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Transport Connectivity and Development: Some Experiences from Asia

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Introduction

- Transport networks (roads, railways, waterways, and airways) are very vital to support and catalyze development.
- Road networks are very basic for economic growth and any type of development.
- Development may be sectorial or territorial/spatial, and also may be at international, regional, national, and local levels.
- Irrespective of developed and developing characteristics of development of a country or at regional, subnational and local units, it is always guided and influenced commonly either by roads or railways, or a combination of both.

- Connectivity of places and spatial units (villages, sub-district, district, and provinces) by roads and particularly the quality of roads define the pace of development.

- Road/Railways/Transport connectivity induces the movement of people and goods within and across the regions.

- Degree of connectivity through transport network development reflects the level of accessibility.

- Higher the degree of connectivity, higher is the level of accessibility.

- Accessibility induces mobility of people, goods and services for production, consumption and service oriented functions.

Road and Railway Connectivity of Asia: Past and Present

- **The Silk Road** (Past but functional at present in respective countries)
- **BRI or OBOR** (Concept and Strategy for global development)
- **Asian Highways of ADB Projects** (in progress and partially operational)
- **BIMSTEC** (Evolutionary)

Historically, the **Silk Road** was an ancient network of **trade** routes, formally established during the **Han Dynasty** of **China**, which linked the regions from east to west of the ancient world in commerce between 130 BCE-1453 CE. The **Silk** Road was not a single thoroughfare but a network of roads and recognized by this common name. This road had extended the trade and commerce activities between Asian and European countries and created new centers (market and urban settlements) along its way.

The **Belt and Road Initiative** (**BRI**) or One Belt One Road (OBOR) is a global development strategy adopted by the Chinese government at present involving infrastructure development and investments in 152 countries and international organizations in Asia, Europe, Africa, the Middle East, and the Americas. "Belt" refers to the overland routes for road and rail transportation, called "the *Silk Road Economic Belt*"; whereas "road" refers to the sea routes, or the 21st Century Maritime Silk Road.

Asian Highway Networks (international routes for trade and commerce and other activities) for Asian integration is an excellent strategy of Asian Development Bank reflected in ASEAN countries, mostly completed and functional, for regional development.

BIMSTEC: Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), a regional development strategy in which India, Bangladesh, Myanmar, Sri Lanka, Thailand, Nepal, and Bhutan are the members. The basic and vital input is an integrated road and railway network connecting South Asia with ASEAN countries for trade and other associated macro regional development.

Transport Network Analysis and Development

(Understanding and measuring the levels of connectivity)

- The transport network system in a territorial unit is defined as a topological graph characterized by Node/Vertice (V), Edge/Link (E) and sub graphs (G).
- ode is the central point of interaction such as central village, market center, administrative headquarters, and transport nodes, etc.
- Edge or link is the connection between a pair of nodes.
- The sub graphs are the disconnected topological graphs of transport network system. The nature of graph may be planer and nonplanar. In planer graph, the edges intersect except at vertices (nodes). Mostly the graphs are nonplanar.
- Using V, E, and G; few indices can be developed for measuring te degree of road connectivity, which are discussed below.

Beta Index = E/V (ration of edges to vertices), 0-1 value indicates low development of network development, implies poor connectivity. The value greater than 1 indicates higher development. This is used irrespective of planer and nonplanar graph.

Alpha Index: It is the ratio between the actual numbers of circuits to maximum number of circuits. The value varies from 0 to 100%.
Mathematically, it is expressed as [(E - V + G)/ (2V - 5)] x 100 for planar graph, and [(E – V + G)/ {V x (V – 1)}/(V - 1)] x 100 for nonplanar graph.

Gamma Index: It is the ratio between the actual numbers of edges/links to maximum number of edges. The value varies from 0 to 100%.

Mathematically, it is expressed as {E/V (V – 1) / 2} x 100 for planar graph and {E / 3 (V - 2)} x 100 for nonplanar graph.

Beta, Alpha, and Gamma Indices are the measures of connectivity.

Higher the index value, greater is the connectivity that reflects well-developed network.

Based on the road network length, several other indicators are developed to understand indirectly the degree of connectivity and road network development.

They are **road density** (road length per unit of territorial unit), **Pi index** or the degree of road network development (The ratio of total length of the networks within a territorial unit to the longest path distance between a pair of points measured in the shortest possible path distance among the available routes of that pair), **Degree of Circuity** or route factor (average mean square deviation of a route/path/network with reference to observed and expected path distance), and **Detour Index** (ratio of observed and expected path distance of a link/route/and spatial unit expressed in percentage).

Degree of Circuity and Detour Index

- **Degree of Circuity or Route Factor**

$= \sum (O_L - E_L)^2 / V$ (for a route/network)

$= \sum \sum (O_L - E_L)^2 / V^2$ (for a territorial/areal unit)

- **Detour Index**

$= (O_L/E_L) \times 100$ (for a link)

$= (\sum O_L/\sum E_L) \times 100$ (for a route/network)

$= (\sum \sum O_L/\sum \sum E_L) \times 100$ (for a territorial unit/areal unit)

Where,

O_L is the observed or actual road length,

E_L is the expected or direct road length, and V, is the number of vertices exist in a network of any territorial unit.

Indicators for Measuring Transport Network Development with Connectivity and Other Factors

- Indicators used for understanding the network quantitatively for comparative analysis between and among the spatial units.
- Road density (road length per unit of area), 2. Alpha Index, 3. Beta Index, 4. Gamma Index, and 5. Pi Index
- (Higher the value, higher is the degree of transport network development)
- Degree of Circuity and Detour index
- Lower indices value indicate well-developed transport network.
- The above indicators can be combined together to formulate composite index to understand the overall degree of transport connectivity and development of territorial units.

Key Points

- Connectivity may be low even in a region of high road density due to topographical barriers in hilly and mountainous regions and in the coastal and deltaic region where the plane is dissected by a large number of distributaries of a major river system.
- Positive relationship exists between the transport network development with overall economic development of spatial units.
- Higher is the transport network development (connectivity level), higher is the economic development.
- Three levels of transport connectivity is the requirement for integrated sectorial and territorial development based on the available development potential.
- Degree of connectivity can explain the specialization of economic activities and growth.

Three Levels of Transport Connectivity

- The levels of connectivity are as follows.
- **Level 1**: Connectivity from the settlement (village) to the central places (market and other central places with production, consumption and service oriented functions)
- **Level 2**: Interconnectivity among the central places
- **Level 3**: Connectivity from central places to higher order secondary, regional and national centers with within and outside service areas/greater influence zone or region.

- In addition to the connectivity, quality of road and vehicle speed should be taken into consideration while designing the new road network and improving the existing networks.

Road Density of Selected Countries
Source: NationMaster.com
Note: * data may not be reliable

Country	Road density per 100 sq. km of Area
Japan	316.00 (2007)
Thailand*	35.26 (2006)
India	111.55 (2007)
Nepal	12.00 (2004)
Laos	12.59 (2006)
Cambodia	14.18 (2006)

The above table confirms the fact that developed country like **Japan** has higher road density, more than 3 km per one square km. **India** has only 1.12 against less than 1 of other counties mentioned in the table. In general developed countries has higher road density against developing and least developed countries. **Thailand** data does not match with the reality of situation, where connectivity is very high with good quality of roads from the capital to any distant settlement.

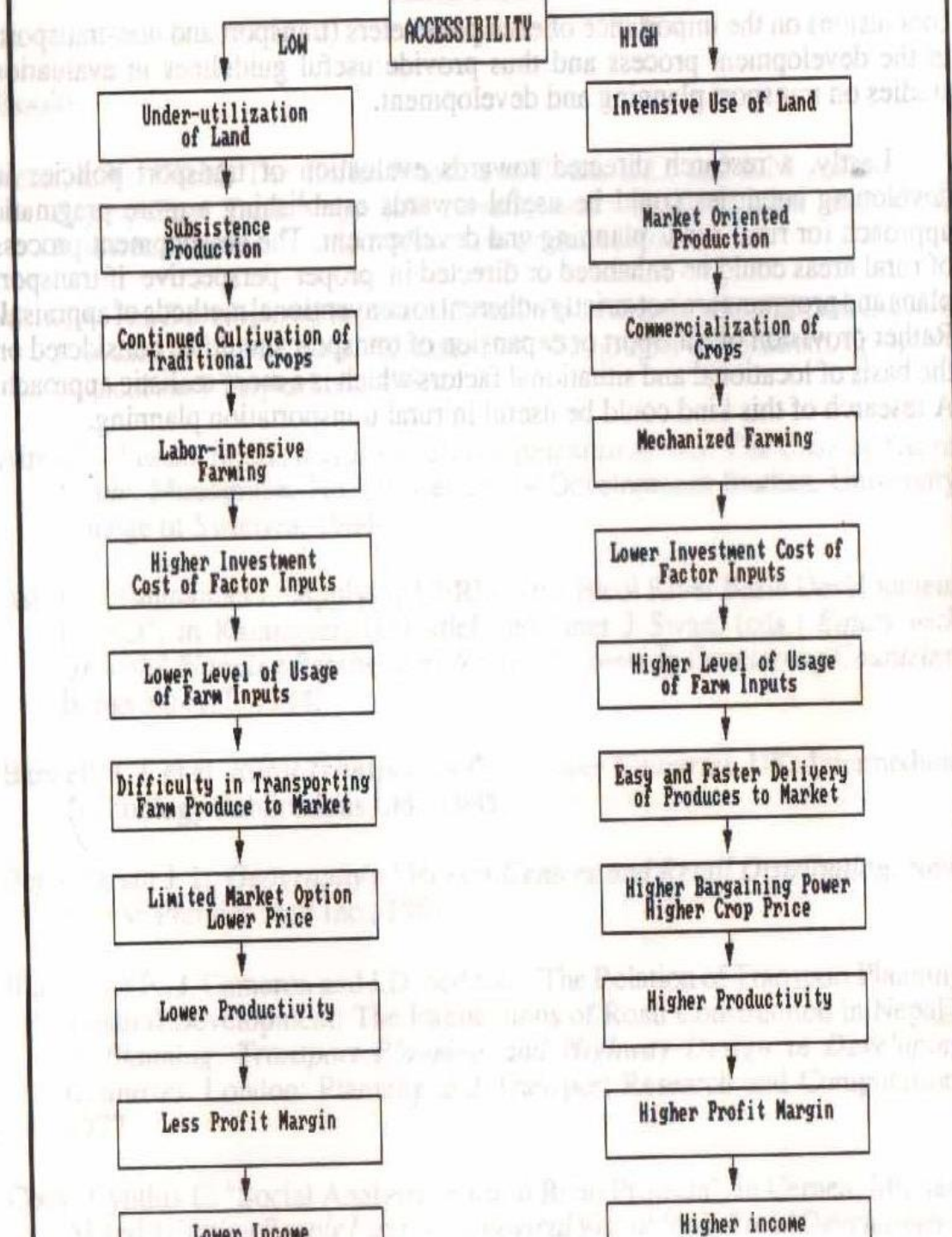
Nepal being a hilly and mountainous country dissected by topographical barriers, and a large number of Himalayan rivulets and deep valleys and gorges, the connectivity and accessibility is poor cauterized by detours and higher degree of degree of circuity except along the major highway system. Alignment of major settlements and service cum multifunctional centers are more likely to cluster along such highways. Transport connectivity is important for all types of development in any country.

High road density implies the formation of more nodes and links, and thus higher connectivity and accessibility to places.

Uneven road/transport connectivity leads to rural regional disparity.

Increasing road density with quality of roads is the implied message for all developing countries in order to increase the road connectivity followed by accessibility and induced mobility.

Potential and Real Impacts of Roal Accessibility (Stella Amor J. Francisco and Jayant K. Routray (1992)


ACCESSIBILITY
LOW
Under-utilization of Land
Subsistence Production
Continued Cultivation of Traditional Crops
Labor-intensive Farming
Higher Investment Cost of Factor Inputs
Lower Level of Usage of Farm Inputs
Difficulty in Transporting Farm Produce to Market
Limited Market Option Lower Price
Lower Productivity
Less Profit Margin
HIGH
Intensive Use of Land
Market Oriented Production
Commercialization of Crops
Mechanized Farming
Lower Investment Cost of Factor Inputs
Higher Level of Usage of Farm Inputs
Easy and Faster Delivery of Produces to Market
Higher Bargaining Power Higher Crop Price
Higher Productivity
Higher Profit Margin
Higher income

Key Reference:

1. Peter Haggett and Richard J. Chorley (1969), Network Analysis in Geography, Edward Arnold, pp. 31-60.
2. Stella Amor J. Francisco and Jayant K. Routray (1992), Road Transport and Rural Development, A case Study in Philippines, HSD Division, AIT, Bangkok.
3. S. Madhur, G. Wignaraja and P. Darjes (2009), Roads for Asian Integration: Measuring ADB,s Contribution to the Asian Highway Network, ADB Working Paper Series No. 37.

End of Presentation

Thank you