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Framework for public transport integration at railway stations and its implications for quality of life

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FRAMEWORK FOR PUBLIC TRANSPORT INTEGRATION AT RAILWAY STATIONS AND ITS IMPLICATIONS FOR QUALITY OF LIFE

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Abstract

Integration of public transport modes has been cited by many as one of the primary factors that enhances public transport ridership and makes public transport investments more viable. Asian cities are witnessing huge investments in high-speed rail (HSR) infrastructure, which will be instrumental in inter-city travel. The HSR station should serve as a multimodal hub, providing users with a seamless interface to various transport modes of the city, thus enabling in the provision of a sustainable transportation solution to the urban area. This paper focuses on the public transportation integration at railway stations by drawing upon existing literature along with specific case studies from Asian cities. First, a generalized framework for integration is developed based on literature sources. Second, six Asian railway stations were reviewed to identify the components essential for developing the public transport integration framework. Finally, the implication of such integrated transport nodes is addressed with reference to the urban quality of life. Results reveal that a framework with three levels of integration—physical, informatory, and monetary, is required to achieve successful public transport integration at railway stations. These levels of integration also need to be supported by additional interventions, such as those that enhance user perception of transit service quality, provides contextual information of the surroundings, and garners active participation of the stakeholders, which will, in turn, enhance the sense of belonging and aid in augmenting users' quality of life.

Keywords: public transport integration, station area development, transit-oriented development, quality of life

JEL Classification: O18, O21, R53, R58

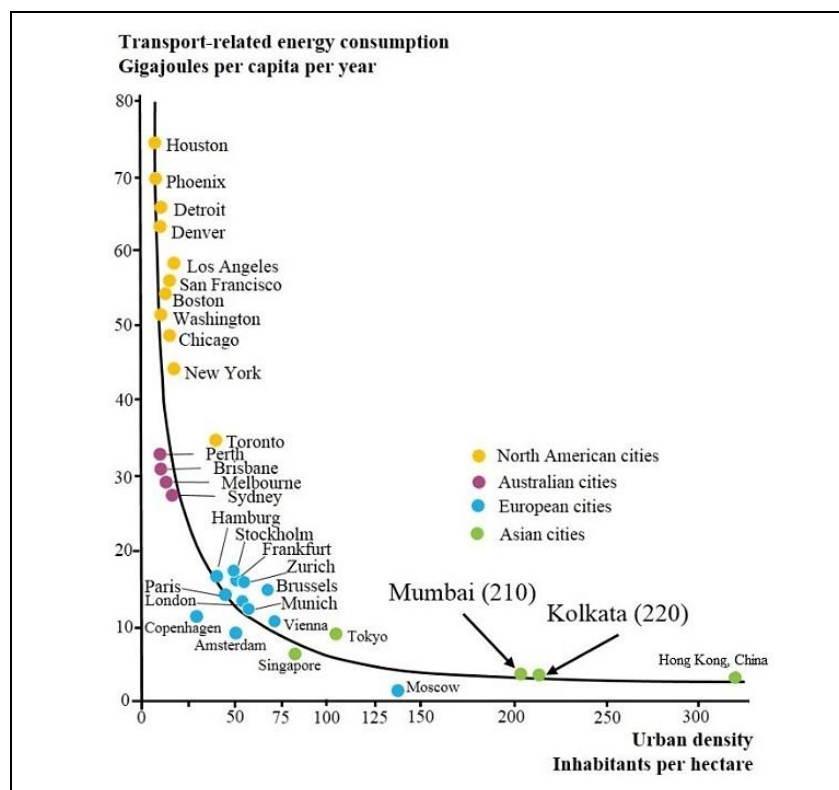
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1. BACKGROUND: OPPORTUNITIES FOR ASIAN CITIES

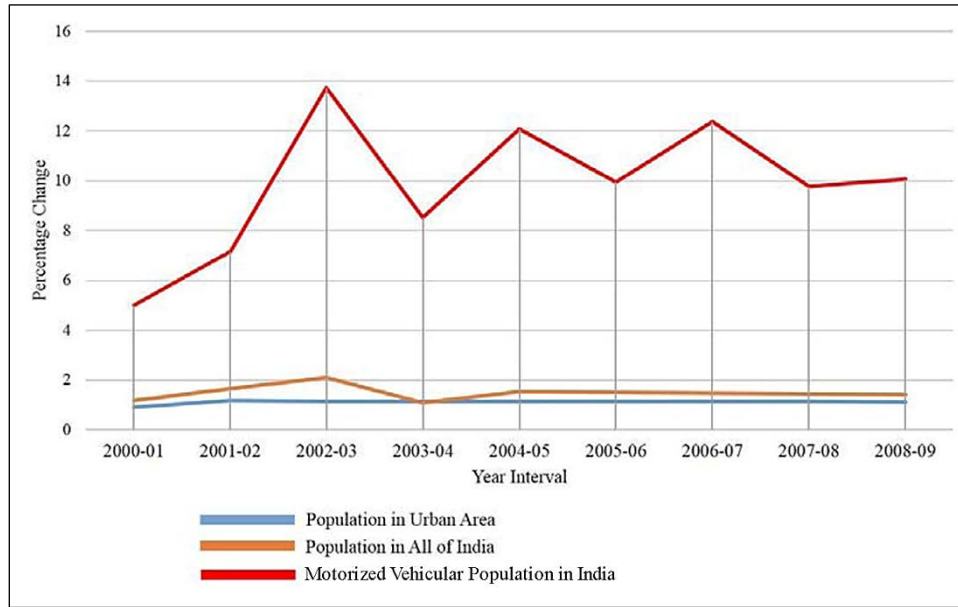
A report by NEA Transport Research and Training (2003) defined transport integration as “the organizational process through which the planning and delivery of elements of the transport system are brought together, across modes, sectors, operators, and institutions, with the aim of increasing net social benefits.” From the definition itself, transport integration has been identified as the intervention which ultimately leads to societal benefit. This is because commuters are better connected to their destinations, which satisfies their needs (e.g., job place, market, etc.). This is in turn responsible for improving commuters’ satisfaction. For example, if a commuter undertakes a journey with different schedules and transfers but without adequate coordination on passenger information, the commuter often feels dissatisfied. Furthermore, a World Bank report by Zimmerman and Fang (2015) suggested that amalgamating timetables, fares, and stops between the commuter rail, subway, and buses will not only make it more convenient for commuters, but will also improve the operational revenue of these public transport modes. They also suggested that seamless and integrated public transportation “is particularly important in urban environments with fast growing economies, such as [People’s Republic of] China and India”, such that public transport competes with private vehicles usage. Fortunately, Asian cities are blessed with an advantage that is conducive for promoting public transportation. Newman and Kenworthy (1989) pointed out that there is an inherent advantage for cities with high urban densities, where they indicate that as urban density increases, transport-related energy consumption decreases. This is because a more compact city will lead to a lesser amount of vehicle kilometer traveled (VKT) in comparison to a spread-out urban configuration. This phenomenon can be seen in Figure 1, where the green dots represent Asian cities, all of which fall below 10 gigajoules per capita per year consumption rate. Overlaying the urban densities for Mumbai and Kolkata in Figure 1, we also see that Indian cities fall under this low transport energy consumption rate, too. Additionally, Sung and Oh (2011) also demonstrated that high-density cities like Seoul can improve their public transit ridership by applying public transport integration strategies. Thus, there is an opportunity for such cities to boost public transportation ridership with the right set of strategies.

Figure 1: Relationship between Urban Density and Transport-Related Energy Consumption from Newman and Kenworthy (1989) Overlaid with the Urban Density of Kolkata and Mumbai



2. INTRODUCTION: PUBLIC TRANSPORT INTEGRATION

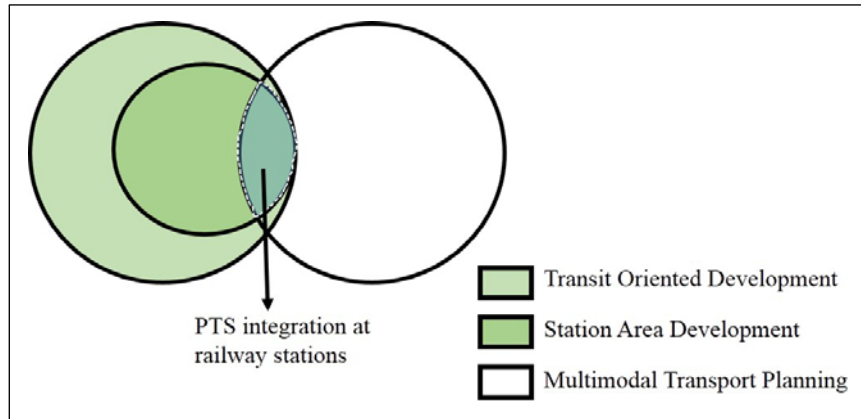
Berlepsch et al. (2018) ascertains that public transportation could be made attractive by enhancing the service quality and integrating all modes of public transportation. A report from the Ministry of Statistics and Programme Implementation (2017) in India shows that the average yearly growth in urban vehicular population in India is an alarming 10.07%, which was higher than the average yearly urban population growth of 3.2% in the period 2001 to 2015. Building wider roads to accommodate this extra traffic will no longer be a solution, as not only does the extra capacity induce further traffic, but at the same time, land is a limited resource in congested urban areas. The only solution to buck this trend is to reduce the number of vehicles on the road—moving people rather than vehicles and influencing more people to use the mass transit systems. High-speed rail (HSR, categorized as high speeds of 200 kmph or more) plays a crucial role in this aspect, especially in the case of inter-city travel. The multimodal connectivity with HSR could be a positive driving force in realizing significant societal and economic benefits for the country. The HSR infrastructure, should not only include tracks, propelling technology and signaling systems, but also the facilities in and around the HSR station. The station area connects to feeder services and the last mile infrastructure, and therefore designing such transfer facilities is of the utmost importance. Bharule (2019) identified that apart from social capital building, extensive case studies have helped build empirical research on the local impacts of HSR stations on urban development. Therefore, such an intervention has positive economic repercussions.

Figure 2: Rising Vehicular Population in Indian Cities

This paper therefore focuses on a framework for public transport integration around station areas. Such integration, with other modes and the transport network, would not only make HSR intermodal but also help increase its ridership, as is indicated by Chava, Newman, and Tiwari (2018). The next section deliberates upon the different components required for integration, followed by real-world practices from Asian cities that demonstrate such integration.

3. CONCEPTUAL COMPONENTS FOR INTEGRATION

Transport integration draws closely from two domains of knowledge—Station Area Development, which is a part of the larger concept of Transit-Oriented Development (TOD), and Multimodal Transport Planning (see Figure 3). Multimodality in transportation planning refers to considerations for various modes and the interconnections between them. Multimodal considerations may vary from interventions in transportation nodes such as, integrating a railway station area with public transits, to the transportation mode itself, such as allowing bicyclists on the subways or having a bicycle storing facility for public buses. Station Area Development is the upgrading of the station area in such a manner that there is enhancement of the transport integration which, in turn, will further drive the development of the adjacent area. This is the reason why Station Area Development is depicted as a subset of TOD in Figure 3. The intersection of these three-domain knowledge gives rise to the basic components that favor public transport integration. These components are described in detail in the following sub-sections.

Figure 3: Conceptual Domains of Public Transport Integration at Railway Stations

3.1 TOD—Station Area Development Principles

Transport integration in Station Area Development is the first step toward integration in the true sense as it accommodates the design in the physical level. Sands (1993) categorized HSR stations at two levels—first, HSR introduced to an existing conventional railway infrastructure and second, new stations built for HSR exclusively. There is a fine difference between the two levels in terms of station area. Terrin (2011) described a HSR Station area (as quoted by Bharule 2019) as “a new kind of mobility infrastructure that is a hybrid of an airport hub, service-oriented shopping space, while remaining a multi-cultural public space at the same time.” Evidently, the difference in an HSR station area and an existing railway station area remains in the form of additional service upgradation. However, the basic functional layout of spaces and their integration to other public transit modes remains the same.

The Institute of Transport Policy Report (Bhatt, Paradkar, and Fliert 2012) describes a guide for station area planning in Indian cities. The report also enumerates ten key principles:

1. Aligning the development character with the transit and place type
2. Creating a walkable urban street network
3. Promoting comprehensive street network
4. Managing public and private parking to curb car use
5. Designing better public spaces and amenities
6. Ensuring integrity of natural systems and the environment
7. Conserving the built heritage
8. Preserving affordable housing close to the station area
9. Involving key stakeholders
10. Value generation for financial sustainability

These principles focus heavily upon the built environment aspect, which can be seen from point number two through eight. Further, points number two through five focus on developing the surrounding built environment of the station area, whereas points six to eight are related to conservation, preservation, and maintenance of the surrounding infrastructure. Therefore, it can be concluded that the physical space is an important part of the station area.

Location and character of the surrounding area is an important consideration. Point number one stresses upon this aspect, which is further supported by Loukaitou-Sideris et al. (2012). These researchers have discussed six variables that intervene and influence the development of the station area—geographical context, ridership, station location, network type, type of guideway, and type of parking. Therefore, location and context are a significant concern, due to which a model station area plan may not be replicable between different stations and may warrant specific considerations based on the surrounding site.

Reiterating the inferences so far, physical integration is therefore a must for public transportation integration to the station area. However, a true integration would not be possible if the modal transfers are not seamless and coordinated. Therefore, there must be other levels of integration which will be explored in the next section of this paper.

3.2 Multimodal Transportation Planning

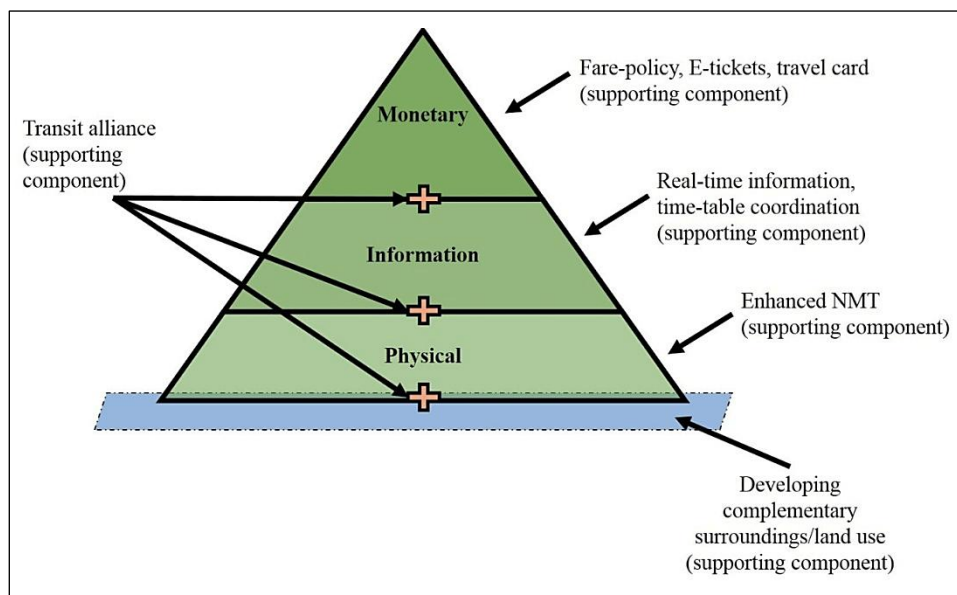
Once the physical integration is in place, the other components need to be incorporated, much like the hierarchy of needs as proposed in psychology by Maslow in 1943 (McLeod 2007). He suggested that individuals must satisfy lower-level deficit needs to a certain extent before progressing on to meet higher-level growth needs. Bivina and Parida (2019) extended this concept to the needs of pedestrians and their expectation of the walking environment. The lowest level of pedestrian need is for a safe walking environment, followed by their own security; thereafter there is a need for unimpeded mobility and efficient infrastructure. Lastly, the pedestrian's need is for a comfortable and convenient walking experience. Similar to the concept of the hierarchy of needs, the commuter's need for utilizing a multimodal transit system could also be categorized. Berlepsch et al. (2018) suggest that a commuter's need will entail convenience, easy access, comfort, affordability, competitive travel times, and safety. Barring comfort and safety, which is characteristic of the mode being used, the remaining four needs are addressed through the transport integration strategy. As explained earlier, physical integration between public transit modes would be a good intervention for increasing the convenience. Close proximity between the modes would ensure easy accessibility for the commuters.

Once the physical integration is in place, it would enable travel decisions to be made by commuters such that they save time and money. This leads to the next stage of integration at the information level. Consistent travel time information and well-coordinated transit schedules would help the commuters to plan their journey well in advance. A commuter will select between modes and routes to complete their journey. This will open up a number of possibilities and therefore give access to a more equitable distribution of transportation benefits. However, the complete transfer of benefit to the economically weaker sections will not take place if these joint travel decisions are not supported with affordability. The multimodal experience will only be complete with fare integration.

Fare integration is the last level of integration in the conceptual hierarchy of needs model. An integrated fare policy will not only save the hassle of booking separate tickets, but will also make a total journey affordable. Most integrated fare policies, in an effort to make the transit attractive, support subsidized fare amounts for longer and multimodal routes. Thus, cognitively, a commuter plans journeys that are optimally suited in terms of time, money, or both.

Therefore, along with physical integration, information and monetary (fare) integration form the hierarchy of needs for an integrated public transport commuter using the railway station. Figure 4 shows a conceptual figure of the same. It is interesting to note that Berlepsch et al. (2018) further sub-divide the information levels into—(i) integrated passenger information; and (ii) coordinated timetables and real-time information.

Figure 4: Integrated Public Transport Hierarchy of Needs



3.3 Supporting Components

To support this pyramid—other elements need to be present so as to provide a seamless integration experience for the commuters. Physical integration would be amiss without the site-specific support of proper Non-Motorized Transport (NMT, more precisely walking) infrastructure. Commuters alighting and boarding between modes in an integrated public transit station area will be within close proximity; therefore, it is intuitive to provide walking infrastructure for the interconnection between these modes. Therefore, NMT support is an important requirement.

Information integration would be impossible with proper access to the timetable information for the various modes. For this purpose, the station area would need an upgrade regarding the visual design of information. Real-time updating of information is also a useful component, as it helps commuters to plan both beforehand and on the go.

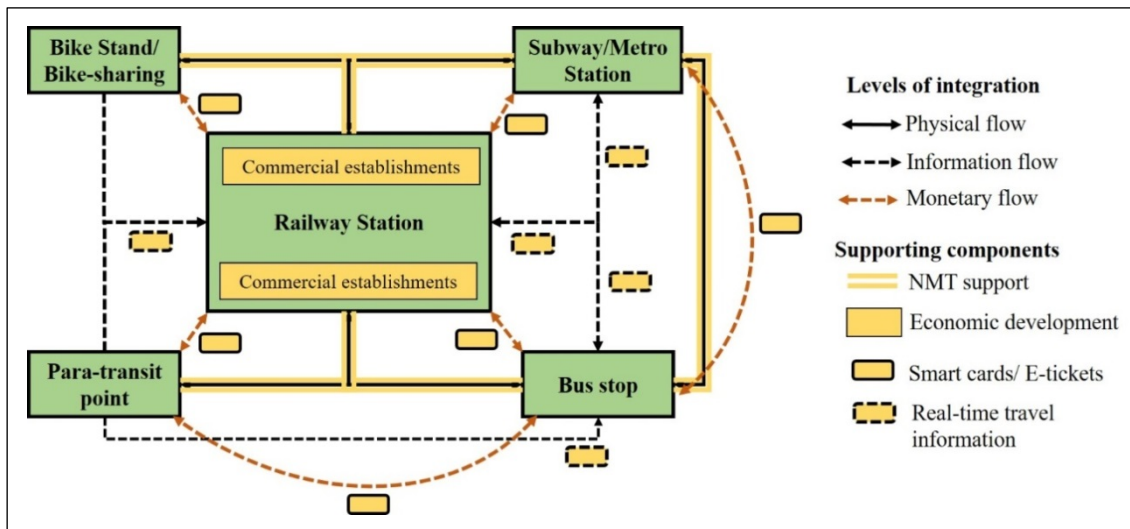
Monetary integration is supportive only if the fare policies from the different modes are brought under one aegis. Smart travel cards and other e-ticketing systems act as a good intervention for seamless and hassle-free travel.

Transit alliance, as defined by Berlepsch et al. (2018), is an organizational option for integrated public transport planning. Under this intervention there are alliances between public transport operators and public transport administrations. The task of such alliance would be (i) planning transport network and services; (ii) organization of fare system and ticketing; (iii) planning coordinated timetables and dissemination of information; and (iv) service quality control. Under such an alliance we see that all the needs in the hierarchy are systematically served.

4. SCHEMATIC FOR INTEGRATION

Utilizing the conceptual components from the previous section, it could be concluded that along with the physical, information, and monetary integration, supporting elements play an important role to sustain the integrative environment. A diagrammatic representation of these relationships is shown in Figure 5.

Figure 5: Conceptual Framework for Public Transport Integration at Railway Stations



An important point to be noted in Figure 5 is regarding the integration between each mode is through the railway station. The physical flow is deliberately made absent between the bicycles and para-transit since it is unlikely that users of such mode will have to come to the railway station to avail them. The only integration between these modes are through the railway station and/or the bus and metro modes. The information flows are also unidirectional for bicycles and para-transit i.e., the information regarding the railway timetable needs to be shared with the users arriving to the station area premises using these modes and not the opposite, since bicycle and para-transits do not have fixed timetables. However, fare integration remains the same, as it is convenient.

5. CASE STUDY AND POLICY INTERVENTION FROM ASIAN CITIES

In this section, we study various integrated railway station areas from Asian cities and investigate the components, as described in earlier sections. Refer to Table 1 for the summary.

Table 1: Case Studies on Integrated Public Transport Rail Station in Asian Cities

Case Study	HSR/ Non-HSR	Physical Level	Information Level	Monetary Level	Supportive Elements
Hong Kong West Kowloon Station, Hong Kong, China	HSR; also houses intra-city subway.	Set in a “rail village” location; provides transfer between light rail and buses. Primarily in the form of pick-up and drop-off points.	Available on display screens but not for all modes. Information available to commuters through online applications such as Google Maps. Coordinated timetable was not evident.	Smart card available along with e-ticketing. Partial subsidy in fare integration on specific routes.	<ul style="list-style-type: none"> • Pedestrian and motorized segregation. • Integrated rail-property development policy—land use—transport interface. • Economic development of area evident due to real estate and commercial development. • Transit alliance not observed.
Kyoto Station, Japan	HRS; also houses municipal subway system.	Provides transfer for light rail, city buses, and taxi. Taxi ranks present in a pick-up and drop-off pattern. City buses can be availed at bus bays present outside the station.	Information booth for tourists that is prefectural and station-specific. Travel information presented at Kyoto Station website. Coordinated timetable was not evident.	Smart card available with integration between Shinkansen (HSR), light commuter rail, and city rail. No fare integration with taxi. Smart card integration with city buses available on certain routes.	<ul style="list-style-type: none"> • Commercial development within station premises. • Walking infrastructure well connected between HSR, light commuter rail, and city rail. • Transit alliance not observed.
New Delhi Railway Station, India	Non-HSR; heavy rail for long distance travel.	Provides transfer with Delhi metro located at station premises. Para-transit integration includes taxis and auto-rickshaws.	Integrated information for rail commuters only.	Smart card for express and local rail only. No fare integration between modes.	<ul style="list-style-type: none"> • UBER (ride-sourcing agency) taxi integrate public transit information with Delhi metro station. • Transit alliance not observed.
Marina Bay, Singapore	Non-HSR; Urban metro in the form of Mass Rapid Transit.	Provides transfer to public transport modes like bus and light rapid transit and acts like feeder services. In addition, it provides better integration with para-transit like taxis and integrated mix use of urban district with comprehensive pedestrian and cycling network.	Coordinated and comprehensive information on all aspects of traveling on bus, MRT, ^a and LRT ^b in a single booklet and on web. Real-time information through i-transport platform. Coordinated timetable between the MRT and bus is established.	Smart card called “EZ card” as common fare card for all bus, MRT, and LRT services.	<ul style="list-style-type: none"> • Transit station is integrated with retail and commercial spaces with walking network. • A land transport authority is formed, which combines the functions of planning and regulatory agencies of both private and public transport. • Transit alliance observed.

continued on next page

Table 1 *continued*

Case Study	HSR/ Non-HSR	Physical Level	Information Level	Monetary Level	Supportive Elements
Kuala Lumpur Central Station, Malaysia	HSR with intermodal transport hub.	Provide transfer to monorail, inter-city commuter rail, electric train, airport high-speed rail, rapid bus transit, and taxis. The attractive communities have been created with strong network of cycling and walking.	Display screens with transit information is provided at all transit interchanges. Information is printed in booklets and distributed to tourists at a tourist service booth at the transit hub. Website and apps are created to provide information to commuters with scheduled time of all transit. Coordinated time is established between the inter-city rail and bus transport.	Smart reloadable cards can be used for fare payment on public transport. MyRapid Card can be used to pay the fares of HSR, LRT, monorail, and rapid bus transit. Touch n Go card works on all types of public transport. A benefit of 20% discount provided on public transport fares on both the cards.	<ul style="list-style-type: none"> Station area is divided into different economic generative development localities like office spaces, housing, retail, and commercial locations. Land public transport commission has been setup to regulate and improve the land transport matters. Cashless card used to pay the fares of public transport can be used to pay the multi-level parking facility at many stations. Transit alliance is observed.
Seoul station, Republic of Korea	HSR with light rail transport facility.	Development of transit center at transfer hub connecting feeder lines and shorter transfer distance with light rail transit, subway metro, inter-city bus terminal, urban rapid bus transit service. It provides para-transit services like taxi, mini bus, and bike. In addition, parking spaces are provided for bus, bike, car, and bicycle. Regional plan is integrated with railway station.	Information of rail, bus, and taxis are provided with smart phone apps and websites. A real-time location of public transport of all mode is made available in apps. The commuter receives travel information on his/her mobile about the trip with all the details. Transport Operation and Information Service (TOPIS) of the Seoul Metropolitan Government gathers and processes the city's road traffic and subway train information in real time to enable the city to efficiently manage the intervals between buses and trains.	Cashless and e-ticketing facility is available to pay the fare for public transport. Transfer from bus to bus and even bus to subways at the station is allowed free. A benefit of 30% discount provided on public transport fares on both the cards. The smart card can also be used at convenience stores, parking lots, and online shopping malls.	<ul style="list-style-type: none"> Integrated administration is developed between land use, transport, and infrastructure to establish institutional integration. Network and operation integration between inter-city transport through multimodal connectivity through rail and rapid bus, inner city connectivity through suburb bus and taxis and last mile.^c Development of economic generation areas like a shopping mall, office spaces, and retail and commercial spaces are integrated with walking from station. Public spaces are developed to attract more people around the station area. Transit alliance is observed.

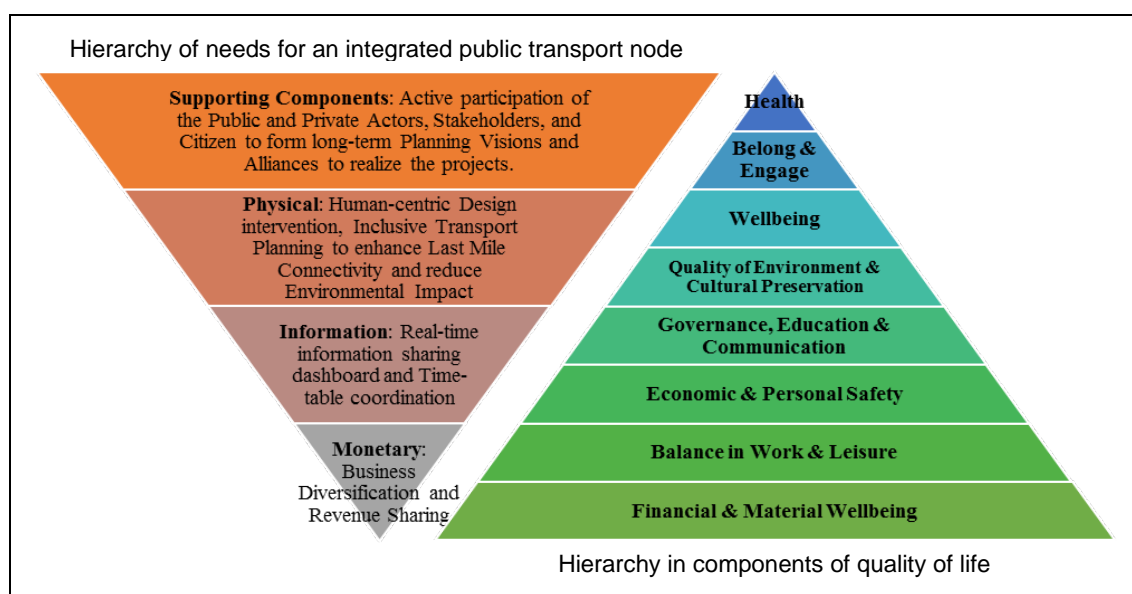
^a MRT: Mass Rapid Transport.^b LRT: Light Rail Transport.^c Last mile is a term used in transportation planning to describe the movement of people and goods from transportation hub to final destination. In case of railways, last mile can be described as connectivity between railway station and final

destination of a passenger. In recent years, 'last mile connectivity' has become an emerging area of research in Transportation Planning and Supply Chain Management Studies.

6. COMPONENTS OF INTEGRATED TRANSPORT NODES AND THEIR IMPLICATIONS ON QUALITY OF LIFE

The case studies and earlier two sections explicitly illustrate the critical need for integrated transport infrastructure. The case studies provide an insight on the current efforts to integrate different transport modes in Asia. In this section, the implications of integrated transport infrastructure on quality of life is addressed. The lessons drawn from the study cases, based on the hierarchy as discussed in the earlier section, are discussed below and summarized in Figure 6.

Figure 6: The Components of Integrated Transport Node and Its Implications on Quality of Life



Institutions operating transportation infrastructure often face revenue deficits and lack an adequate level of service. Monetary needs of a transport business require immediate attention, with financial deficiencies addressed by diversification of businesses and developing models for revenue sharing. Such models provide ease of added convenience with in-station commercial services, introduction of an integrated smart card, and other value-added services. These services not only offer financial stability and assure the wellbeing of the system; it also becomes a data exchange node for the stakeholders, as well as the users.

Real-time data collected from the user services are vital in keeping a transport node functional. Stakeholders and actors need to receive processed data in a relevant context. For instance, for a transport node, passengers need to receive delay alerts, so as to reduce congestion in the serviced areas, rail operators need to be informed about health of the railway coaches to manage and maintain regular services, civic authorities need to know the footfall in the station precinct to plan future parking and design adequate street network, para-transit operators need timetable information

to synchronize their services with the railways, and so forth. However, to form such an ecosystem it requires meticulous and visionary long-term planning while setting a sound institutional mechanism in place to maintain it. Establishing such monitoring, governing institutions, and applied research centers to learn from the collected data would not only aid effective communication among stakeholders to enhance passenger safety and security but also help in designing an evidence-based, data-driven system to plan station areas.

A well-integrated transport node, in most instances, operates with evidence-based frameworks. Collected real-time information aids in understanding passenger behaviors in the paid and unpaid areas of a transport node. Research on passenger behavior data becomes the basis for human-centric, context-sensitive design interventions, and sharing the information with stakeholders provides an opportunity to plan and develop inclusive and smooth transfer of passengers. Evidence-based frameworks create an opportunity for the service providers to take an initiative that is sensitive to the local cultural context that in turn nurtures social wellbeing in its users. Successful implementation of such frameworks enhances the overall quality of environment.

A transport node well rooted in the local context often becomes a landmark in the local urban context and offers a feeling of belongingness to its citizens. While the complete process of transport node and station area development is complex, it also requires equal amount of participation from its stakeholders and engagement from the involved actors to form alliances. Such alliances serve to augment the belongingness of the citizens and assures actor engagement in developing the planning vision of the transport infrastructure, thereby securely forming a healthy, and connected society.

7. CONCLUSION

This paper proposes a generalized framework for public transport integration at transport nodes. The case studies depict the components of this framework, which includes physical, informational, and financial integration, at various railway stations in Asian cities. Integration of public transportation at the railway station should be designed such that sustainable transportation goals are achieved. A good integration between modes should always be economically beneficial, ecologically non-impacting, socially acceptable, and should enhance the quality of life of its users. Before the integration plan is formulated, an initial analysis must be undertaken to understand the context of the railway station's surrounding area. Existing service quality must also be assessed through the perception of their users. This information will help formulate a tailor-made plan for a particular railway station area. The levels of integration discussed in the paper also need to be supported by additional interventions, such as the ones that enhance user perception of transit service quality, provide contextual information of the surroundings, and garner active participation of the stakeholders, which will in turn enhance the sense of belonging and aid in augmenting users' quality of life.

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