often water tight & designed to avoid any type of ecosystem to grow on it.
- **Modern grey infrastructure such as permeable pavements & some roof water retention systems mimic the natural water retention capacity of the landscape & help to restore more natural patterns of run-off & infiltration. It includes channels, pipes, sewers & STPs, ditches, dikes, dams...**
- **It is so-called because it is often constructed of concrete. Unlike green infra. grey infra. typically does not deliver multiple benefits. Grey infra. such as sewers & sewage treatment works are needed in urban areas but their effectiveness can be enhanced by green measures which help to restore the natural water retention capacity of the landscape.**

TYPES OF INFRASTRUCTURE

➤ Transportation infrastructure

- Road & highway networks (including structures (bridges, tunnels, culverts, retaining walls), signage & markings, electrical systems (street lighting & traffic lights), edge treatments (curbs, sidewalks, landscaping), & specialised facilities such as road maintenance depots & rest areas)
- Mass transit systems (Commuter rail systems, subways, tramways, trolleys, City Bicycle Sharing system, City Car Sharing system and bus transportation)
- Railways, (including structures, terminal facilities (rail yards, railway stations), level crossings, signalling & communications systems,)
- Canals & navigable waterways requiring continuous maintenance (dredging, etc.) Seaports & lighthouses
- Airports, (including air navigational systems)
- Cycle tracks & pedestrian walkways (including pedestrian bridges, underpasses & other specialised structures for cyclists & pedestrian)

TYPES OF INFRASTRUCTURE

- IT Infrastructure comprises of technical systems such as networking equipment & servers, which provide critical function of sharing & moving data within a specific environment
- **Energy infrastructure comprises of 6 sub-sectors :**
 - Electrical power network, including generation plants, electrical grid, substations, & local distribution
 - **Natural gas pipelines, storage & distribution terminals, as well as the local distribution network, may also include gas wells, as well as the fleets of ships and trucks transporting liquefied gas.**
 - Petroleum pipelines, storage & distribution terminals. may include oil wells, refineries, as well as the fleets of tanker ships & trucks.
 - **Specialised coal handling facilities for washing, storing, & transporting coal..**
 - Electric vehicle networks for charging electric vehicles.
 - **Solar energy ; Wind Mills ; Biogas ; Nuclear Energy**

TYPES OF INFRASTRUCTURE

- **Economic Infra.** is internal facilities of city/region/country that support business & production. Such as communication, transportation & distribution networks, financial institutions & markets, & energy supply systems
- **Critical Infra.** refers to processes, systems, facilities, technologies, networks, assets & services defined by a Government as being essential to the health, safety, security or economic well-being of citizens such as facilities for shelter, telecommunication, public health, etc.
- **Complementary infra.** brings perfection or completes the existing infra. like networks of light railways, tramways, etc.
- **Institutional infra.** determines the framework within which economic agents may formulate their economic plans & carry them out cooperation with others

INFRASTRUCTURE AS DEFINED IN INDIA

- **Dr. Rakesh Mohan Committee “The India Infrastructure Report” (1996)**
- **Dr. C. Rangarajan, Chairman National Statistical Commission** submitted report on 5th Sept 2001
- **Central Statistical Organisation (CSO) ; Economic Survey 2000-2001**
- **Reserve Bank of India** 2nd July 2007 circular included sectors - power, telecommunication, railways, road including bridges, sea port , airport, industrial parks & urban infrastructure (WS, Sanitation & Sewage Projects) for raising external commercial borrowings
- **Insurance Regulatory & Development Authority (IRDA)** through its 2nd Amendment 2008, defined infrastructure
- **Income Tax Deptt.** - For an Infrastructure Company, Section 80-IA allows deduction of 100% profit from its income during 1st 5 yrs of operation & then 30% deduction of profit from income during next 5 yrs
- **Empowered Sub-Committee of the ‘Committee on Infrastructure’** compared 23 sectors and arrived to some consensus in April 2008
- **Isher Ahluwalia Committee, 2011**, “Urban Infrastructure covers urban roads, transport, renewal & redevelopment including slums, WS, sewerage, drainage, SWM & street lighting.”

Comparative Table on definition of Infrastructure sector and Decision of the Empowered Sub-Committee of Committee on Infrastructure (CoI).

| Sector | Rangarajan Commission | Rakesh Mohan Report/ CSO | RBI | Income Tax | IRDA | Ministry of Finance- Economic Survey | World Bank | Decision of the Empowered Sub-Committee of CoI |
|----------------------|-----------------------|--------------------------|-----|----------------|------|--------------------------------------|------------|--|
| 13 Electricity | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes (incl. R&M of power stations) |
| Water Supply | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Sewerage | Yes | | Yes | Yes | Yes | Yes | Yes | Yes (incl. SWM and street lighting) |
| Telecommunications | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Roads & Bridges | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Ports | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes (incl. Inland waterways) |
| Airports | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Rail (rolling Stock) | Yes | Yes | | | | Yes | Yes | Yes |
| Railways | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes (incl. MTS) |
| Wind Energy | | Yes (CSO) | | | | | | Yes (incl. Solar Energy) |
| Irrigation | Yes | Yes | Yes | Yes | Yes | | | Yes (incl. watershed Development) |
| Storage | | Yes | Yes | Yes (at ports) | Yes | | | Yes |
| Housing | | | | | | | Yes | |

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|--|-----|-----------------------|--------------------------------|-----|------------|-----------|--------------------------------------|--------------------------|--|
| Urban services; as Street lighting, Solid Waste Management (SWM) | | | Yes (Rakesh Mohan), - No (CSO) | Yes | | Yes (SWM) | Yes | Yes | |
| Oil production & pipe lines | Yes | | | | | | Yes | Yes (oil pipelines only) | |
| Mining | | | | | | | Yes | | |
| Gas distribution | | | Yes | | | | Yes | Yes (gas pipelines only) | |
| Aircrafts | Yes | | Yes | | | | | | |
| Vehicles, trucks, buses etc. (Road Transport System) | Yes | | Yes | | | | | | |
| Industrial Park/ SEZ | | | Yes (RM), No (CSO) | Yes | Yes | Yes | | | |
| Educational Institutions | | | | Yes | | Yes | | | |
| Hospitals | | | | Yes | | Yes | | | |
| Posts | | | | | | | Yes | | |

INFRASTRUCTURE AS DEFINED IN INDIA

- The Cabinet Committee of Infrastructure (CCI), on 1 March 2012, identified the sectors that should get infrastructure status.
- The move emanated from the lack of consistency in definition of what constitutes infrastructure.
- The harmonised master list approved by the CCI has five main sectors and 29 infra subsectors.
- The five sectors include transport, energy, water sanitation, communication and social and commercial infrastructure.
- The infra tag allows certain benefits including access to easier borrowings overseas, ability to raise funds through tax-free bonds, tax concessions, and access to dedicated lenders such as IIFCL, and the debt funds

INFRASTRUCTURE AS DEFINED IN INDIA

- **The new master list to serve as a guidepost for all the agencies responsible for supporting infrastructure in various ways.**
- **However, each agency will be free to draw its own list of sub-sectors out of the master list, which it intends to support, with adequate justification for inclusion or exclusion.**
- **Any fresh sector or a subsector will be included in the master list if it has six characteristics identified by Dr. C. Rangarajan**

CCI's Master List of Infrastructure

| SN | Category | Infrastructure Sub-sector |
|----|-----------|---|
| 1 | Transport | Roads and bridges |
| | | Ports |
| | | Inland Waterways |
| | | Airport |
| | | Railway Track, tunnels, viaducts, bridges ¹ |
| | | Urban Public Transport (except rolling stock in case of urban road transport) |
| | | |
| 2 | Energy | Electricity Generation |
| | | Electricity Transmission |
| | | Electricity Distribution |
| | | Oil pipelines |
| | | Oil/Gas/Liquefied Natural Gas (LNG) storage facility ² |
| | | Gas pipelines ³ |

CCI's Master List of Infrastructure

| SN | Category | Infrastructure Sub-sector |
|----|---------------------|--|
| 3 | Water Sanitation | Solid Waste Management |
| | | Water supply pipelines |
| | | Water treatment plants |
| | | Sewage collection, treatment and disposal system |
| | | Irrigation (dams, channels, embankments etc) |
| | | Storm Water Drainage System |
| 4 | Communi- cation | Telecommunication (fixed network) ⁴ |
| | | Telecommunication towers |

CCI's Master List of Infrastructure

| SN | Category | Infrastructure Sub-sector |
|----|--------------------------------------|---|
| 5 | Social and Commercial Infrastructure | Education Institutions (capital stock) |
| | | Hospitals (capital stock) ⁵ |
| | | Three-star or higher category classified hotels located outside cities with population of more than one million |
| | | Common infrastructure for industrial parks, SEZ, tourism facilities and agriculture markets |
| | | Fertilizer (Capital investment) |
| | | Post harvest storage infrastructure for agriculture and horticultural produce including cold storage |
| | | Terminal markets |
| | | Soil-testing laboratories |
| | | |

CHARACTERISTICS OF INFRASTRUCTURE

Dr. C. Rangarajan, Chairman, National Statistical Commission (2001) indicated 6 characteristics of Infrastructure sectors :

- **Natural monopoly** – one organisation catering to entire demand for goods & services at most efficient price
- **High-sunk costs** – cost incurred but cannot be recovered
- **Non-tradability of output** – good that is intangible & not tradable
- **Non-rivalness in consumption** – no conflict over additional consumer enjoying the benefits of a good/ service
- **Possibility of price exclusion** - pricing not regulated by market forces
- **Bestowing externalities on society** – externalities are spillover effects (costs or benefits) accrue to other (third) parties

Natural Monopoly

- When one firm can potentially supply market's entire demand for goods & services at most efficient price, it is said to exist natural monopoly
- When the fixed costs become so large that only one firm can feasibly operate, & the average costs continue to fall over the entire range of production, the one firm will emerge as natural monopoly
- Production of certain goods & services are subject to scale economies- like Infrastructure facilities
- Production of infrastructure facilities (like railways, electricity, telecommunications, gas-pipelines & other public-utilities) require a certain minimum scale of production
- Natural Monopoly is often viewed as market-failure

Natural Monopoly

Figure 1 shows cost & demand curves of a natural monopoly.

A firm produces Output Q_1 , where Marginal Cost (MC) = Marginal Revenue (MR).

At this point the Price per unit of Production is P_1 & Average Cost is AC_1 .

Price is greater than average cost ($P_1 > AC_1$), the profit per unit of output = $[P_1 - AC_1]$.

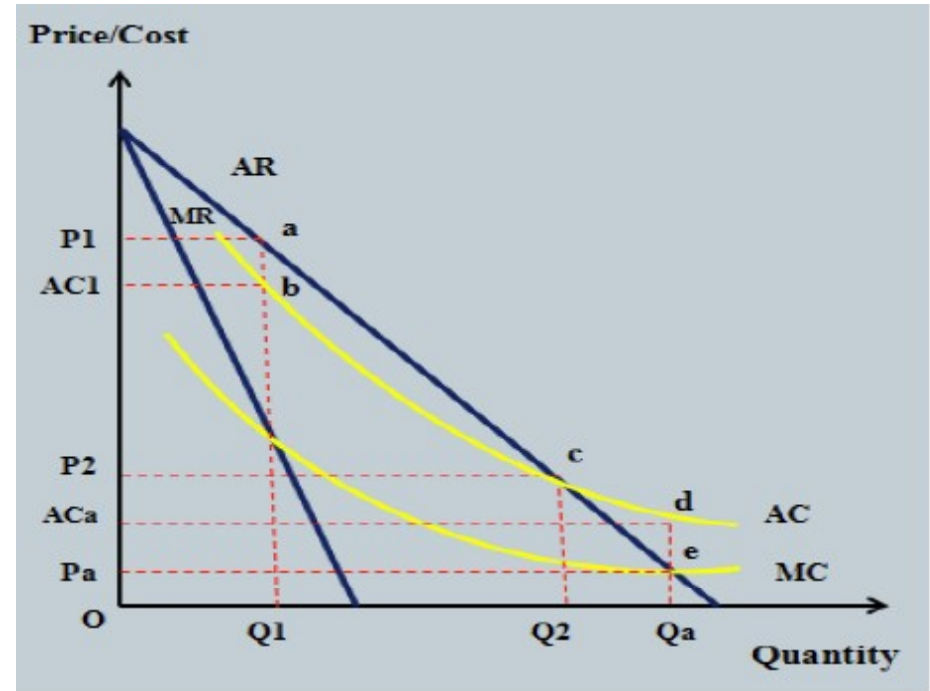


Figure 1: Natural Monopoly

If this natural monopoly starts to operate as perfect competitive firm, the marginal cost pricing $[P=MC]$ principle, then it must produce output Q_a & price will be P_a . In this situation, there is a loss $(AC_a - P_a)$ per unit of output.

Sunk Costs

- The expenditures that has already made & cannot be recovered even when the firm go out of business
- Sunk costs may be a barrier to entry into infrastructure development projects for private investors
- If sunk costs are high relative to marginal cost, price will almost surely exceed marginal cost, even though economic profits are zero
- Examples of sunk costs include investments in product development, the construction of a specialized production facility, large infrastructure projects etc. Such expenditures cannot be recovered & are therefore essentially irrelevant for any on-going decisions that the firm must make
- Sunk costs should not be considered for future investments decisions
- Examples: telecommunication towers, sewerage, railways etc. have high sunk costs

Non-Tradability of Output

- Infrastructure output are the services that are evoked from the use of particular infrastructure facility. Thus the characteristics of services are equally applicable to infrastructure: intangible nature & non-tradability (intangible- unable to be touched; not having physical presence)
- This means that infrastructure services must be consumed / purchased at the place they are produced
- These services generally can not be transported (with some exceptions)
- This characteristic has significant policy implications, because the viability of a particular infrastructure establishment has little role to play
- For instance: roads, railways, bridges, airports etc. can not be transported

Non-Rival Consumption

- Consumption by an individual does not affect the consumption by others
- Thus an additional consumer can enjoy the benefits of consuming a good or service without conflicting the benefits of others
- Zero marginal cost of providing the benefits of a good to an additional consumer
- For instance: roads & telecomm

Price Exclusion

- The benefits will be provided only to those who pay for the services/goods
- Price exclusion is a feature of private goods
- Perfect competition and efficiency merit marginal cost pricing, i.e., $P=MC$, that the prices must be set at marginal cost
- But, in the case of infrastructure, it will be very difficult to recover the costs of providing the facilities
- Thus, pricing of infrastructure facilities are not regulated through market forces

Externalities

- Externalities are the spillover effects (costs or benefits) that are not included in the prices and accrue to other (third) parties than those involved in the transaction. For instance: health & education
- Externalities are said to exist when production or consumption of an entity affect the productivity or well being of another entity
- Two conditions are necessary for an externality
 1. Interdependence between economic entity
 2. Non-compensation for the effects of interdependence
- Two types of Externality:
 - i) Positive Externality
 - ii) Negative Externality

**Thanks for
kind attention**