Towards A Systematic Model For Classification of Infrastructure Systems

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Abstract. Infrastructure, by definition, refers to those systems that facilitate, nurture and sustain the economic activities of society in a manner conducive to the welfare and wealth-creation of its people. Over the years, with economic development and technological changes, the nature of infrastructure required for economic activities has undergone a sea-change. In the first place, the infrastructure used to be predominantly physical and static in nature; this is no more so. Most infra-projects, today, have intangible and dynamic elements built over the physical elements transport - communication, logistics, supply chain management, support-services, advisory services etc. Appropriate infrastructure is a key factor in the success of a business – anywhere, anytime. With economic development and technological changes, the requirements of infrastructure have undergone a sea-change to include a whole variety of products and services. The purpose of this paper is to explore the logic of evolution of the infrastructure systems over the ages, understand their significance in the success of the businesses being sustained. The developing countries which represent the vast majority of the world need to create and provide infrastructure to nurture their businesses in a big way, in a short span of time; only then can they hope to bridge the gap between the haves and the have-nots. In this chase and quest, the author believes, clear understanding of the infrastructure requirements and their classifications would go a long way in our ability to plan and create them in the most effective manner. The methodology employed is exploring the historical evolution of infrastructure- systems and then exploring classification-attempts in the past. In the absence of any such attempts, author has looked for systems of classifications in other domains that can be relevant to the domain of infrastructure. The resulting analysis has helped zero-in on a system of classification. This is the finding of this paper – a system of classification of infrastructure-sub-systems is proposed. Impacts/advantages of the classification system: [1] It becomes a checklist for all future projects of infrastructure and would facilitate their designing, planning and execution. [2] By linking the infra-project to the objectives of overall development would help create tangible benchmarks for comparison. [3] In the 21st century, infra-systems have a wider role of creating and sustaining the competitiveness of nations. The effectiveness of the infra-systems, the speed of execution, the relative costs of execution etc. would have significant impact on the competitiveness of the firm/nation and hence on its competitive advantage.

Keywords: Infra-systems classification, Infra-systems and Competitiveness.

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1 Preamble

What can be a working definition for infrastructure-systems? Physical facilities, organizational structures and systems that help create, nurture and sustain economic activities that are intended for welfare and wealth creation of society can be called infrastructure-systems [infra-systems for short]. Over the ages, triggered by technological changes, economic activities have undergone tremendous growth and change. Changes were not restricted to economic activities only; changes happened in social, cultural, commercial, educational, entertainment, sports, and all other human activities. Apart from roads, rails, highways, airports, sea-ports, bridges, dams and canals, townships, industrial-estates, sports-complexes, stadia, auditoriums, educational institutions [school, colleges, universities], forms of governments, stock-exchanges, banks, financial institutions, financial-centers, regulators/regulating authorities in almost all sectors, have evolved over time come under the umbrella of infrastructure-systems. These were critical pre-requisites for the variety of human activities. Along with technological sophistication over time, the infra-systems also have acquired complexity and diversity.

This conceptual paper is an attempt to explore the existence of any pattern among these diverse infra-systems or among its elements. If any pattern is traced, it would help gain significant insights into the design and creation of these myriad infra-systems.

Today, infra-systems have become pre-requisites or basic necessities for quantum leaps in economic as well as industrial development. Among the large number of underdeveloped nations, infra-systems have become tools to achieve competitive advantage and usher in the development process. In this context, knowledge about infra-systems, its components, the logic of relationships among them or the logic of creation etc., would be a great asset in designing and creating them.

2 Literature Review

Literature review is pursued from two distinct perspectives:

a. To understand the evolution of infra-systems over the ages, the manifold variety, and technological sophistication they have acquired over time.
b. To explore and search for rubrics and patterns in their structures, so as to understand their creation and sustenance.

2.1 Evolution of infra-systems over time

Search for literature on the first perspective led to the works of Alvin Toffler and Michael Porter. Toffler describes human progress and development in terms three waves or revolutions [1]. The first wave, according to him, is the transition of man from

nomadic stage to the agricultural stage. This happened many millennia back. The second wave is the industrial revolution that happened in the middle of the second millennia. The third wave is the information revolution that began after the second world war, in the middle of the 20th century.

Toffler's thesis can be described in the following paradigms

- Technology [knowledge and skills about nature and its phenomena] has been the trigger for all changes, at all times.
- The first wave lasted the longest since changes in this era was the slowest; this was because the stock of technology available in the initial stage was the least. As the stock of technology gained in scale and scope, the changes, inventions, and innovations started happening faster. This is visible in abundance during the second wave.[1]
- Technological changes would impact every domain of human activity – social, economic, educational, industrial, commercial, political, intellectual, entertainment, arts etc. No field will be untouched. The break-down of feudalism, evolution of capitalism, mass production in factories, newer forms of government in place of monarchies, ownership of enterprises in company formats through limited liability of shares, monetary system, currency units, banking system, financial institutions etc., were examples of innovations man achieved as he progressed.
- The velocity of change would increase with time and the existing stock of technology. This caused the slow pace of change and progress in the first wave as also the relatively faster pace in the second wave and the still faster pace in the third wave. In future. the velocity of change would be so fast that man would find it hard to absorb and internalize[2].
- As man progressed, the level of knowledge and skills at every level increased and they began to be stored at individual, social and organizational levels leading to the evolution knowledge-societies, knowledge-economies and civilizational changes.
- At every subsequent stage of these changes, infra-systems required to create and sustain the core activities of man, acquired increasing sophistication and complexity.

Michael E Porter, in analyzing economic development, describes four stages which are experienced sequentially.

a. Factor-driven stage: Earliest stage, least pre-requisites
b. Investment-driven stage: Second stage; after moderate development has taken place.
c. Innovation-driven stage: Third stage: After significant development has taken place
d. Wealth-driven stage: Saturation stage; New drive and motivation required.

A detailed analysis of these stages[2], show that sophistication and criticality of the infra-needs of each stage increase sequentially and with time. In Diamond Factor Model[3], Porter identifies infrastructure as a key component within a factor called 'related and

supporting industries' which forms one of the four elements of the model[3]. Porter's thoughts on diamond factor model, competition analysis, managerial & resource capabilities, value analysis etc. were combined into the holistic concept of competitiveness of firms and nations at a later stage. His analysis is at a macro-level with nation's perspective. For our purpose, we need to understand the macro-perspective as well as the micro-perspective of the firm.

Toffler's works give insight into the evolution of infra-systems. Over the ages, the infra-systems and services needed for business enterprises have acquired tremendous variety and sophistication. These facilities decide the velocity of business and its capabilities. Porter's works give broad hints into the logical structure of the infra-systems and the pattern of their development across time

2.2 Literature on classification and Patterns

In value-chain-analysis, Porter has classified the overall conversion process involved in business into primary activities – the core conversion/production process - and secondary activities [4]. Secondary activities [Procurement, HR, R&D, Quality Management, Finance, Marketing, Logistics (In-bound & Out-bound), Overall Supervision etc.] are of support nature; can they all be treated as parts of infra-systems?

Nonaka and Takeuchi [5] have developed a model [SECI Model] to describe the knowledge transfer and creation process. According to them knowledge creation and transfer takes place in four distinct dimensions:

- *Socialization* where tacit knowledge [personalized, unformulated form] remains in the same form but gets shared with colleagues.
- *Externalization* where tacit knowledge gets shared with organization, mental models are formed, documentation takes place and explicit knowledge is created.
- *Combination* where Explicit knowledge gets shared with colleagues and further systematization or documentation would happen.
- *Internalization* where Explicit knowledge is shared with others and transferred to them. This could be learning by doing and similar other methods. The learner internalizes the knowledge and stores it in tacit form.

This model, despite its features, does not appear suitable or is out of context, as far as calibrating infra-systems in finer grades or layers.

Jim Collins has classified an intangible attribute like leadership into five levels of competence [6]. These are:

- *Competent Manager* describes a manager capable of performing well under the given structures and resources
- *Contributing Team Member.* In this level, the manager connects to his team members through proactive relationships that ensures effective performance of the team as a whole.

- *Highly Competent Manager.* A manager in the third level is described as one who is good at utilizing the people and resources at his disposal to the maximum extent towards the fulfillment of the goals of the organization.
- *Effective Leader.* A manager at the fourth level is described as one, who beyond the level-three would stimulate higher performance goals and create higher standards, for all persons under him. He would also groom people under him towards these higher performance levels.
- *Level-Five-Executive*. The fifth level describes a leader who would exhibit a blend of extreme humility, passion for the goals and professional skills.

Collins has provided a desirable sequence of five levels for a manager to aspire and rise up to. This model shows that intangible attributes like leadership, can also be defined in finer shades.

Another hierarchical model that is commonly familiar to management professionals is Maslow's hierarchy of needs [7]. Abraham Maslow, an American psychologist, has classified human needs into five levels or layers as:

- Physiological Needs (food, water, shelter etc.),
- Safety Needs (Security, Safety),
- Belongingness & Love Needs (Relationships, friends),
- Esteem Needs (Prestige, feeling of accomplishment), and
- Self-actualization Needs (achieving one's full potential, creativity etc.).

In this hierarchy there is a clear gradation from physical needs to emotional needs to intellectual needs. This scheme appears to be more adaptable to the classification of infra-systems which have many physical components at the bottom layers and then there are many intangible components at the higher layers.

Pancha Kosha Theory of Personality offers another hierarchical system of classification which is not so well-known among management professionals [8]. This theory has its origin in the *Taitiriya Upanishad* of Indic philosophy. As per Indic philosophy human consciousness is a combination of physical, emotional and intellectual dimensions. Personality is a sub-set of consciousness. *Pancha Kosha* theory describes human consciousness as consisting of five enclosed layers or sheaths comprising of

- *Annamaya Kosha* (Physical Sheath),
- *Prana maya Kosha* (Vital Sheath),
- *Mano maya Kosha* (Mental/Emotional Sheath),
- *Vijnana maya Kosha* (Intellectual Sheath), and
- *Ananda maya Kosha* (Bliss Sheath).

The Bliss Sheath represents the inner core and the Physical Sheath represents the outermost layer. Human needs are manifestations of personality biassed by the internal and external environmental conditionalities. This perspective would enable us to realize that *Pancha Kosha* theory appears to be basic to Maslow's Hierarchy of Needs. This

explains the similarity in the schemes of classification inherent in Maslow's concept vis-à-vis the *Pancha Kosha* Theory. Further, there is a fine gradation from physical systems to emotional systems and intellectual systems.

Thomas A Stewart, while describing the brain or strategic capability of a firm, visualizes three sub-systems namely [1] Human Capital, [2] Customer Capital and [3] Structural Capital (Stewart, 1998). He described these three sub-systems as circles or spheres intersecting each other; further he describes the synergic sum of these sub-systems making the intellectual capital of the firm. He does not envisage the sub-systems in any hierarchical order. While this model has its merits in explaining the strategic functions of the firm, it is considered less appropriate to describe the various sub-systems of an infra-system.

Another hierarchical framework is seen in the works of Wolfgang Mewes,[4] where he has used a 5-level hierarchical framework for analyzing organizations/systems. The levels are identified as Physical-systems, Technical-systems, Informational-systems, Financial-systems and Strategic-systems. Subsequently, this model and the related concepts were extensively used by Hermann Simon, in a seminal work on the success strategies of a number of firms who became market leaders in Europe, though not so well-known globally [9]. Mewes, while deriving his concepts of EKS, had referred to Maslow and some aspects of Indic thoughts on psychology; he had also followed the gestalt approach as seen in 'general systems theory' [10].

3 Methodology

Over time, requirements and specifications of infra-systems have been undergoing drastic changes – both in terms of variety and technological sophistications. Literature review is considered the best method to understand these changes and to get an insight into the triggers and implications. These are studied carefully to ascertain the underlying logic of transformation of the infra-system-requirements. Further explorations are carried out to find out parallels from within the domain of infra-systems as also from other domains of knowledge to identify a system of classification.

4 Analysis & Discussion

4.1 Definition and properties of infra-systems

We began with the working definition of infrastructure [or infrastructure system or infra-system] mentioned earlier:

> *Physical facilities, organizational structures and systems that help create, nurture and sustain economic activities that are intended for welfare and wealth creation of society can be called infrastructure-systems [infra-systems for short].*

A broad understanding of a business enterprise is that it has to be located on the ground, it needs people to work, machinery/equipment to convert inputs into outputs, energy (prime-mover) to drive and sustain activities, raw materials, resources and other inputs, transport to move people and materials, markets to sell, customers to buy and consume etc. From among these, if we segregate those responsible directly for conversion/production, we end up with a broad list of components of the infra-system in sync with the working definition.

Is there a logical pattern or a logical sequence of the structure and constituents of the facilities required by an enterprise or a group of enterprises? Is there a hierarchical order of things? We are not sure. At this stage all that we can say is that it depends on the location, nature, type and scale of business, geographical conditions and a lot of external factors.

Is there any rule or standard of practice on inclusion or exclusion of the components? There is no universal rule or standard; it is all situational. For instance, power supply is generally considered as part of infrastructure; but a large cement plant located in a remote place may choose to have its own power-plant. So we go by a generic definition that all facilities of support-nature are part of infrastructure. Specifics are left to the individual enterprise depending on its specific situations.

Lately many firms have started the practice of outsourcing most of the support activities and more, in accelerating project-executions and achieving faster volumes. This practice gained momentum with two factors:

- Japanese automobile firms[8] demonstrated significant success, from 1960s onwards, through outsourcing their inputs and activities so that they could focus on the core activities and achieve higher overall volumes.
- Increasing industrialization enabled grooming of vendors to match parent-firm requirements in terms of quality and quantity more appropriately.

Given this scenario, the list of facilities/activities that can come under infra-systems would have to be far more comprehensive. A tentative listing will be:

- Basic facilities like premises, roads, rails etc.
- Water and energy resources, their storage & distribution, effluent treatment systems etc.
- Logistics covering transportation, special-purpose-vehicles, cargo-stations, warehouses, sea-ports, airports, material handling systems etc.
- Communication systems – Posts/Couriers, Telecom & Internet access, Digital facilities of different levels.
- Institutions to facilitate and regulate various economic activities [Capital Markets, Banking & Money changers, sectoral regulators like RBI, SEBI, IRDA, TRAI, DGCA, Competition Commission etc.]
- Skills in terms of people and enterprises etc.
- Townships, transportation, hospitality, security services, house-keeping services, catering services, maintenance services, HR providers, financial advisory, business consulting, business services etc.

A primary look at these will indicate certain features that could help in categorizing them:

- Some are physical, static facilities [premises, buildings, roads, etc.]
- Some are physical products [water, fuel, etc.; power is not tangible, but a product]
- Some are services but require significant investment in physical systems [Transportation, ware-housing services, material handling services etc.]
- Some are intangible services are of low investment and low value, but volumes could be high [House-keeping, Security, Manpower services, etc.]
- Some are information/know ledge services of high value [Management Consulting, Financial advisory, Market Research, Corporate advisory etc.]

4.2 Primary Scrutiny of Models explored in Literature Review

The Literature Review has reviewed seven sets of models that can possibly be relevant to the question of finding a model that would classify the various infra-systems logically. These are [a] Michael Poter's model on stages of economic development, [b] Nonaka-Takeuchi Model of knowledge creation, [c] Jim Collins model on 5-levels of Leadership, [d] Abraham Maslow's Theory of Hierarchy of Human Needs, [e] Pancha Kosha Theory on Human Consciousness, [f] Thomas Stewart's model on the Brain of the Firm and [g] Wolfgang Mewes' EKS model.

Of these, Michael Porter's model on the stages of economic development gives a lot of insight into the process of economic development and consequently the evolution and historical sequence of the infra-sub-system and the manifestations of their variety.

The Nonaka-Takeuchi model of knowledge creation and Thomas Stwart's model on the Brain of the Firm are considered less suitable for the purpose of classification of infra-system. Jim Collin's model on levels of leadership is totally on behavioral aspects; since infra-systems have significant elements of physical systems, the Collin's model is considered less suitable for the current purpose. However, this model demonstrates the scope and insights of finer classifications.

4.3 Creating a Model from Comparables

That leaves us with three models: Abraham Maslow's hierarchy of Human Needs, Pancha Kosha Theory on Human Consciousness and Wolfgang Mewes' EKS Model (Refer Annexure 1). These have some features in common; [a] Each have 5 layers. [b] Each transit gradually from physical systems to non-physical systems to intelligent systems [Hard/Soft or Tangible/Intangible systems].

The features of the 'comparable' models have been compared and contrasted with the features of the elements of the infra-system and an attempt has been made to segregate the features into 5 [five] sub-systems. The result is summarized below:

a. *Physical sub-system*: In the initial stages the entire infra-system was only physical in nature. As infra-system became more sophisticated the physical segment became the primary part of the total system over which other segments were built-upon.
b. *Utilities [Energy] sub-system:* As the infra-systems became more sophisticated, a significant portion was related to the motive energy and water that were in use. Possibly we can group this part of the infra-system as another segment. Possibly this can be considered the second significant system as this offers vitality and dynamism to the entire production system.
c. *Logistics & Connectivity sub-system*: Movement of inputs to the production system, movement of outputs to the markets, commuting of people, etc. needed to be catered to as part of the infra-systems. This became another significant part of the infra-system. [Logistics, Transport, Warehousing, Access to Hospitals/Schools, etc.]. This can be treated as the third segment.
d. *Support sub-system:* Whole range of support services are required by any production system – [House-keeping, Security, Maintenance, Couriers, Catering, Effluent Management systems, Other Services etc.]. The relative significance of this system in terms of value, criticality may vary from situation to situation. These can be grouped as the fourth segment.
e. *Strategic sub-system:* These are value-added services which are very critical, they are knowledge-based services and of high value. [Financial Services, HR Services, Investment Banking, Market Research, Corporate Advisory Services, Consultancy, Forex, Audit Services – Financial and ESG, etc.]. These constitute the strategic sub-system.

This gives the rudimentary basis for classifying the subsystems and elements of the infra-system. The classification cane be modified or improved based on logical considerations. The nomenclature of the sub-systems can also be improved to represent the significance of each sub-system in a better manner.

4.4 Validation of the Model with recent Ceses

In validating the model for its relevance in analyzing and gaining insights, the author has chosen to look at a number of recent cases and experiences therein. Most of these cases have occurred in about 30 years or less; they are not too far in the past nor too near to the present. This facilitates objective analysis and insights to be derived from each. Brief details of the cases are given in Annexure-3.

Only a set of conclusions in the form of a table is presented below. Every project has elements in all five categories of subsystems. We are only listing the most critical factor/element for the sake of clarity and convenience. If a cell is blank, it does not mean that there are no factors in that category. If we list all factors, then the table will be cluttered with data; hence only critical factors are listed.

We have taken six cases at random. Three of them are normal industrial projects while the other three a infrastructure projects. In all of them it is possible to list the elements/sub-systems/factors as per the definition described in Annexure-2. We are not listing them for clarity and convenience. We are capturing the most critical element/factor/subsystem in each case. In some cases, there are more than one. They have been accommodated.

The Table-1 demonstrates that it is possible to classify the subsystems of an infra-system as per the hierarchy proposed in the paper. This should enable better understanding the infra-system as a whole; that understanding would be the starting point for better designing and construction of the infra-systems.

Table-1: Mapping of the Most Critical Factor

Name of Project	L-1: Physical Factors	L-2: Energy/ Utilities Systems	L-3: Logistics/ Connectivity	L-4: Support Systems	L-5: Strategic Systems
Tata-Nano Project	Procurement of Land [Apparent perception]				Real critical Issue: Inability to manage the concerns of the farmers, the land-sellers.
Mobile Plant of Samsung		Real Issue-1: Uninterrupted power-supply			Real Issue-2: Managing safety of Human Resources
Copper Project					Real Issue: Inability in Managing Pollution-free effluents.
Narmada Dam					Real Issue: Understand the concerns of the dam-outsees, provide Tangible solutions and convince them
Euro Tunnel Project					Real Issues: 1.Coordination with nations with different systems in almost everything 2.Safety of people & environment.

5 Conclusion

Till now nations and regions were deciding the infra-systems in accordance with their levels of economic development. This again was dependent on their technological and resource capabilities. From now on, the equation is bound to change. Global competition – which will be primed by geo-politics and geo-economics - would drive competitive capabilities and competitiveness of nations. In this context, infra-systems would emerge as yet another instrument of competitive advantage. Understanding the nuts and bolts of infra-system is the first step in enhancing its competitiveness of nations.

Economists and managers proclaim that products and services should have the essential attributes of acceptability, affordability, accessibility, and awareness. These attributes are listed as critical pre-requisites in marketing any product/service [11]. Systematic planning of the matrix of infra-facilities should aim to provide good experience, risk minimization, speed of implementation, and faster growth of the businesses. In the ultimate analysis the infra-system of any region/nation has the prime objective of enhancing the competitiveness of the region/nation as a whole. Systematic classification of the elements of the infrastructure would go a long way in effective planning, designing and execution of the developmental process.

Infra-system needs to be perceived not as a support system to industrialization, but as a strategic and competitive asset in the processes of industrialization and development.

6 End Notes

1. The technological changes, how they trigger further changes, their impact on society etc. can be seen from some of the critical changes that happened in the second wave.
    a. James Watt invented steam engine in 1769, James Young started to refine oil in 1840, Rudolph A Stuart invented oil engine in 1890, Rudolph Diesel invented Diesel Engine in 1892, Nikolaus Otto invented Petrol Engine in 1876, Carl Benz invented automobile car in 1886, Ford made the commercial car in 1904.
    b. Benjamin Franklin demonstrated that lightening was electricity in 1752; in the subsequent decades, Michael Faraday and others came up with the electro-magnetic theory; this led to the development of electric motors and generators. Thomas Alva Edison, in the second half of 19th century, apart from making electric bulb and other utility products, established the first electric utility that supplied electric power for homes and cities for lighting purposes. Around the same time Nikola Tesla worked on alternating current systems leading to creation of electric grids.

c. Controlled and sustained flight of a powered, heavier-than-air, craft was demonstrated by Wright brothers [Orville and Wilbur] in 1903; this led to the first scheduled commercial passenger flight in 1908, from Florida to Tampa.
d. In 1928, Frank Whittle invented jet-propulsion – the phenomenon of achieving very high speeds in one direction by pushing a jet of fluid, under high pressure, in the opposite direction. This technology found application in marine vessels, aircrafts, rockets, and space-crafts.
e. Enrico Fermi and associates conducted the first, controlled, self-sustaining nuclear-chain-reaction in 1942; this led to culmination of Oppenheimer's Project Manhattan, in 1945.

2. Stages of Economic Development, their description and infra-needs at each stage are described in the table below:

Stage of Eco-development	Description	Infra-needs
Factor-driven-stage	Based on natural resources; no pre-conditions	• Instruments to extract the natural resources • Facilities for temporary storage • Facilities to transport; vehicles and paths.
Investment-driven-stage	Pre-conditions: Significant investment in social & physical infrastructure has already taken place.	• Extraction & processing systems • Storage system for medium duration: Water-tanks, Fuel-tanks, etc. • Delivery system: Material handling systems, Water-pipe-lines; Powerlines; Drainage system; Effluent treatment & discharge system etc. • Transportation: Roads, Rails, Rail-stations, Seaports, Airports etc.
Innovation-driven-stage	Pre-conditions: Significant industrialization has already taken place.	• R&D Backup • Incubation Centers • Funding Mechanisms: capital markets, regulatory systems • Market Research • Advisory services etc.
Wealth-driven-stage	Stage of saturation, and decline.	More or less same as in the Innovation-driven-stage.

3. Diamond Factor Model: While exploring *comparative advantage* among industrialized nations, Michael Porter came up the Diamond Factor Model. According to this model four pillars determined the comparative advantage of a nation; these are:

a. Factor conditions: These are factors that a nation is endowed with at a given point of time. They could be natural resources or articulated resources [like skills] at that time.
b. Demand Conditions: Expectations and needs (demand) in the domestic market of a nation at a given point of time provide the primary trigger for growth, innovation and quality. Strong domestic demand is critical for the immediate and rapid growth of an industry at a given point of time. The instant success of Maruti-Suzuki in the mid-1980s can be attributed to the strong domestic demand for small/economy cars in India at that time. Two decades later, Tata-Nano could not be successful because the demand conditions had undergone a sea-change.
c. Related and supporting Industry: This refers to the presence of enterprises (or even clusters of enterprises) that supply inputs, components/parts, sub-systems etc. for the subject industry. Many foreign automobile makers could start their assembly plants in India since the 1990s due to the presence large number of vendors of components/parts who could cater their needs.
d. Firm-structure, strategy and rivalry: This refers to the firm's managerial resources and capabilities and the market competition of the time. For instance, India, in 2025, is venturing into semiconductor-chips business, on the strength of resources and managerial capabilities of a set of enterprises/promoters within the country and the overall market scenario. They need to bring in only technology from outside.

The first three pillars refer to factors external to the firm; while the last refers to inherent capabilities of the firm relating to resources and capabilities. He has also mentioned about the role of government in facilitating these in the form of infrastructure.

4. Wolfgang Mewes, a management consultant, in Germany had developed a concept called EKS [Energo Kybernetisches System (in German) – a rough English translation will be Energo Cybernetic System] in 1976. The system envisaged analyzing a system from all dimensions that it has interactions with and finding the most critical/limiting element that is hindering its natural progress. If this critical obstacle is resolved, the system will grow further until another element hinders its further growth. The process of ensuring continuous growth is the process of analyzing the system continuously and resolving the most-critical-hindrance at every stage. The concept is somewhat similar to the *Theory of Constraints* developed by Eliyahu Godratt in his book The Goal (Goldratt, 1986). Most of the works of Mewes are in German. A blog written by Mewes in English is: *Mewes, Wolfgang (1976): Cybernetic Thinking* https://gevert.com/2013/07/11/cybernetic-thinking-by-wolfgang-mewes-1976/

5. Reference to Japanese Style of Management specific to their automobile industry. Japanese automobile firms tend to outsource all support activities[4]

and focus only on the core /critical activities. This way they conserve their managerial attention and resources on the growth and development of core activities. In the post-OPEC era of the 1980s, faced with Japanese firms acquiring 25 % of the North American automobile market, the developed world also tended to accept this Japanese practice as superior.

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ANNEXURE-1: Comparison of Different Hierarchical Models

L-5	Self-actualization [Achievement of full potential, creativity]	Anandamaya Kosha	Strategic Systems	Strategic Systems
L-4	Esteem Needs [Prestige, Accomplishment]	Vijnanamaya Kosha	Financial Systems	Support Systems
L-3	Belongingness & Love [Relationship, affection, love]	Manomaya Kosha	Informational Systems	Logistics & Connectivity
L-2	Safety Needs [Security, Safety]	Pranamaya Kosha	Technical Systems	Utilities/Energy Systems

-1	hysiological Needs [Food, Water, Warmth, Rest]	Annamaya Kosha	Physical Systems	Physical Systems
Levels	**Maslow's Hierarchy of Human Needs**	**Pancha Kosha Theory on Human Consciousness**	**EKS concept of Hierarchy of Systems/Organization**	**Proposed Classification System for Infra-systems**

ANNEXURE-2: Proposed Model for Classification of Infra-systems

L-5	**Strategic Systems** • External Stakeholder & Environment [ESG] • Shareholders, Competitors, Industry etc. • Corporate Advisory Services etc.
L-4	**Support Systems** • Security Services, House-keeping Services, Catering Services, • Maintenance services • Outsourced agencies etc.
L-3	**Logistics/Connectivity** • Transport, Terminals, Cargo Handling etc. • Telecom, Internet, etc. • Vendors/Suppliers, Hotels & Caterers, Education& Training Institutions etc.
L-2	**Energy/Utilities Systems** • Power, Fuel, Gas, Water, • Storage & Distribution systems • Waste Mgt/Drainage/ Effluent Handling system
L-1	**Physical Systems** • Premises, Building, Auxiliary Systems, • Townships etc.

ANNEXURE-3: Brief Details of Cases used Validation of the Model

- *Tata-Nano project at Singur, West Bengal:* Tata Group had more than a century of experience in executing new projects and managing businesses. Tata Motors was in existence for more than half-a-century at the point of embarking on the Singur Project. After almost a decade of struggle at Singur they had to abandon the site. The primary reason was that they could not procure the land for the project amicably. Deeper analysis indicates:

    - The selected to locate the plant was fertile agricultural land with good irrigation facilities. It belonged to small and marginal farmers who were solely dependent on agricultural income.
    - Jobs were offered to youngsters based on their education. Most youngsters lacked education and industry-specific skills. The promise of jobs did not make sense.
    - In the competitive political scenario, there were ample rivals to the ruling party, to fan the anxiety and scare among the farmers.

  The apparent issue was delay in land acquisition, which falls under L-1 of the proposed model. On deeper analysis, the real issue can be seen as sub-

optimal management of the farmers concern about livelihood and sustenance. This aspect comes under strategic aspects, L-5.

- *Mobile Assembly plant of Samsung at NOIDA:* When Samsung decided to set up a mobile assembly plant (Capacity 68 million nos. p.a.), in 1996, it chose NOIDA. The industrial estate offered space and road-access to satisfaction. Closeness to Delhi ensured availability of skilled manpower. There were two critical concerns: 1. Power supply was not interruption-free (L-2); 2. Law and order situation was not among the top (L-5). These required careful management of the external environment. Samsung with its resources and experience focused on these and transformed the situation satisfactory levels. In 2018, the firm had no hesitation in scaling up its capacity to 120 million nos. p. a.

- *Copper Smelter Project of Vedanta Resources in Tamil Nadu:* Copper is a critical material for electrical, electronics and micro-electronic sectors. India was short of copper vis-à-vis the domestic demand. Sterlite (later Vedanta) Group) initiated a copper smelter and allied projects in 1997. Within a short time, the project got mired into a series of controversies. Salient features of the project are:
    - Copper industry in any form has potential to be hazardous environmentally. Copper projects need to be handled with utmost tech-care to ensure pollution-free operation.
    - Within few years of operation, local community & activists became agitated. They approached authorities for action. National agencies like NEERI, Nagpur had been asked to study the impact of pollution in the vicinity of the plant on several occasions. NEERI study had confirmed existence of toxic contamination in ground water, air, and soil of the vicinity. The last report was submitted to Supreme Court in 2005 (Sofia, 2018).
    - Since the investment in the project was significant and since copper is of strategic significance, various efforts were made to revive the project. The latest position is that Supreme Court decreed on a final closure of the plant in 2018.

  As a large project it had complexities in technical aspects, financial aspects, marketing aspects and strategic aspects. Most critical of these challenges, was definitely the environmental issue forming part of ESG and belonging to L-5 in the proposed model.

- *Vizhinjam Port near Trivandrum:* The international seaport at Vizhinjam was conceptualized in 1991. Not much did happen till 2015 when the formal agreement was signed between Government of Kerala (GOK) and the Adani Group for the formal development of the seaport. As per this agreement GOK will be the owner of the port and Adani Group will have the right to build and operate the seaport for 40 years. The port was formally inaugurated in 2024.

As an infrastructure project, it had all the complexities in terms of technicalities, construction, financing, obtaining all clearances govt/statutory authorities besides addressing to the interests of its stakeholders. The vicinity of the seaport was surrounded fishing villages, whose population had fishing as their primary livelihood. They feared the emergence of the seaport would harm their livelihood. Their concerns built up gradually into anger. They were mostly Christians, and the clergy took the lead-role in channelizing their anguish. Though GOK was a party to the project, they were not effective in convincing the anguished fishermen. In 2022, the fishermen's anger peaked and erupted into violent clashes with police/security agencies. At this stage Government of India (GOI) joined hands to initiate dialogue with the fishermen and their leaders, the clergy. It took some time to address their grievances and extinguish their fears; but the concerted efforts did help create trust between the fishermen and the project authorities. Since then, the project has been progressing very fast.

Despite all the complexities of the project, managing the community of fishermen and their concerns assumed primacy as the most critical and strategic aspects of the project (L-5).

- *Narmada Dam Project:* Narmada Dam Project stands out as one the largest river-dam projects, conceptualized to provide irrigation to farmers, water supply to urban/rural habitats and to the large number of industrial towns across the state. Most of the western and northern regions of the state are arid and desert-zones; the project exists as a life-line to these areas. The first phase of the project was creating the canal network across the service-areas. The second phase was the construction of the dam proper. The entire project was implemented by a company fully-owned by the Govt. of Gujarat [GOG], as a special purpose vehicle. The project had several challenges: the size of the project, the technological challenges of creating the pipe-line network across vast region crossing roads, highways, railways and even rivers, funding and managing the project, to its maximum potential etc.

  But the most audacious among these was that of convincing its stakeholders about the dam height and the plans of rehabilitating some tribal villages that would be sub-merged when the dam came up. Activists like Medha Patkar [Narmada Bachao Andolan], vehemently opposed the dam itself on the ground that normal cash compensation would vanish from the hands of the tribal population in no time, leaving them destitutes in rehabilitation colonies. GOG had appointed a tribunal to hear the concerns of the tribals/activists and elicit suggestions. The tribunal insisted on 5 acres of land to be given to each male member of the tribal family besides cash compensation and other facilities. The activists were not pacified. In the meantime, World Bank withdrew from funding the dam due to the environmental concerns. GOG had to resort to commercial funding of the project at distinctly higher interest

rates. GOG had to carry out a prolonged legal battle till it was cleared by Supreme Court with stiff conditions.

Some tribal families were shifted to higher level of the hills; others were shifted elsewhere; all with the compensations stipulated by the tribunal. A research project conducted almost 25 years later has documented the differential progress between the group that shifted outside the dam area and that remained in the dam area. A blog on this clearly mentions that the activists were wrong [12].

- *Euro Tunnel:* The idea of an undersea tunnel between London and Paris was in the imagination of the people of England and France since 1809 [13]. when a French mining engineer proposed a tunnel under the English Channel with oil-lamps and horse-drawn carriages. The conceptualization took some shape only when English and French governments signed the Treaty of Canterbury in 1986 [14]. This treaty created a basis of the concession to construct and operate the tunnel by private firms and the terms of arbitration in the event of any dispute. The system was to have three tubes: one each for movement of trains in either direction and a middle tube for the maintenance team to reach quickly wherever they needed to. There will be rails inside each tube for movement of the trains. The project was commissioned in 1994. Besides the challenges of design, construction, funding, pricing etc., most critical challenges were two-fold:
    - the coordination with two governments were extremely complex. The constitution, legal framework, regulations etc. were distinctly different; the democratic processes were different. This is one of the main reasons the project conceptualization took such a long time.
    - Concern for high levels of safety and environmental factors were of utmost importance since the entire operations were underwater.

  Both these aspects come under the grouping of ESG, which in terms of the proposed model will be at L-5.