plication of an actor-ational approach in Bus pid Transit-land use eraction

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population is growing at a rapid rate and most of this growth is uous in cities. According to UN Habitat, 54% (4 billion) of the world's tion is living in urban areas and is expected to double by 2030 (UN, 2016) necessitates new sources of mobility. Consequently, governments are ng enormous capital to provide efficient modes of transport. As such, pid Transit (BRT) has gained popularity around the world. Especially in eveloped countries, its cost effectiveness compared to expensive rail ht Rail transit (LRT) systems stimulated the implementation of BRT.

pid Transit (BRT) is a high-quality bus based transit system that delivers mfortable and cost-effective urban mobility through the provision of ted right of way infrastructure, rapid and frequent operations, and excel- marketing and customer service" (Wright & Hook, 2007, p. 11).

ovides similar travel characteristics to those of rail (e.g. comfortable, t, and reliable) at a much lower cost than that of a bus (Cervero, 2013; Nelson, 2010). BRT has transpired as a low-cost substitute to expensive d Metro systems. The development cost of BRT is ten times lower than Metrorail systems (Suzuki, Cervero, & Iuchi, 2013) and four times less at of LRT (Cervero, 2013). Currently, 169 cities worldwide have imple- some sort of BRT system which carries approximately 33 million daily gers (Centre of Excellence for BRT, 2020).

searchers suggest that investment in public transport has impacts on oring areas (Banister, 2007; Cervero & Dai, 2014; Pagliara & Papa, 2011). k between transport investment and urban development has been the

focus of researchers in the last two decades (Cervero & Kang, 2011; Hass-Klau, Crampton, & Benjari, 2004; Knowles, 2012). They focus on various types of externalities attached to transport investment such as land use development, travel behavior, economic development, and many others (Kimball, Chester, Gino, & Reyna, 2013; Knowles & Ferbrache, 2016; Pagliara & Papa, 2011; Rodriguez, Vergel-Tovar, & Camargo, 2016). The externalities attached to transport investments are important to consider as these can become a source of funding for other transport projects. Moreover, urban development benefits can help in the creation of sustainable neighborhoods. In spite of these arguments, empirical evidence investigating the impacts of BRT on surrounding areas is limited. If we go into more detail, the impacts of BRT are interrelated (e.g. BRT > urban development > change in travel patterns) and no specific study has been carried out to explore the nature of the interrelationship among differing impacts of the BRT. Therefore, we need to unfold the motives and processes linked to BRT investment and specific characteristics coupled with its impacts.

The impacts of BRT vary in different urban settings. For example prominent land use impacts of BRT can be observed in Curitiba, Brazil however, no such impacts were evident in case of BRT in Ahmadabad, India. In the case of Bogota, the urban development impacts of BRT are highly context-dependent and change over the entire length of corridor. Therefore, it was worthwhile to consider a case for discussion. Subsequently, BRT Lahore, Pakistan is the focus of this discussion.
In the case of bus rapid transit (BRT) in Lahore, 2 government agencies are responsible for urban development with fuzzy jurisdiction. Similarly, over 10 government agencies are working for the city's transportation management, policy, and operations. This fragmentation not only results in duplication and inefficiencies but also makes it complicated to study interaction between transportation-land use. Similarly, BRT investment has been done without considering its external land use benefits. The complexity coupled with BRT systems in Lahore encourages us to consider it for this article.

In this article we will discuss different theoretical models proposed to express relationships between transport and urban development in general. It seems that present models are more general and do not sufficiently describe the interrelation between BRT investment and land use seeing the complexity of the situation. Therefore, in this article we focus on the complexity of BRT and land use interaction and consider whether actor-relational approaches (ARAs) can be used to explore the BRT impacts and complex BRT-land use interaction.

Bus Rapid Transit, Lahore

Lahore is a historical city and shares its roots back to 630 AD. Lahore is the capital of Punjab province and the 2nd largest city of Pakistan having a population of 11,126,285 (11.1 million) (Pakistan Bureau of Statistics, 2018). Lahore spans over an area of 1,772 square kilometers and is the hub of economic activities in Punjab Province. A sharp growth in personal vehicles was observed between 2001-08 as registered vehicles increased by 294% during this period. The rapid growth of personalized vehicles (1.9 million vehicles in 2008) resulted in congestion and long delays (increased travel time). To reduce congestion in the city and to fulfill the mobility needs of residents, the government decided to implement its first mass transit system (BRT) in the city, which became operational in 2013. At the initial stage this corridor was planned for a rail base system. However, due to financial constraints, the Punjab Government decided to build it as a BRT. The BRT route stretches over a length of 27 km (Shahadhra-Gajjumata) with 27 stations. The project cost was approximately 29.8 billion ($ 303.6 million) (Centre of Excellence for BRT, 2020) with average daily ridership of 133,319 (PMA, 2019). However, no land use policy was devised to streamline urban development in the areas served by the BRT. Despite any land use policy, major urban development activities were observed along the corridor after the development of BRT.

Present models of transport-land-use interaction:

According to Giuliano (2004) in an urban setting the association between transport investment and land development is a continuous process as shown in Figure 24. Investment in transport improves the accessibility which is then capitalized on through urban development benefits which ultimately alter the travel patterns of people. This cycle is continuous. Higgins et al. (2014), identified six factors that influence land development as a consequence of a rapid transit service. These factors include transit accessibility, positive growth and demand, positive social conditions, positive physical conditions, land availability, and complementary planning.

Instead of a simple linear relationship as presented in Figure 24., the relationship between transportation, travel patterns, and land development is of an endogenous nature and there are countless exogenous factors which influence these interrelations. The factors related to travel patterns may include socio-demographic characteristics and attitudes. Factors related to transport invest-

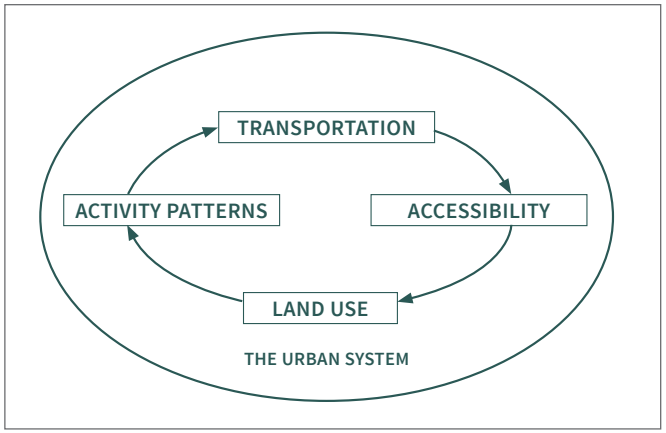

Figure 24.1. Transport and Land use Connection
(source: Giuliano, 2004 by Higgins, Ferguson, & Kanaroglou, 2014)

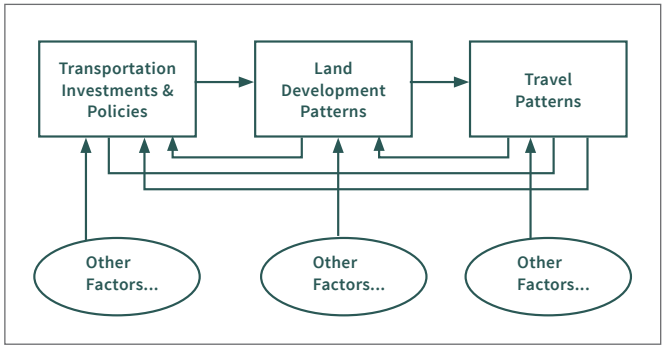

Figure 24.2. Complex links between Transportation and Land Use
(source: Handy, 2005)

ment and urban development may include political forces and land use policies (Handy, 2005). Moreover, these interrelations are not as simple as they seem to be; rather these interrelations are more complex as there are more numbers of actors and factors involved in this process as shown in Figure 25.

The complex link presented here does not reflect on the intermediate process which triggers urban/land development after investment/improvement in transport. Involvement of different people/agencies and their choices make this link between transport and urban development complicated. These models do not express anything about the conditions or factors which are prerequisite for any land value or land use change (Cervero, 1984; Knight & Trygg, 1977; Vessali, 1996).

Moreover, actors and institutions have an important role to play in transport-land use interactions. The poor coordination between different actors (actors related to transport and land use) often results in negative spill-overs and inefficiencies. In reality, decision making is distributed among many actors and jurisdictions. Therefore, there is need for more complexity-sensitive approaches to explore different actors involved, factors influencing each component, and their interrelations. According to Luhmann (1997), to deal with this complexity it is appropriate to approach the complex and volatile reality through distinct and autonomous subsystems. For this purpose, it is necessary to study how each system (transportation, urban development, economy, and travel behavior) works, which factors and actors are important and how these systems are governed.

Therefore, we build our study based on the concept of Luhmann and Post-structuralist theories. According to these, a society (system) is composed of different (sub) systems, such as a political, economic, or legal system. Communication or relations within systems can be considered as a basis for assessment of operations of that system (Mattheis, 2012). Therefore, it is necessary to know what constitutes systems of transport and urban development and how these systems interact with each other. If we apply these theories to understand the interrelation between BRT investment and urban development we can conclude that there are different sub-systems in an urban setting which interact in different ways. Moreover, to study the overall system of urban transitions we need to study the interrelations between different sub-systems. However, before exploring the nature of interaction between different sub-systems we also need to focus on constituting elements of these sub-systems which are elaborated on by the actor-relational approach (for details see Chapter 1 of this book).

The phenomenon of innovation (e.g. introduction of BRT) and the interaction between different sub-systems has great implications for transport investment. Inducing any change/innovation in transportation (sub)systems would

affect the other (sub)systems such as urban development, economy, and travel behavior. Innovation is referred to as the application of a new system or product to cater to the market demand (Maranville, 1992). As in the case of transport it can be viewed as the implementation of a new transport system like Bus Rapid Transit (BRT) in Lahore. This change in society may occur because of the actors, factors, or institutions involved. So, actor-relational approaches could help to better understand how systems of transport, urban development, and travel behavior are constituted and how these systems are interrelated. The following is the example of what constitutes transport and urban development systems in the case of BRT Lahore.

BRT Lahore from the perspective of an actor-relational approach

The transportation and urban development system from the perspective of an actor-relational approach is presented in Figure 26. There are numerous actors, factors, and institutions involved. When we have a close look at the subsystem for transportation it has transportation plans and policies (institutions) to control public and private transportation. Under these institutions (transport master plan) the BRT system was proposed. These policies triggered implementation of the first BRT system which directly influenced the actors involved. Some of the actors changed their travel patterns and this resulted in inclusion of new actors (e.g. metro bus authority). New feeder routes were also introduced in the vicinity of the BRT corridor. As transportation and land use are highly interrelated, innovation in the subsystem of transportation induced changes in the urban development sub-system. Investment in BRT influences the perception of people and a change in development is then observed along the corridor. So, it can be seen through ARA how different systems are constituted and how they are working in an urban setting. Through this approach the different actors can be identified, and their role can be studied in a more appropriate manner. Some of the actors (government agencies) have overlapping jurisdiction and roles which further complicate the situation. The figure can help identify the actors with overlapping roles and their activities can be managed to streamline the work of different sub-systems. Moreover, people's transportation behavior has an important role which can be accommodated through active involvement of these actors using ARA. When it comes to the interrelated process that influenced people to change their behavior, this can be mapped through inquiries.

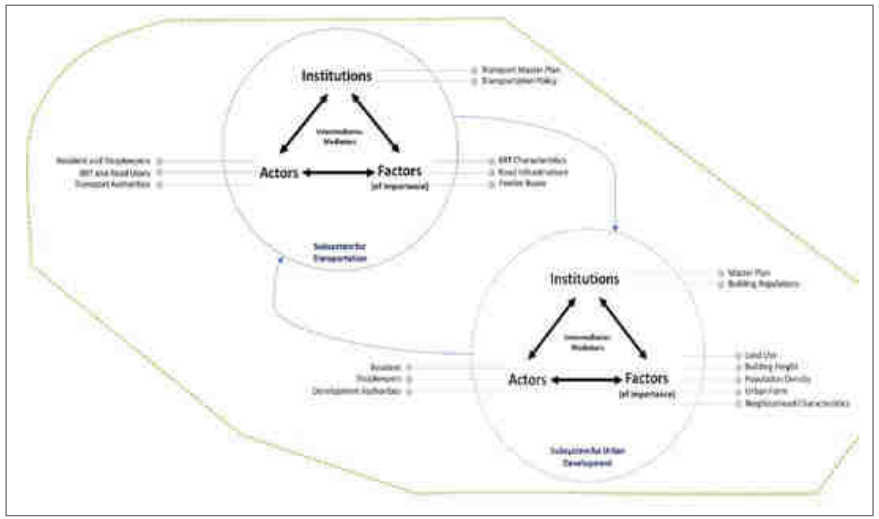

Figure 24.3. BRT-Land use interaction in Lahore

In the existing case, BRT Lahore has influenced the urban development patterns, economy, and transportation modes. It is important to identify these impacts in the creation of sustainable neighborhood and transit-oriented development. A more complexity-sensitive approach like an actor-relational approach can help to better understand different sub-systems and the interrelation between them. The example presented above shows the interrelation between BRT and urban development. But in a broader spectrum, transport investment also influences the economy as well as social aspects, and these can also be studied through the application of an actor-relational approach. The actor-relational approach can help to identify important factors in each system and their interrelation with other systems. This is necessary to explore transport-land use interaction in the case of Lahore and has mostly been ignored in past studies. Thus, in such complex situations like in Lahore, the actor-relational approach not only provides a way forward where one can study different complex systems and the interrelations among them but also provides the way to improve the interrelation of different sub-systems. ARA delineates the process of studying various systems and sub-systems first through identification of components of a sub system (including actors, institutions, and factors) and secondly by evaluating interrelations among several sub systems.

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