INDICATORS THAT MATTER: Measuring Transportation Performance in Ahmedabad

by

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ABSTRACT

In light of the growing challenges of planning for transportation in India, this thesis proposes that a set of indicators, sensitive to local conditions, developed, implemented and managed through a collaborative partnership with public and agency stakeholders can provide an effective framework to evaluate investments in transportation infrastructure. It analyzes the implications of following the Indian Ministry of Urban Development's (MoUD) Urban Transportation Service Level Benchmark indicators, and offers an alternative set of indicators with an eye towards expanding the set of capabilities and choices available to all transportation system users. In evaluating the MoUD's benchmarks and an alternative subset of Human Powered Transport (HPT) indicators, this thesis utilizes participant observation on four main corridors in the city of Ahmedabad, India, a tier II Indian megacity of 5.5 Million people. In light of historical transportation performance and development indicator practices, an alternative set of indicators is developed which attempt to reset the focus on the transportation needs of India's urban population. Finally, this thesis ends with a discussion of the ways that indicator creation can actually become an iterative and reflective process, used by stakeholders to provide equitable transportation outcomes.

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CHAPTER ONE: CONTEXT

INTRODUCTION

In the summer of 2011, I was drawn to Ahmedabad, India (the capital of the Western Indian state of Gujarat) to work with the Institute for Transportation and Development Policy (ITDP), a non-governmental organization (NGO) which has sought to operationalize sustainable mobility practices and policies in India and other developing regions. I arrived in Ahmedabad seeking to better understand the relationship between urban form and transportation performance.

One of my first accomplishments was to obtain a bicycle and explore my new neighborhood, Mirzapur, without experiencing injury. My newly procured wheels allowed me to explore and expand my understanding of the city: Following every lane, becoming lost in every twisted maze of a street, and terrorizing with my handlebar bell many a stray dog. The conditions of Ahmedabad's streets and scale of the city support a large numbers of bicyclists. While these were predominantly men on their way to work – It was not uncommon to see entire families sharing a single bicycle.

From my bicycle, I scanned for indicators of transportation performance through crowded and congested streets. This is an exercise that I repeated on my commute to the office, when making social calls or simply moving around my new environs. When the pre-monsoon heat and challenges of two-wheeled travel proved too difficult a task, I would retire to small glasses of cold sweet coffee and contemplate my progress. While I researched Indian transportation policies, international best practices and indicators of sustainable transportation, my daily experiences outside the office were disconnected from the ideal measurement and sustainable practices described in government documents and glowing reports. My thesis is born of this disconnect. My work seeks to reconcile the competing visions of the Indian street.

Figure 1: Transportation in Ahmedabad

CHALLENGES

I strongly believe that enhancing people's mobility is fundamentally and causally related to improving their economic and social well-being. While planners have been tasked with promoting equity in their work, assuring fairness in their policies, and distributing justice through their interventions (Harvey 1973, Davidoff 1965), few transportation planning objectives directly pertain to equity or social justice concerns (Deka 2004). This neglect may be indicative of the highly technical nature of planning, or it may relate to the highly subjective nature of defining and identifying equity issues. Although some efforts have been undertaken to disrupt patterns of inequity in transportation planning processes – Most notably strategies to increase public participation and community input - an emphasis on participatory processes does not necessarily guarantee outcomes that are equitable or just. The distribution of personal circumstances (and societal conceptions of justice) complicates which transportation interventions are considered fair and equitable. A "Capabilities approach" to social justice positions an individual's freedoms to achieve personal goals (via social, economic or physical mobility) as proxy for well-being (Sen 1999). Thus, at the heart of this study is the issue of providing <u>transportation outcomes</u> that are equitable and that expand the set of capabilities and choices for a diverse group of users.

Transportation planners and traffic engineers have long attempted to remedy the evils of urban congestion and traffic stagnation in constructing new facilities, such as elevated expressways and high-capacity urban arterials. Transportation *performance indicators* – specific, measureable outcomes - are often harnessed to indicate progress (or lack thereof) towards a planned objective. This work explores the ways that we measure transportation improvements and queries the multiple roles of indicators in transportation planning. Specifically, it asks: Where do transportation indicators fit in the context of economic development and urban modernization initiatives?

As incomes around the world rise, more and more people demand the convenience and increased mobility that private motor vehicles allow, but the social, economic and environmental costs of such demands are great. In developing cities in particular, the negative externalities of rapid motorization pose significant challenges to public health and safety. This research also asks how transportation measurement practices are applied in the context of the developing world. What do indicators look like to meet the needs Indian transportation demands and aspirations? What should they look like?

Finally, my research asks how transportation indicators can be made to *matter* in cities of the developing world, where improved public decision-making in policy, planning, and management are identified as core needs (Dimitriou & Gakenheimer 2011). In the context of planning institutions and governance, how are indicator initiatives implemented, maintained, and otherwise sustained?

RESEARCH METHODS

This work is grounded in a theoretical study of development indicators, transportation planning and mobility improvements in developing regions. Through reviewing primary and secondary sources, attending professional conferences, and informal interviews with residents, government officials, planning academics, public and private sector engineers and planners, stakeholders from NGOs, and representatives from civil society, I will explore transportation indicator practices in Ahmedabad. This work is especially important in Ahmedabad where recent developments in transportation infrastructure and urban form have begun to reflect new priorities for mobility.

Figure 2: Firaylal Chowk in Ranchi / Anuj Malhotra

In India, an economically diverse and quickly developing country of 1.2 Billion people, a landscape of rapid motorization, in the form of roadways and elevated overpasses, has emerged in response to congested streets (as well as the perceived impact of congestion on economic development) and aspirations for increased personal mobility. While Indian cities have historically developed with fine-grained urban forms and dense cores that support modes of transportation that are low cost and energy efficient, such as walking and bicycling (Badami et al. 2004), Indian cities have recently become physically decentralized and oriented towards private vehicles (scooters, motorcycles, and automobiles). Despite rapid growth in motor vehicle ownership and activity, non-motorized transport (NMT) modes – including walking and cycling - continue to be utilized by large numbers of travelers. In India's megacities, 30% of the trips are made by NMT, 50% by public transport and intermediate public transport (IPT) such as taxis, autorickshaws, shared autorickshaws / vans, etc. (Tiwari 2011).

Figure 3: Traffic Jam in Delhi / Flickr User N-O-M-A-D

Guided by international transportation benchmarking efforts, the Indian Ministry of Urban Development (MoUD) has promoted a framework of city and metropolitan regional scale "urban transport" benchmarks and indicators to "Introduce accountability in service delivery", measure performance of urban transport activities over time, and facilitate comparison between cities (MoUD 2009). Improving the performance of the transportation sector is especially important in the context of India's demographics, where an overwhelming majority live in rural areas or in medium and smaller (Tier III) cities with a population below 200,000 (McKinsey Global Institute 2010). It is estimated that the resources available to smaller cities will not be sufficient to support civic infrastructure investments required by their growth. Thus, to accommodate such projected growth, these cities will require massive public investments from the state and central governments.

Due to the rapid growth and potential demands for institutional capacity, Indian cities in particular are important sites to explore applications of transportation development indicators. Today, sustainable transport indicators, performance measurements and benchmarks are emerging as popular tools for quantifying the impacts of national, regional, and local mobility strategies. Indicators are favored in this context because of their ability to provide informative signals on the many issues inherent in considerations of sustainability.

THESIS

In light of the growing challenges of planning for transportation in India, I propose that a set of indicators, sensitive to local conditions, developed, implemented and managed through a collaborative partnership with public and agency stakeholders can provide an effective framework to evaluate investments in transportation infrastructure. I will analyze the implications of following the MoUD's transportation indicators, and while recognizing the complicated and potentially problematic relationship between indicators and development, I will offer my own alternative set of indicators with an eye towards expanding the set of capabilities and choices available to all transportation system users. My goal is to adjust the focus of a set of transportation performance indicators to make them more compatible with the Indian context: a rapidly emerging economy in which the overwhelming majority of the population lives in cities and has an unmet demand for low-cost mobility. This is not a hypothesis-testing work, per se, rather it is a proposition and demonstration via analysis.

DEVELOPMENT, ORDER AND LEGIBILITY

It is important to think about the relationship between development and indicators. Statistics and other forms of enumeration are key tools to how we conceptualize degrees of relative progress between nation-states. In this way, statistics produce conditions of development and underdevelopment (Davis and Kingsbury 2011). I will explore how measures and standards of modernization may manifest through the development of transportation systems in India.

Briefly, I would like to reflect on the how differences between developed and developing countries were measured and the process of development was quantified. Following the industrial revolution the pressures were immense to introduce the most modern and expensive technology to developing regions to have "Factories Quick!" (Gershenkron 1963) However, because of the rapid pace of development it was difficult for countries to accurately appraise industrialization impacts. Development was measured in terms of labor skill levels, economic output, and the dependence on other countries' commercialized technology to establish modern industries. Since World War II, development has generally meant an increasing focus on growth of production, consumption of material goods, and an expansion of choice. Such comparisons assumed a particular aspirational model for political, economic and knowledge systems and labeled other systems superstitious, unscientific, and markedly inferior (Scott 1999, Sen 1999). Later, developing countries were measured by dominant institutions (such as The World Bank) on how they created "World standard" state institutions with approved structures of governance and values.

Next, I'd like to think about how the process of development itself creates an order that may not be a natural or traditional one. As countries move along the path from developing to industrialized, a particular cultural and political order - through physical space, as well as people's minds and bodies - is established (Mitchell 1991). In the context of developing transportation systems, a modern subway system in a place like India is a site of disciplined behavior. Instead of relying on discrete, one-to-one relations to continually reestablish a system of order, the subway is highly regulated, with every motion and every space put to specific use. Through the order and discipline of entrance gates or station platform boarding areas, a new form of political power is expressed. With modern transportation practices and new forms of mobility, new behavioral requirements and user regulations closely follow. Thus, it is important to evaluate how transportation modernization initiatives transform local practices and systems of order.

As advances in technology are transferred from developed to developing countries they are often tied to dominant practices (Marglin 1990). For instance, a transportation system like an at-grade, multi-lane urban arterial, may utilize elevated pedestrian footbridges, that prioritize the flow of automobile traffic over pedestrian movement. While this design may be appropriate for a specific cultural context with a specific demand for vehicular movement, it may not be a worthwhile investment where the greatest demand is for pedestrian mobility. Thus, technical planning interventions must be harmonized with local contexts so that modernization and improvements in standards of living can take place without being tied to a dominant cultural or political model.

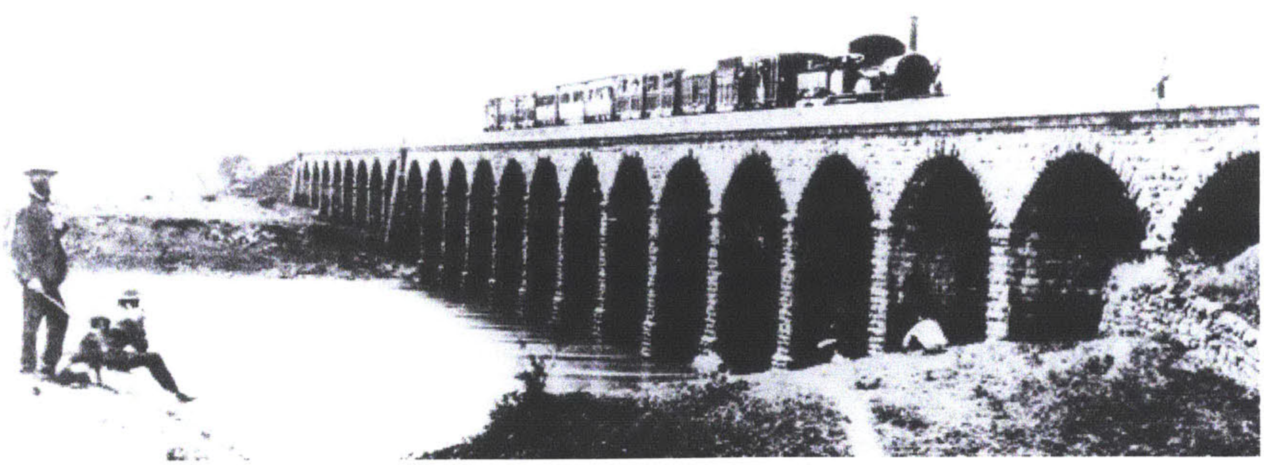

Figure 4: India's first passenger train traveling on a bridge between Bombay and Thane, April 16, 1853. / Public Domain (Found at http://www.irfca.org/~shankie/irhistorybook/irhistindex.htm)

The recent colonial history of India offers a good example. At the time, British politics was based on a strategy of utilizing structure to reveal a pre-existent plan and political authority (Mitchell 1991). Thus, the framework created by colonial order would always appear as though it were conceptual structure. It divided the world into two realms: a realm of things and a realm of order. In the realm of establishing order, the British developed an organized system of transportation into India in 1853, the Indian Railways. Prior to the railroad era, goods transport within India took place on roads, rivers, and coastal shipping routes. The bulk of inland travel was carried by bullocks, along the road network (Donaldson 2010). To the British, the perceived disorder of movement must have represented not just a challenge to the efficient performance of systems, but a paradox: How did Indians cope with what the British saw as an absence of an organizational framework? Despite the perception of disorder, weak authority, and the confusion of movement, the transportation system managed to maintain some sort of order. While this process may have appeared precarious, negotiated, and continually in flux, the production of "disordered movement" was simply a reflection of ordered British practices.

In general, planning interventions sponsored by state or national governments have sought to establish an order to urban systems that emphasizes a particular type of knowledge (such as valuing quantitative measurement) and focus on a singular urban phenomenon (such as congestion). Planners (or state bureaucrats, civic administrators, etc.) observe and measure phenomenon characteristics without the distraction of the potentially complex and unwieldy conditions of the surrounding environment. Thus, central to the field of planning is the production of legible phenomenon (Scott 1991) through strategically essentializing external systems to fit a planner's frame of reference (for example, social use of public space may be ignored to streamline pedestrian movement). As transportation phenomenon are made more legible through planning interventions, it is important to recognize phenomenon that fall outside the narrow focus of analysis and observation of state planners. For example, regarding NMT facilities in India, the state may be concerned with providing a maximum number of kilometers of high-capacity pedestrian footpaths along major urban corridors; however, instead of capacity, local users may value the quality of the footpath, the availability of seating, shade and dedicated space for street vendors. Gaps thus emerge between state and local measurement practices (as well as transportation priorities). Planners representing state interests may consider data collected via local practices suspect and unreliable, as vernacular practices are often messy, temporal, historically specific, and politically loaded (Scott 1991). Also, heterogeneous local practices may not lend well to aggregation into a single series that would facilitate comparison by state officials. Similarly, state efforts to rationalize, simplify, and standardize measures may encounter local resistance or disregard if they are not sensitive to local concerns (Scott 1991).

Endeavors in transportation planning attempted to break tradition in favor of modern notions of development. Such notions sought to impose order on systems viewed (often via colonial or neocolonial powers) as disordered. Through seeking legibility and order, transportation planning projects may run the danger of dismembering existing systems. Today, we see this modern approach to transportation planning (such as modeling and evaluation tools) and investment (such as flyovers), which imply value systems that might not be consistent with local context nor capacities. An example of this is constructing an elevated highway overpass at a busy intersection, where everything that interferes with efficient movement of private vehicles, like the complex system of movement for other modes, such as walking or bicycling may be eliminated. The dichotomy between modern transportation interventions and systems of vernacular movement is especially pertinent in the context of rapid urbanizing regions, where the social and physical needs of pedestrians are undervalued (Tiwari 2010, Thomas and Jacobs 2011, Litman 2011), and the "Sidewalk ballets" of Jane Jacobs (1961), are ultimately discarded in favor of maximizing capacity or providing parking for private vehicles (Montgomery and Roberts 2008, Leather et al. 2011). In the context of modernizing transportation systems, what are the unintended consequences of standardization and interrupting exceptionally complex processes? Is it possible to improve transportation systems without dismembering existing practices?

Figure 5: Newly built elevated overpass and bicyclist, Ahmedabad

OF GOVERNANCE, STATISTICS, AND INDICATORS

Governance refers to a complex set of values, norms, structures and processes that are both public and private, whereby power is exercised in the resolution of conflict (formally and informally) and the management of a country's affairs (Jessop 1998). Governance involves not just the state, but also includes civil society actors, such as community-based organizations, transnational corporations, unstructured groups and the media at all levels (local, national, regional, Global, etc.). The civic realm that is maintained by political actors from the state and society is essential to governance. The concept of *good governance* has emerged as a set of social, political and economic mechanisms that have been subject to contentious debates, which often pit market-friendly reforms against a strong and centralized state. The absence of favored good governance characteristics (Accountable, Transparent, Responsive, Equitable and Inclusive, Effective and Efficient, Based on rules of law, Participatory, Consensus oriented) produces *bad governance structures*, and informal decision-making practices become an analog for corruption (UNESCAP 1997, World Bank 1994).

Global governance acknowledges a shifting of the location of authority from nation-states to international institutions such as the UN, World Bank, etc. in the context of global integration and political fragmentation (Weiss 2000). One of the most notable features of global governance has been the avalanche of statistics. Ian Hacking's Taming of Chance (1990) illuminates how in the 19^{th} Century chance was brought under control of natural or social law. This led to the creation of bureaus of statistics and widespread recognition of regularities in the collection of data (such as homicides, suicides, and divorces), and a shift of beliefs away from nineteenth-century causal determinism towards mathematical probability and statistical laws. Traditionally statistics were utilized at the level of the nation-state to make legible state characteristics (Scott 1990) - To wit, the term statistics is ultimately derived from *statisticum collegium*, or "Council of state" (Latin) and *statista*, or "statesman / politician" (Italian). While the numbers were initially collected for and about the nation-state, with the emergence of global governance more statistics have been produced by international and transnational organizations to observe and evaluate global phenomenon and the effectiveness of policy objectives.

Statistics are often harnessed to present political decisions as objective or disinterested instead of ideological or values-based. To a great extent, statistics shape the objects of policy-making in providing definitions of that which is desired, possible and conceivable (Thedvall 2012). Thus, the creation of statistical categories may be seen as creating society. People, phenomenon and ideas are illuminated through diagrams, tables and charts, which then shape the concerns of policy-makers and communities. Statistics have become closely associated with representing reality objectively, holding decision makers accountable, as well as rendering policy outcomes transparent (Thedvall 2012);

However, it is important to recognize the contradictions that follow these claims. While apparently objective, there is nothing neutral about statistical data (Hacking 1990).

What is an indicator?

While there is no agreed definition of indicators, they generally refer to collections of statistical measures that are tracked over time. Merry et al. (2010) provide the following conceptual delimitation:

> "An Indicator is a named collection of rank-ordered data that purports to represent the past or projected performance of different units. The data are generated through a process that simplifies raw data about a complex social phenomenon. The data, in this simplified and processed form, are capable of being used to compare particular units of analysis (such as countries or institutions or corporations), synchronically or over time, and to evaluate their performance by reference to one or more standards."

The use of indicators as (Social) technologies of global governance has been rapidly increasing over the last three decades (Thedvall 2012, Davis and Kingsbury 2011, Merry et al. 2010). The growth of indicators owes much to the development of statistical knowledge and the role that it has played in modern state-making and the creation of standardizing processes. Also reflected by the growth of indicators is the increasing supply of information and the greater demand for readily available and easily used comparative knowledge to inform decision making.

Indicators are *hybrid objects*, related to questions of technical and social sciences, but combining aspects of science, politics, economics, law, religion, technical applications and fiction (Duchene et al. 2002). However, beneath this messy description lie numbers. Indicators take the form of raw numerical data. By itself, the indicator data does not carry significance, but when it is simplified and categorized it can become more meaningful (Ackoff 1989). The process of data simplification may consist of aggregation from multiple sources. It may also involve filtering to remove irrelevant or outlying data, and / or replacement by statistics (such as means, standard deviations, etc.) to convey information. Information thus represents an understanding of a relational connection (like a cause and effect relationship). Of course, just giving data meaning does not make it *useful* (Whitford and Wong 2009). Knowledge then represents a collection of information that is intended to be useful. Generally, knowledge implies a pattern of connections that provide a degree of predictability.

Indicators can turn any complex field into a data array that feeds into knowledge-building and decision-making processes. Found in many different performance-based management practices, indicators have emerged as a key way of thinking through the logics of implementing policies as they provide evidence that a certain condition exists or certain results have or have not been achieved (Merry et al. 2010). They enable decision makers to assess progress towards the achievement of intended inputs, outputs, processes, and outcomes. Input indicators can include measures of characteristics of resources necessary for the project or program. Output indicators measure the quantity of services delivered or products / byproducts produced. Process indicators measure ways that a project is accomplished or service is provided. However, where technical skill is important, it not only matters that the process is followed, but how well it was carried out. More broadly, Outcome indicators attempt to reflect all aspects of processes. Outcome indicators are measures of system results and project goals that are achieved.

Regardless of the type of indicator listed above, indicators must be reliable and valid if they are to be effectively utilized (Zegras 2006, Keiner 2004). Indicator Reliability simply tells us if repeated measures of a phenomenon of interest using the same indicator yields the same values. An indicator is reliable if it results in similar values regardless of how many times it is measured, or who is doing the measuring. Two threats to reliability include *subjectivity*, when the data collector's judgment influences indicator value, and *imprecision*, where errors result from a poor indicator definition, or an insufficient sample size. Indicator Validity refers to how accurately an indicator measures what it is intended to measure – the concept of interest. In other words, validity corresponds to the extent the indicator data is meaningful in describing a phenomenon. Thus to ensure validity, it is important that indicators are chosen that truly measure this concept and are not simply those that are easily measurable. With indicators in practice, the focus often shifts to measurable phenomenon instead of those that are relevant or important (Keiner 2004).

Developing a set of indicators requires creating a measurement hierarchy of arranged tasks. Within the hierarchy, the first stage of work is concerned with what to measure. The initial tasks completed are the identification of performance domains and sub-domains. Next, the indicators are defined. The second stage consists of detailed technical work focusing on how to measure. The data sources required to construct each indicator must be identified, then detailed specifications for data items and for data handling must be developed. For indicator development to be successful, all elements of the measurement hierarchy must be completed (Mowbray 2003). It is important that the primary conceptual tasks of determining what to measure not be appropriated by technical debates about data specifications. Of course, the technical issues must be resolved for a set of indicators to be practically implemented, but developing a clear vision of goals and objectives should drive the process, including the measurement process.

Indicators may be data driven or they may be driven by a scientific or theoretical problem. Some indicators may be effective at describing a phenomenon, but will have little use in a practical manner. On the other hand, practical indicators may prescribe a particular worldview - There are many trade-offs. What is clear is the power of indicator production. The indicators must be clearly defined so that their connections to policy targets are clear, and the actions connected to the indicator are easily interpreted. Gudmundsson (2011) recommends the following three stages of indicator evaluation:

1. Self-validation: Are the indicators good from a technical point of view?
2. Expert group validation: Which indicators are the most meaningful?
   How do the indicators communicate with a wider scientific community?
3. Societal validation: Are the indicators relevant to key public stakeholders?

Indicator creation is an iterative process (See Figure 6), so critical feedback is absolutely necessary. Indicators and sub-variables evolve over time with improvements in data collection, demographic changes, and variations in cultural value systems, as well as increased knowledge about development processes / impacts. It is beneficial for indicators to be continuously challenged by competing indicators (Gudmundsson 2011). Indicator production has largely remained in the realm of technicians, and the process by which they come to life tends to be treated as a black box (Duchene et al. 2002). Thus, strengthening the societal validation and participatory element may improve the salience and legibility of indicators to the public. A local-focused approach may engage citizens and domestic leaders in a creative and democratic construction of indicators. Opening the process to a wider community may also result in a set of indicators that are less likely to decontextualize and promote an abstract universalism (Gudmundsson 2011).

I'd like to highlight the fact that my own position in developing this thesis similarly treads potentially problematic terrain. As I champion local participation, I am submitting my own indicators as the non-local, technical expert. Ultimately, I believe that the two visions of planning must be reconciled. I do not mean to create a false binary of local vs. technocratic, rather in the realm of indicators, I want to emphasize the potential benefits of augmenting technical recommendations with a participatory framework. Participation is not by itself a pancea, the promotion of qualitative and participatory modes of producing knowledge may ground the indicators in local practices, and thus support the ability to collect and maintain indicator data. It should be noted that indicators created through deliberative processes involving public and stakeholder input do not eliminate uncertainty over how indicators are ultimately employed. They also can further increase power differences between the populations who are impacted by indicators and the experts who produce and apply indicators (Stone 2010).

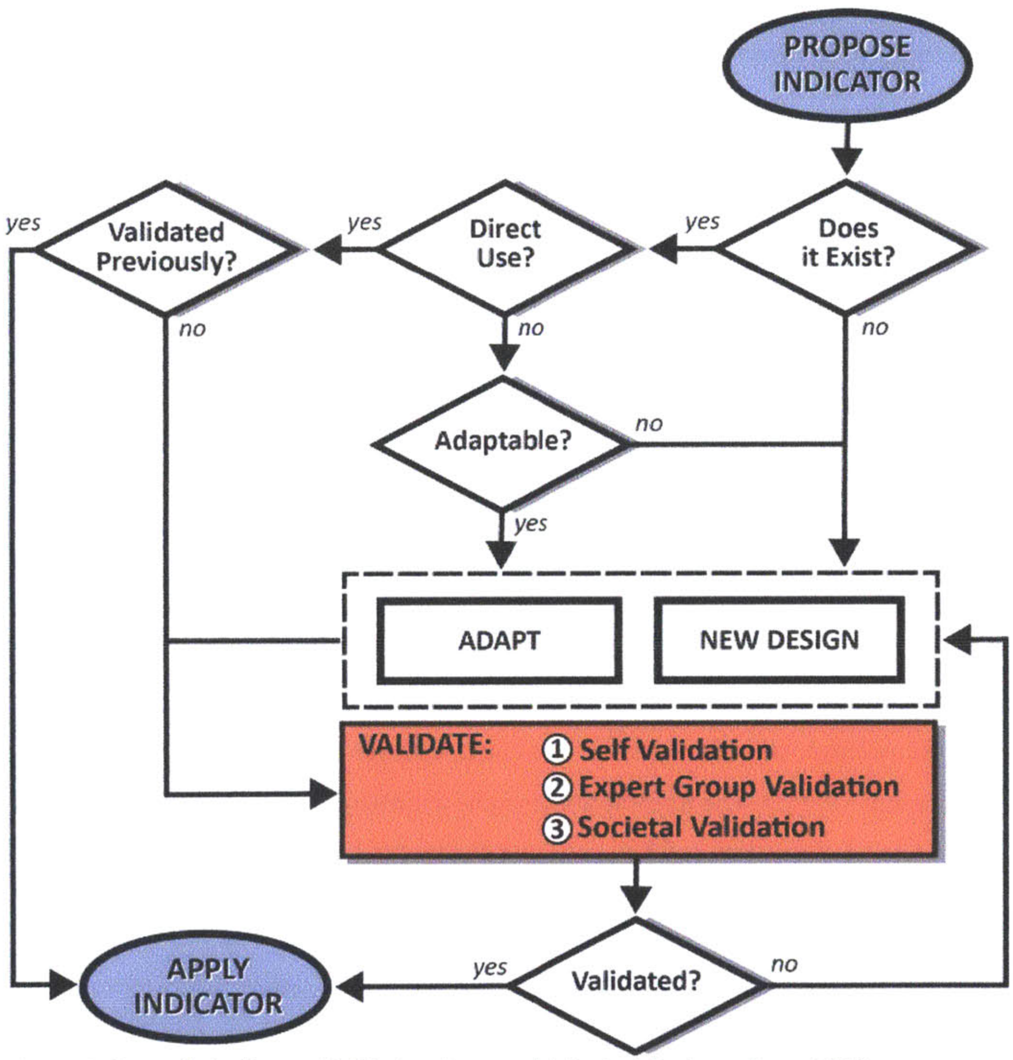

Figure 6: Example Indicator Validation Process / Adapted Gudmundsson 2011

Indicators can play a productive role in highlighting problems, setting priorities, evaluating policies, or monitoring progress. They can help simplify complex arrays of information related to the nexus of transportation and urban development. Through this process of simplification, indicators become important tools for informing decision makers and the public about key challenges, as well as guiding the actions necessary for managing problems. Thus, indicators will vary based on the jurisdictional scale at which they are deployed, and the needs / abilities of the organizations that deploy them. Indicators may be utilized by a multitude of different jurisdictional scales: at the local level by social movements or NGOs, at the city level by municipal corporations or city administrators, at the state level by a particular ministry or government department, at the regional level across governments as a whole, at the global governance level, as well as the many scales in between. An indicator may be utilized on multiple levels, exerting power differently at each level. In practice, it is rare that the same indicators are used across the different levels, as each level of authority may prioritize different strategies and emphasize different sets of data (Stone 2010).

INDICATORS AS INTERVENTIONS

Indicators are everywhere in development policy (Davis and Kingsbury 2011). There are indicators for a multitude of social problems: Child Mortality, Morbidity, Human Development, Human trafficking, Corruption, etc. Indicators have transformed from neutral methods of selecting, evaluating or publicizing interventions to being interventions on their own. As interventions, indicators actively frame problems by making statements about a particular problem's nature and existence. They imply solutions in defining how problems are measured and in this way, indicators become a starting point for dialogue about a problem. Instead of neutral techniques to measure phenomenon of interest, Indicators can transform into especially effective *interventions* when people come to see a particular indicator as a complete representation of a problem's extent. For instance, the Human Development Index (HDI) measures a country's average achievement as a weighted formula of population health and longevity (life expectancy at birth), knowledge (mean years of schooling, expected years of schooling) and standard of living (GNI per capita – PPP $). The logic underlying the formula weighting is a construction of a particular system of values, yet the HDI becomes equated with measuring *human development* (Davis and Kingsbury 2011).

Indicators often become sources of contestation and competition between the organizations and institutions that commission or develop them. There are conflicting incentives, misunderstandings, and diverse assumptions among the different indicators as well as competing ambitions and values of those working directly with the indicator data. Thus, a resulting "Cacophony of indicators" emerges as indicators of multiple scales compete and intermingle (Merry 2011, Stone 2010). In many instances, the indicators are simply not utilized, and the required data are not collected. This may initially be attributed to a lack of skills, technological resources, or constant requests for improvements in the indicators themselves (Stone 2010). Competition between different indicator regimes, constant recalibration of indicator collection goals and methods, often litters developing countries policy grounds with the carcasses of failed indicator projects (Stone 2010). A succession of failed indicator attempts may be a sign of agency resistance to the exercise of power from an internal or external source. Thus, it is important that indicators be aligned with the ambitions of those in positions of immediate and legitimate authority.

Quantitative data and indicators have long been associated with the production of transparency. However, indicators do not automatically increase the transparency of decisions and the understanding of complex phenomena. Indicators carry normative orientations and theoretical assumptions and have significant intended and unintended performative effects (Merry et al. 2011). Technical indicators carry their own claims to legitimacy. In the context of governance, indicators are wielded as instruments of power. Indicators quantify system performance. Thus, elected officials can utilize indicators to manage the operations that they are responsible for. Indicators are available to many different actors with various relationships to authority. Where multiple officials at different hierarchical levels and departments are competing with multiple sources such as local and international NGOs, and foreign governments, for influence over a government policy, supporting a particular regime of indicators can be an effective way to gain control of policy and priorities. This can be a particularly effective method, when more blatant an exercise in power would be met with fierce opposition. The use of indicators in developing countries may be especially powerful as international donors and institutions of global governance can exert tremendous pressure.

In this chapter, I have introduced key concepts and criticisms related to the use of statistics and and indicators as tools for not just diagnosing, evaluating, communicating information about problems, but actually defining problems and influencing solutions (Davis and Kingsbury 2011). Well-crafted indicators can be powerful interventions in addressing development problems because they have the power to influence beliefs by highlighting relationships between actions and outcomes. With the next chapter I will outline key concepts for understanding how indicators are utilized to measure transportation performance.

CHAPTER TWO: MEASURING TRANSPORTATION

In this chapter, I will discuss the use of indicators in measuring transportation systems and in understanding the role of transportation in supporting principles of sustainable development. Distinguished sociologist and quintessential urbanist, Lewis Mumford (1964) asked "What is transportation for?" to critique transportation engineers' *monotechnical* focus on America's highway networks at the expense of other transportation modes. In response, Mumford proposes:

> "The purpose of transportation is to bring people or goods to the places that they are needed, and to concentrate the greatest variety of goods and people within a limited area, in order to widen the possibility of choice without making it necessary to travel."

Thus, a good transportation system minimizes *unnecessary* transportation. If this is indeed the case, which transportation do we define as necessary? Reducing the general demand for transportation may relieve the pressures for rapid motorization that are currently shaping Indian cities; however, transportation systems are not entirely closed ones. Rather they are closely knit and deeply tangled with other systems. Therefore, transportation planning decisions may significantly impact economic growth and job creation, the character and intensity of land use, and socioeconomic and geographic transfers of wealth. A better understanding of the goals of urban development is needed before we can say which transportation is necessary and which is not.

Transportation planning and infrastructure development are powerful policy instruments that guide development in beneficial locations and deflect it from unfavorable ones. Too often, transportation planning has tended to concentrate on highways, traffic, costs and benefits with environmental factors limited to engineering consideration (McHarg 1969). Good transportation planning requires good evidence, which includes detailed descriptions of the performance of the existing transport system as a whole that reflects the opportunities and constraints for all users. Often, the evidence regarding the full impact of transportation interventions is incomplete, if it is available at all. For example, how does one measure the successful performance of a busy commercial street - By traffic throughput (an input indicator), by economic activity (an output indicator), by the presence of on-street parking (a process indicator) or by happy customers (an outcome indicator)?

In regard to transportation planning and operations, statistics and quantitative measurements are utilized to begin to answer the above questions. Like indicators, performance measures are tools for telling a story about a particular organization, or a specific program or policy. Performance measures are constructed to describe goals and objectives, and monitor progress towards achieving them. Transportation performance measures may be used to evaluate existing projects, prioritize potential future investments, as well as link specific projects to regional planning goals. Performance measures are also used to strengthen connections between long-range transportation plans and current services and programs. They may also be harnessed to communicate key information to public stakeholders, and to hold political leaders / policy-makers / government bureaucrats accountable for their decisions. Of course, measuring performance alone, without sufficient resources or institutional support, will not drive better performance results over the long term. Implementing a system for collecting performance data may take additional organizational resources or at least a redistribution of existing resources devoted to planning and programming activities.

At this point, it is important to differentiate between measuring transportation performance and establishing criteria with which to evaluate transportation projects. Evaluation criteria are any factors or standards that are used to support decision-making. Ideally, they are developed to support a specific set of goals and objectives of a transportation agency or planning institution, and to harmonize with a state's laws, policy and regulations. Evaluation criteria can play formative (improving a particular project as it develops), or summative (judging a project's relevance, effectiveness, or success) roles. In the context of prioritizing transportation plans and effectively allocating resources, they can be utilized to assess and appraise the effects of alternative plans, and as justification for selecting a preferred alternative. Where evaluation criteria represent estimations of what we think will happen, Performance measures embody what has actually happened. Thus, performance measures are indicators of the degree to which plans meet project goals and objectives. Performance measures may be used to guide a project's scope, scale and progress through the ongoing and regular collection of data. Measures and targets are set periodically (e.g., yearly), and their effective use requires a constant review of data and collection methods (TRB NCHRP 2010). Releasing frequent and usable reports (both internally and publically) of performance data are key to effectively demonstrating progress, and to developing an institutional culture that values ongoing measurement.

Benchmarks use comparative performance measures to highlight differences. While benchmarking initially referred to the shoe maker's practice of marking feet sizes on their a "cobbler's bench" (Stapenhurst 2009), it has evolved to refer to a cyclical and on-going practice of measuring one's performance relative to others and setting goals for improvement based on industry best practices. This process of self-examination also enables organizations to attain (and maintain) exceptional performance. Benchmarking practices were pioneered by Xerox in the 1970s and have been extensively used in the private sector to back up marketing strategies and efficiency policies (Stapenhurst 2009). They have recently been championed by the transport sector as essential tools in ensuring the quality of public service.

Transportation system challenges are often interdependent on the external environment and adjacent systems. Because transportation systems have such open connections to other activities, changes in transportation may induce changes in human behavior. Therefore, performance measurements must acknowledge the complex relationships between transportation and other systems, especially behavioral changes. A comprehensive list of transportation system performance measures and indicators is at once potentially limitless and operationally impossible. This is especially true when indirect impacts, such as economic development, community well-being, or land-use patterns, etc. are considered. Data for these types of indicators may simply not be available, or if they are available, they are measured at scales that do not allow comparison. Thus, a key challenge for performance measurement is determining which information is most meaningful and most readily available.

MOBILITY AND ACCESSIBILITY

Transportation planning is concerned with the key concepts of mobility and accessibility. Mobility represents an individual's capability to move through space and time. Mobility is measured in terms of "how far do we go" and "how quickly do we get there." The demand for mobility can be attributed to the spatial separation between different types of land uses; however, enhanced mobility can also be seen as a driver for increased separation of land uses. In contrast to the physical nature of transportation-based movement, "Social mobility" refers to people's ability to move ahead and engage in beneficial economic, educational, social cultural and recreational activities. Improvements in physical mobility may increase an individual's capacity for movement, and provide access to opportunities and increased social mobility. Thus, the relationship between physical mobility and social mobility is inherently complementary (Wachs 2010).

Accessibility is the extent by which cities and transport networks enable us to reach our destinations. Accessibility (or access) describes the ability to reach social and economic opportunities, and reflects the generalized costs (in terms of time, money, discomfort and risk) needed to reach them. For example, accessibility can be measured as a function of the cumulative count of opportunities available within a specific travel time or distance. Improving (or maintaining over time) accessibility and reducing these costs is considered the ultimate goal of transportation systems. When planning transportation infrastructure and services, it is important to differentiate between mobility and accessibility. For example, in cities with high levels of congestion, citizens who travel by automobile may experience relatively poor levels of mobility (slow travel speed, low individual travel mileage). However, the cities themselves may be economically successful due to their accessibility (cumulative number of opportunities, activities that are clustered together, many travel options, overall low cost of travel). Transportation systems exist to provide economic (and social) connections - Travel is rarely an end in itself. In terms of transportation performance indicators, mobility is an "input" to accessibility the "output." This distinction is also key to interpreting Mumford's "unnecessary" transport. See Zegras (2011), who says, basically, that a "good" transportation system provides more accessibility per unit of mobility.

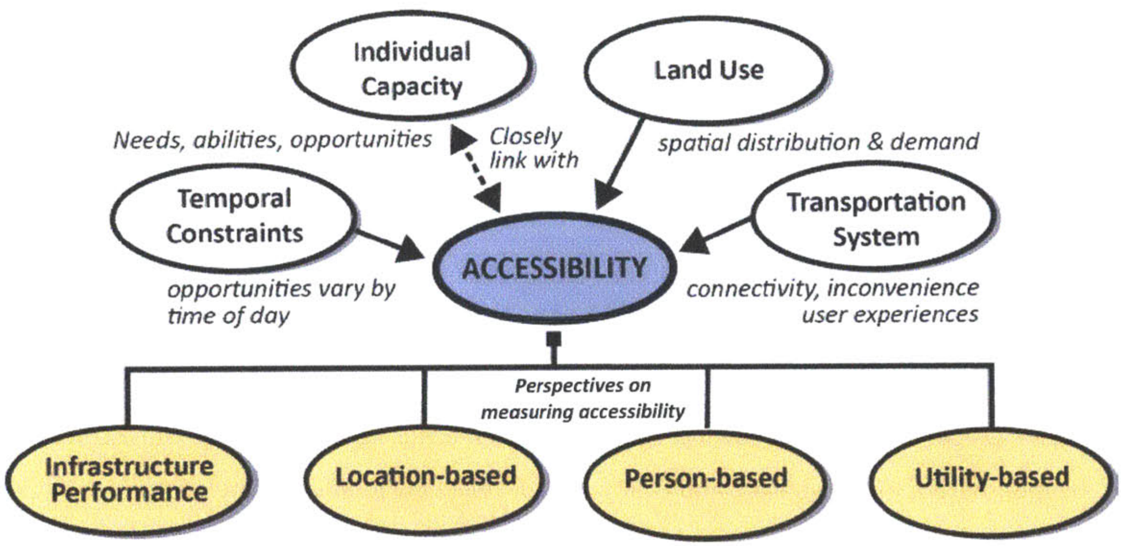

Figure 7: Perspectives on Measuring Accessibility / Geurs and van Wee 2004

While accessibility is seen as a central precept in determining the quality of life in a metropolitan region, planners have long struggled to find a meaningful measure of it. Accessibility is a construct that is often misunderstood, poorly defined or poorly measured. When thinking about defining and operationalizing accessibility, connections between accessibility and the following must be highlighted (See Figure 7):

Land Use: The amount, quality and spatial distribution of opportunities provided at each potential destination. How land is used impacts the demand for these opportunities at the location of the individual.

Transportation system: The way by which cities and developments (private residential compounds, office complexes, commercial centers, etc.) are made accessible. This consists of individual elements like footpaths, cycle tracks, roads, streets, highways, bus and rail infrastructure, bodies of water, or nearly any structure that allows the circulation and movement of people or goods. Accessibility is impacted by the degree to which this system inconveniences the traveler on the journey between trip origin and destination using a particular mode. This highlights the relationship between the supply of infrastructure (such as location and capacity) and the demand for passenger and freight travel.

Temporal constraints: Access to opportunities varies by the time of the day and week (rush-hour traffic peaks, late-night, weekends, etc.).

Individual capacity: Needs, abilities, and socio-economic status that influence a person's access to transport modes and spatial opportunities. It is important to note the reciprocal nature of this relationship - Increased access to opportunities increases an individual's capacity.

Ideally, these factors should all be reflected in the process of deriving comparative measures of accessibility. While there is no single method to measure accessibility that is both comprehensive and convenient (Litman 2005), planners need reliable, accurate and responsive measures to make decisions. Geurs and van Wee (2004) offer the following categories for measuring accessibility: Infrastructure Performance, Location-based, Person-based, and Utility-based. I will now briefly explore each.

Infrastructure Performance: Typically, transportation system measurements are based on the characteristics of physical infrastructure that are most easily captured: travel time, levels of traffic congestion, network speed, total length of roadway network, or number of train stations. Infrastructure-based measurements play an important role in transportation planning simply because the data are so readily available. The capacity of infrastructure and demand for travel determine the performance, or level of service (LOS) provided by roadway or public transportation networks; however, their simplicity is their biggest limitation. These measures do not incorporate relevant information related to accessibility impacts of land use, temporal constraints, or individual capacity (Geurs and van Wee 2004). If the absence of these impacts is not recognized or described, inaccurate or misleading valuations of accessibility are likely.

Location-based: These measures are often utilized in urban planning and geographical studies to describe characteristics of accessibility to opportunities within a specific spatial distribution. Typically, they are a function of the cumulative count of opportunities available within a specific travel time or distance (connectivity), or multi-destination contour measures (travel time catchment areas around a specific node with measures of opportunities per each contour). Location-based accessibility measures may also include gravity-like effects[1] comparing the drawing power of potential opportunities (supply and demand) to the friction of inconvenience created by travel time, distance or cost. Potential accessibility measures have become the most widely used as they are based on data that is easily available, and they yield results that are easy to interpret and communicate (LaMondia et al. 2010).

Person-based: Measuring accessibility is dependent on individual's freedom of action within an environment at a specific time. Person-based measurements demonstrate the relationship between human spatial activity and limitations of capability, coupling and authority. While person-based measures satisfy most of the accessibility components, they require detailed travel data and intense computational requirements which create strong disincentives to utilize these measures.

Utility-based: Derived from random utility, discrete choice models, these measures analyze the economic benefits that individuals reap from access to opportunities that are spatially distributed. Utility-based measurements calculate individual or social benefits of accessibility by estimating which opportunities are preferred (not just by measuring the physical proximity to them). Accessibility is then framed as the result of finite transportation choices. The major disadvantage of utility-based measures is their complexity (LaMondia et al. 2010). While these measurements are able to provide nuanced social and economic evaluations of land use and transportation initiatives, they are seen as being very difficult to interpret and share between planners and decision makers (Geurs and van Wee 2004).

As new transportation developments and infrastructure are proposed or as existing initiatives unfold, it is important to understand how each proposal or project impacts the level of accessibility to

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[1] Potential accessibility measures (also known as "gravity-based") are useful for analyzing opportunities like job accessibility where the effects of competition occur at the origin and destination locations. The accessibility of specific zones are computed with commonly available land use and transport demand models, but they require a iterative process to weigh the attractiveness of each zone based on characteristics such as number of employees, number of employment opportunities, square footage of facilities, etc. (Geurs and van Wee 2004).

essential opportunities as described above. Thus accessibility measurements could play an important role in evaluation criteria as well as ongoing performance measurement. Each measurement category requires that extensive data for a given geographical area (such as population demographics, household–level travel behavior, etc.) are collected. These methods of data collection are not always possible (or accurate). Data limitations force a degree of pragmatism. With the next section I will briefly review the use of indicators in measuring transportation.

INDICATORS IN TRANSPORTATION

The process of using indicators to measure government performance has a long history. In the US in the early 1900s the municipal budget began to be redefined from a tool for accounting to an instrument that was capable of showing the performance of government, fostering transparency and holding elected officials accountable (Williams 2003). To invigorate citizen trust and develop confidence in decision makers, a strategy of both educating the public about the budget process, and publically publishing accounting statistics was adopted at that time. Performance measurement methods included: Conducting comparative studies, promoting routine data collection, measuring outcomes, as well as introducing new quantitative measurement techniques. By the 1930s, performance measurement techniques were realized as an advanced management tool for observing the government at work (Williams 2003). Interest in public performance measurement was renewed in the early 1990s with government performance and accountability reforms gaining traction in the US, the UK and New Zealand (Holzer and Kloby 2005). Following trends in management techniques that emphasized "What gets measured, gets managed" (Drucker 1954) the focus of government began to shift towards delivering more results-oriented public services and performance indicators and benchmarking began to play a greater role (Holzer and Kolby 2005).

Indicators have been extensively used to measure the effectiveness of transportation systems. Recently, a renewed interest in performance measurement was demonstrated by an OECD Road Research Program (RRP) report published in the early 1980s (OECD, 2000). The RRP report found that benchmark indicators were extremely difficult to consistently measure and compare across different agencies. Instead, the RRP felt that the process of measuring performance would be more appropriately used as a way to measure intra-agency improvements.

Following the initial OECD research, the European Commission (EC) developed a set of key performance indicators for different types of public transport operators and a number of cities to identify the most effective and efficient organizational structures for urban public transport. The indicators were eventually integrated into recommendations by the European Committee for Standardization (CEN); however, it should be noted that these benchmarks were not intended to be compulsory nor were they used to set obligatory targets (OECD, 2000). In the mid to late 1990s, the Railway Technology Strategy Centre at Imperial College, London, UK facilitated the creation of the Community of Metros (CoMET) and Nova benchmarking clubs. The CoMet / Nova benchmarking process uses 36 Key Performance Indicators (KPIs), which measure the performance of the organization through five categories: growth and learning, customer, internal processes, safety and security, and financial performance.

In the US, nationally sponsored public transportation data collection efforts can be traced to an 1890 census report on transportation focused on the street railway industry (APTA 2012). Since 1943, the American Public Transportation Association (APTA) has collected different types of public transit passenger data, operating data, infrastructure data, energy data, financial data, service availability and modal share data. APTA is a nonprofit association of transit systems and commuter rail operators, transit associations, state departments of transportation, and other organizations. Today, APTA collects data monthly and submits this data to the Federal Transit Administration's National Transit Database (APTA 2012). APTA reporting is voluntary, but virtually all of the larger and many medium-sized transit agencies report. Data from bus systems (or other systems with less precise ridership measurement capacity) requires significant extrapolation to approximate complete ridership. APTA publishes reports of public transit performance indicators annually. While there is no national data collection mechanism for the transport performance of intermediate public transit, pedestrians and cyclists individual states, regions and municipalities have crafted their own local versions.

The use of indicators is not limited to public transportation. Founded in 1950, the Texas Transportation Institute (TTI), collects data on traffic, automobile transportation and the performance of roadways in US cities. TTI is a research institute funded by the state of Texas, and private and Federal grants that develops an annual Urban Mobility Report (UMR). The UMR is based upon various indicators of daily traffic volume and traffic speed that emphasizes the economic impacts of highway investments and congestion relief measures. In the US, TTI's annual report has been widely used by the media and by federal, state and local decision-makers to define how cities identify and address transportation challenges. While there is "little evidence that the report is utilized at the federal, state or local levels to allocate funds, select among alternative investments, or evaluate the transportation plans" (Cortright 2010), the report's main measure, a road-based travel time index[2], has been very influential in justifying funding for highway expansion projects. Pointing back to Mumford's description of transportation priorities in the 1960s, the report has been recently critiqued for misstating (and potentially exaggerating) the effects of congestion, for focusing exclusively on the needs of automobile users, and for ignoring the effects of land use and complete multimodal transportation systems on economic development and urban growth (Cortright 2010, Garrick 2010). While the report itself is merely a collection of indicators that represents one aspect of a particular system (travel speed on roadways), it does carry power through its reaching title (Urban Mobility) and reputation, and with that power frames a specific set of solutions. The recent critique speaks not just to the power of report naming, but to the perception of indicators and performance measures as objectively representing reality.

The European Commission's Directorate General for Energy and Transport (DGTREN) funded working groups and the development of the Urban Transport Benchmarking Initiative Good Practice Guide between autumn 2003 and summer 2006. The aim of the UTBI was to raise awareness of the potential for performance benchmarking to encourage transport stakeholders in cities to adopt best practices which could improve their urban transport networks. This project expanded on the previous benchmarking efforts and included pedestrian access, bicycle and Non-Motorized Transport (NMT) indicators, as well less commonly used indicators for disability access, congestion pricing and fare payment methods.

Over the last two decades in particular, indicators and benchmarks have been extensively employed by private institutions, governmental and transnational agencies to capture a broad range of transportation systems performance data. Government agencies, departments of transportation, public transport companies, alike utilize indicator collections to measure system performance, shape public policies, evaluate and guide potential transport projects, as well as communicate accomplishments and aspirations to the public. The predominant focus for these indicator frameworks has been related to the function of public transport and the movement of vehicular traffic, but recently additional frameworks have begun to look at a broad range of transportation performance data. As these initiatives have not been compulsory, participants must see benefits in voluntarily dedicating resources to collecting

[2] This is a measure of vehicular congestion that focuses on each trip and each mile of travel. It is the ratio of travel time in the peak period to ideal travel time in free-flow. A travel time index value of 1.30 indicates that a trip will take 30% longer than it would under ideal conditions - A 20-minute free-flow trip takes 26 minutes (FHWA 2010).

performance data and contributing it to each project. The next section will look at the role of transportation indicators in supporting sustainable development.

TRANSPORTATION INDICATORS AND SUSTAINABLE URBAN DEVELOPMENT

In the 1980s and 1990s, the concept of sustainable development emerged as an international priority and global mission. While there is no single pathway to achieving or operationalizing urban sustainability (Keiner et al. 2004, Zegras 2011), we can look to the 1987 Brundland Commission's report that defines sustainable development as meeting "The needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987). While initially referring to the impact on environmental systems, the concept of sustainability has been expanded to seek a balance between current and future environmental, social and economic qualities. Some argue that the current expectations of sustainability are over-reaching and that it has lost its value as a useful concept (Keiner et al. 2004). The worth of the discourse of sustainability may be that it has become a method for assigning value to non-economic resources and their distribution among future generations (Zegras 2011). One could also argue that in economic terms, development is only sustainable when those that benefit from it pay the full social costs to present and future generations (Shipper 1996); however, the "Full social costs" of development are determined by societal values. Therefore, sustainability may be simply the latest in a series of definitions of how societies measure what is just and good (Zegras 2011).

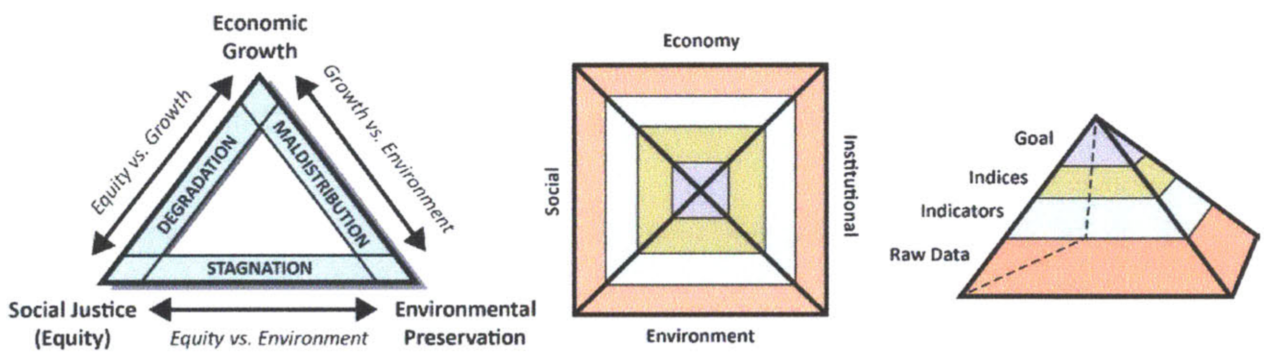

Figure 8: Three Dimensions of Sustainable Development (Feitelson 2002) & Sustainable Indicator Prism (Zegras et al. 2004)

To have the most broad practical relevance and application, transportation performance indicators should be developed as a part of an overall urban policy and planning process. The extent that planning projects and development proposals impact sustainability should be assessed by examining the economic, social, and environmental effects of the transport system (See Figure 8). Feitelson's representation depicts the three dimensions as corners of a triangle, with the tradeoffs between key dimensions noted along the triangle sides. The sustainable indicator prism (also Figure 8) is an effective way to represent the role of institutions in achieving sustainable development. The layers of the prism denote the hierarchical relationship between data, sustainability indicators, indices (indicator combinations / aggregations), and measurement goals.

Sustainable transportation is the application of sustainable development goals to the field of transportation. How a transportation system is defined links its effectiveness to its performance. While there are many ways to measure transportation practices as they relate to sustainable development, there are few practical definitions of, or detailed paths to acheive "Sustainable transport." This murky terrain is fraught with challenging questions: Does the transportation system utilize sustainable practices? Do certain sustainable transportation benefits cancel out liabilities? Does the transportation system impact other regional, national or global sustainable development goals? When the predominant mode of mobility for goods and people – the key goal of transportation systems – is at odds with dimensions of sustainability, should we all stay at home? Perhaps this would be following Mumford's earlier recommendations about avoiding unnecessary transportation.

The Center for Sustainable Transportation (CST) founded in 1996 and based in Winnipeg, Manitoba, was one of the first organizations to offer a comprehensive vision and definition of sustainable transportation. Its goals were to develop quantifiable performance measurements to track progress toward transportation sustainability in Canada. By CST's current definition, a sustainable transportation system is one that accomplishes the following (CST 2002):

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

While initially developed to meet the needs of the Canada's Environmental and Transportation ministries, this definition was adopted (with minor amendments) by the 15 European Union Countries in 2001.

SUSTAINABLE TRANSPORTATION INDICATORS

In an ideal planning process as pictured below (See Figure 9), indicators are defined by the goals and objectives of sustainable development and linked closely with evaluation criteria of alternative strategies. The performance of the transportation system (and key societal and environmental characteristics) comprises the data collected by the indicators.

Sustainable transportation indicators are utilized to examine the possibilities and conditions for sustainable development within the transportation sector, as well as the impacts of transportation systems on sustainable development. The scale of the phenomenon to be investigated (international, national, regional, municipal, specific transport corridor, etc.) will influence the limits for assessment. Recognizing the challenges that radical simplification often creates, it is important that the scale of the analysis and the ultimate goals be clearly identified and transparently communicated.

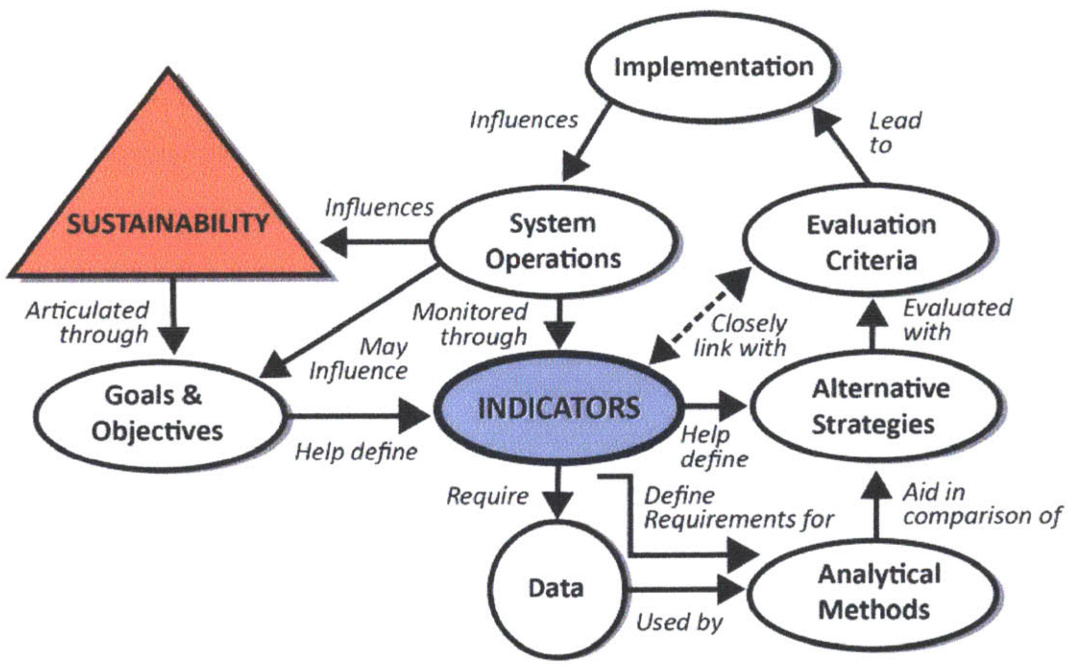

Figure 9: Indicators and Sustainability in Transportation Planning / Adapted from Meyer and Miller 2001, Zegras 2006

Sustainable transport indicators are constructed to measure sustainable transport policy goals, and gauge whether the transport system is moving towards sustainability. Thus, various sets of indicators have been developed and adopted at all levels of governance from the local municipal managers to international development agencies (Pastille Commission 2005). This section presents a brief review of several sustainable transportation initiatives utilized or proposed by the following organizations:

- European Environment Agency Transport and Environment Reporting Mechanism (TERM)
- European COoperation in the field of Scientific and Technical (COST)
- UK Department for Transportation
- US Environmental Protection Agency (EPA)
- Texas Transportation Institute (TTI)
- Partnership on Sustainable, Low Carbon Transport (SLoCaT)
- EMBARQ India
- Indian Ministry of Urban Development (MoUD)

This list is not exhaustive, nor does it indicate best practices. Instead it provides a sampling of the various institutions and jurisdictional scales where indicators of sustainable transportation are being utilized. In measuring sustainable transportation, there is not a general consensus about which indicators to use, or an optimal indicator number (Gudmundsson 2011). These indicators occupy a grey-area between science and policy where scientific information is communicated to decision-makers and vice-versa.

In 1998 the European Environment Agency (EEA) developed the Transport and Environment Reporting Mechanism (TERM) which allowed policymakers to gauge the integration of environmental and transportation initiatives. Between 2000 and 2010, the EEA has released annual TERM reports and developed a set of goals to serve as benchmarks. Annual reports utilize a core set of 12 indicators (CSIs) that are weighed heavily towards tracking environmental targets and are publicly shared via an online interface (EEA 2011). Thus, the efforts of European Union members are visible for policy-makers and constituents alike. Via the TERM process, transportation indicators are collected on a national level then compared on an international / regional jurisdictional scale. These indicators have been refined over the last 13 years, and are quite practical. This collection represents the most realized and institutionally supported indicators of those that I review.

The European COoperation in the field of Scientific and Technical (COST) Research indicators consist of 49 indicators ("Chains of causality") that focus predominantly on environmental and health / safety impacts of transportation developments. As indicators often mix cause and effect variables, the chains of causality approach sought to highlight the processes that were between the transport system and the final target of impacts to the environment (Gudmundsson 2011). COST is an intergovernmental framework that supports interdisciplinary collaborative research on a European level. This particular COST action (#356) took place between 2005 and 2010 and was primarily concerned with building consensus between scientists of 20 European countries on indicator definitions for measuring Environmentally Sustainable Transportation (EST). The indicators recognize the broad scale of environmental impacts from local to international. Because COST was an academic exercise in indicator creation, the EST data has not be collected. If the indicators were implemented, they would draw data from the international, national, regional, corridor and site specific administrative levels. EST data would be compared on an international / regional jurisdictional scale.

The UK's Department for Transportation has developed a set of Input and Impact indicators, primarily to make national progress on sustainability goals transparent. These 15 indicators are not an exhaustive representation of the full impacts of transportation on sustainable development. They represent the specific responsibilities and goals of the department. They focus on the performance of public transportation, economic costs of maintaining highways and transportation systems.

The US Environmental Protection Agency (EPA) recently released the first version of their Sustainable Transportation Performance Measures in 2011. The 35 indicators cover a wide range of typical sustainability measurements that are geared towards municipal policy makers, planners and citizens who are interested in evaluating the sustainability of future transportation developments.

In 2002, the Texas Transportation Institute (TTI) released a research document that attempted to map common transportation performance measurements to transportation sustainability concerns (Zietsman and Rilett 2002). The goal of TTI's indicator framework was to identify, quantify, and use performance measures to support sustainable transportation in the planning process for a freeway corridor: Travel rate; Fuel consumption; Emissions (HC, CO and NOx); Safety, and Travel cost. The TTI set of 13 indicators is from 2009, and is geared toward applying automobile-centric transportation levels of service metrics for discrete transportation corridors.

The Partnership on Sustainable, Low Carbon Transport (SLoCaT) is an nonprofit organization whose goal is to improve the knowledge on sustainable low carbon transport, and assist in developing better policies and catalyze their implementation. The partnership is hosted by UN-DESA; the Asian Development Bank, the Inter-American Development Bank and the African Development Bank, it also consists of technical cooperation agencies, NGOs, research organizations and other organizations. I chose the SLoCaT indicators because in comparison to other indicator collections, as they were the most broad and open to interpretation. The indicator documentation makes clear that they are provided as an example to start a discussion rather than comprehensive recommendations. 10 indicators address the big four concerns of sustainability (the environment, social equity, economic development, and governance / institutions).

The EMBARQ network, is a subsidiary of the World Resources Institute Center for Sustainable Transportation. Based in Washington, D.C., the network consists of five centers in Mexico, Brasil, Turkey, the Andes and India. It works to influence policy and transportation developments to support environmentally sustainability. The 30 EMBARQ India indicators, are taken from a research document that EMBARQ released in 2007. Its focus is on Indian cities of various sizes, and has pragmatically chosen its indicators in recognition of the challenge of finding data that are accurate and appropriate to document transportation sustainability. The indicators support WRI's overall mission to curtail / stabilize motorization, and encourage the development of high quality mass transport systems.

The last indicator set chosen is a benchmarking initiative from the Indian Ministry of Urban Development (MoUD). The Service Level Benchmarks (SLBs) for Urban Transportation were released in 2009 and include 35 indicators, most of which are multi-measurement indexes. While some of the indicators are specific to discrete transportation corridors like the TTI Indicators, there is also great attention placed to municipal regions. The rest of this study will closely examine the institutional structure and indicator variables that were chosen for the SLBs.

In reviewing the collections of indicators, and comparing them to the UN's Indicators of Sustainable Development (UN ESA 2007) the above sub-categories (based on sustainability dimensions and transportation performance) become visible (See Table 2.1).

Table 2.1: Potential Indicator Categories, Sub-Categories for comparison (Adapted from UN EAS 2007)

SOCIAL	• Accessibility • Social Equity • Safety / Health
ENVIRONMENT	• Environmental Damage / Emissions / Waste / Noise • Rate of Motorization / Vehicle Distance Traveled • Use of Alternative Fuels • Vehicle Occupancy (High Occupancy Vehicles / Average Vehicle Occupancy) • Land Use, Intensity of Development • Land Consumption of Transportation • Energy Consumption of Transportation
ECONOMY	• Population, Density & Growth • Economic Impacts • Freight
INSTITUTIONS	• Participation / Governance
TRANSPORTATION SYSTEM PERFORMANCE	• Non-Motorized Transportation (Pedestrian and Bicycle) • Public Transit • Traffic LOS (speed, congestion, reliability) • Use of Intelligent Transportation Systems (ITS) • Vehicle Parking Management

Figure 10 puts the eight chosen indicator sets into broader context. Each indicator collection is given a unique color and arranged by the particular jurisdictional level (global, countrywide, regional, etc.) the size of the circles displayed corresponds to the number of indicators per each sub-category (from table 1). What is most striking about this comparison is the way that the indicators are bunched in the public transit, safety/ health, economic impacts, social equity, and environmental damage / emissions / etc. categories (Red dashed rectangles in Figure 11). Indicator concentrations do point to a common definition of sustainable transportation that is focused on public transport and non-motorized transport performance, and less concerned with rates of motorization or vehicle miles traveled. Of course, these indicators may just be the easiest to measure. While accessibility is a key goal of transportation systems, it is also extremely difficult to measure. Thus, only three of the indicators address it (US EPA: Access to employment by income group & Access to other destinations by income group, UK DfT: Households with good transport access to key services or work).

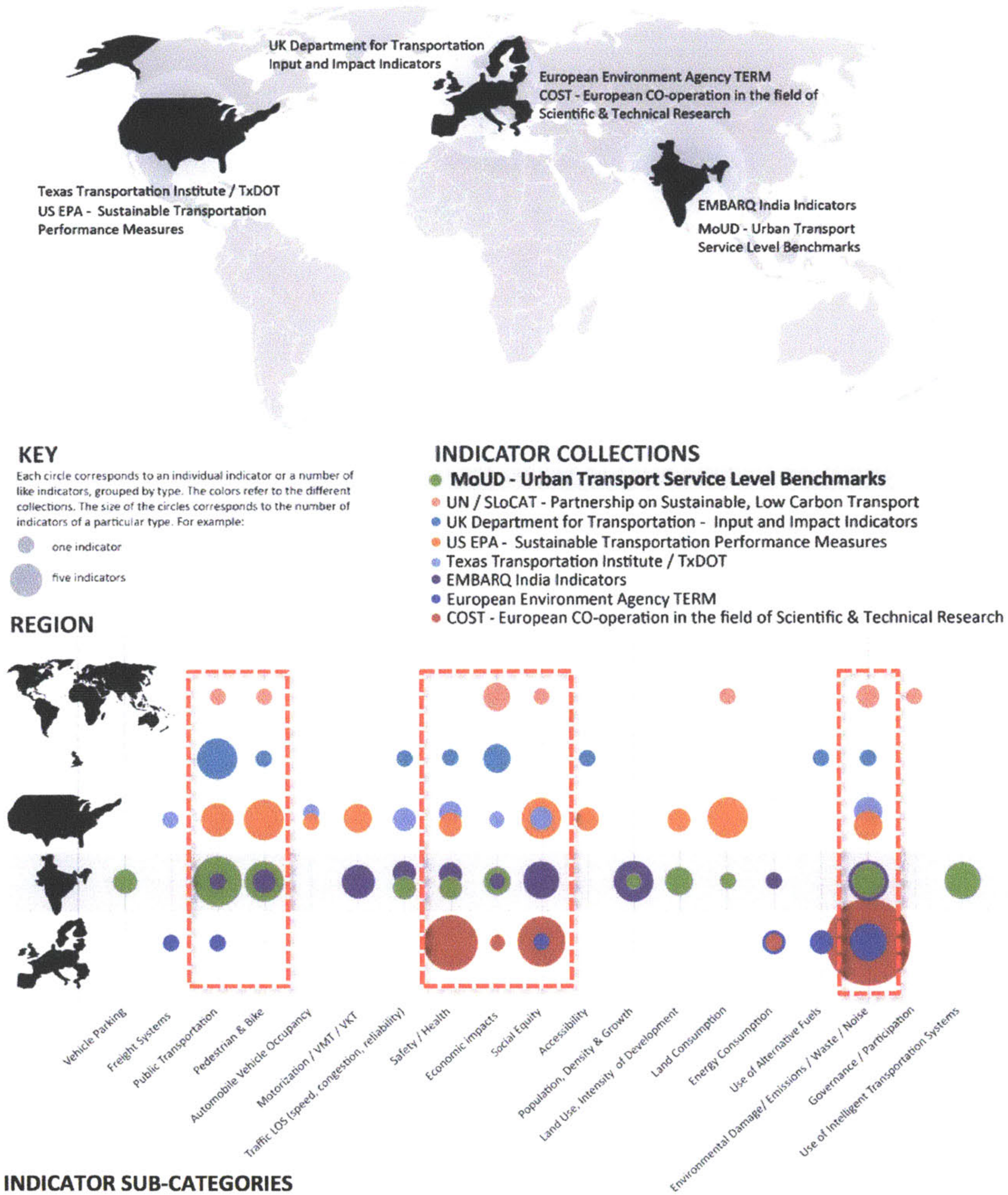

Figure 10: Indicator frameworks by region and across simple categories. Showing MoUD benchmarks

Comparing the indicators from the TERM and COST (European Community), there is a deep concentration on environmental impacts of transport ranging from the proportion of vehicle fleet meeting certain emission standards (TERM CSI 34) to the loss of ecosystem health, loss of biodiversity, due to habitat fragmentation (COST 35). Both collections of indicators have benefitted from the ongoing TERM project efforts (sponsored by the EEA), the historical practice of data collection, and the cultural ethic of data transparency. Indicator creation is an iterative process. Thus, these collections have benefitted significantly from previous transport sustainability indicator refinement. In general, the social demand for measurements and data collection may be specific to this regional union (or to influential states within it). Municipal hygiene bureaus and networks for collecting industrial pollution data have been present in Western Europe since the late 1800s (Duchene et al. 2002). Here it is important to emphasize the specificity of these indicators, not just to the long iterative process from which they emerged, but from the social environment where they are demanded.

With the importance of societal validation to the process of indicator selection and production, it is interesting that only one of the chosen collections focuses on participation. The UN-SLoCAT indicators specifically include "Governance / Participatory transport planning" to involve the public in the decision process for transport policies and projects. This is the only indicator collection to utilize a *process indicator*. While buzzword-fueled "Public participation" initiatives can often result in empty exercises, false promises and frustration instead of actual empowerment, including a diverse array of stakeholders and informed citizen groups is crucial to develop indicators that are sensitive to a greater number of potential outcomes. Governance does matter. The vision of sustainable transportation must be paired with the power of execution in order to make the good possible. The development and use of sustainability indicators is related to the existing networks and connections between policy actors and on the specific form of local institutions. Thus, validation by local institutions must be understood as a set of norms, working practices and organizational structures to match with appropriate indicators.

In the context of the India-based collections, what is interesting is the relationship between the EMBARQ indicators and the MoUD SLBs (Grey horizontal bar in Figure 11). Because both were developed to serve similar purposes - comparing basic transport conditions in Indian cities - one would expect to see less divergence between the indicators utilized. However, the two indicator collections were developed by agencies with divergent goals and interests. EMBARQ collected indicator data by reviewing city development plans, comprehensive mobility plans, comprehensive traffic and transportation planning documents submitted to the MoUD between 2005 and 2007. The EMBARQ indicators focus on social equity by including GDP per capita, Gini coefficient (which measures the inequality among values of a frequency distribution such as levels of income), household median income, as well as household expenditure on transport (in terms of percentage of monthly income and in $ per month). EMBARQ's indicators also address rates of motorization by measuring the numbers of two and four wheelers per 1000 residents, and transport energy use per capita. On the other hand, the MoUD SLBs do not rely on the same documents and data sources as the EMBARQ indicators (even though they are MoUD documents). Instead, they utilize new measurements such as the management of municipal parking facilities, the use of intelligent transportation systems, land-use, intensity of development, road network completeness and land consumption. There is some overlap: the two collections do share indicators on environmental damage measurements. Both utilize air quality data that is being collected and validated by India's central pollution control board (CPCB). Thinking broadly about indicators and specifically about indicators in India, this discrepancy is important. I argue that the MoUD SLBs represent a new and experimental process, while the indicators presented by EMBARQ India reflect the WRI network's depth of experience with transportation performance measurement.

It is important to note that the most of the collections listed reside in academic and theoretical realms. Even when the collections are based from a government agency (such as the US EPA, or the Indian MoUD), they are instructive suggestions for idealistic programs as opposed to realistic mandates for government action. With the exception of the UK DfT indicators, they do not have explicit institutional support to gather data or influence system operations. Also, the EMBARQ and MoUD collections are not labeled specifically as being sustainable, or related to sustainable development, yet they both address the key sustainable development dimensions. In the next chapter, I will examine in detail the MoUD's SLBs and offer a set of concrete suggestions to expand their potential impact. The MoUD SLBs have a greater need for analysis than the EMBARQ indicators because they are sponsored by a government agency that is posed to direct significant capital towards transportation improvements. Although the SLBs are experimental / theoretical in nature, and their current use is minimal, as far as I can tell they have a much greater chance of actually being utilized to impact Indian transportation systems.

CHAPTER THREE: MEASURING TRANSPORT IN INDIA

This chapter will first briefly introduce the institutional framework for the Indian transport sector. It will highlight historical trends, current efforts to measure transportation performance and will explore the Urban Transportation Service Level Benchmarks as developed by the Ministry of Urban Development. The MoUD SLB indicators will be analyzed in detail and an alternative set of experimental indicators will be developed.

INSTITUTIONAL FRAMEWORK

India's transportation sector is supported by private companies, city development agencies, municipal corporations, state institutions and national bodies. On the national level, the Planning Commission and at least four of the forty-six ministries within the Union Council of Ministers (the official decision-making body of the Government of India) are concerned with transportation planning and implementation. This includes the following: The Ministry of Finance (MoF), The Ministry of Urban Development (MoUD), The Ministry of Railways, and The Ministry of Road Transport and Highways.

Similar entities exist at the state jurisdictional level. Each state may have a different set of departments and institutions. The state of Gujarat has the following departments which are responsible for transportation: Finance Department, Revenue Department, Ports and Transport, Roads and Buildings Department, Urban Development and Urban Housing Department, Home Department, Forests and Environment Department, Gujarat State Road Transport Corporation (GSRTC), Gujarat Infrastructure Development Board (GIDB)[3], and the Gujarat Urban Development Company (GUDC)[4]. It should be noted that Gujarat has a reputation for highly effective institutions (Krishna 2011). Thus, in other states, the responsibilities for transportation may be spread across more departments and official bodies.

With the exception of the capital region of New Delhi, most Indian cities are under one government unit, the Municipal Corporation. Often there are regional and municipal development agencies, as well as miscellaneous other civic bodies working in conjunction with the corporation to design and implement civic infrastructure projects. For the Ahmedabad metropolitan region, the following institutional bodies oversee transportation infrastructure and services: Ahmedabad Urban

[3] GIDB is a state government organization responsible for promoting investment and private sector participation in all areas of infrastructure development projects.
[4] The role of the GUDC is to support urban development in Gujarat by coordinating between the state government and municipal / regional agencies. GUDC develops policies, assists in funding and implementation of projects, and provides institutional capacity building support.

Development Authority (AUDA), Ahmedabad Municipal Corporation (AMC), Ahmedabad Municipal Transport Service (AMTS), and Ahmedabad Janmarg Limited (AJL). The AJL is the governing company for Janmarg Bus Rapid Transport System (BRTS) operation in Ahmedabad. It was constituted as a Special Purpose Vehicle (SPV) by the AMC, AUDA and the Government of Gujarat. BRTS in Ahmedabad is generally considered a successful transportation system (and significant political victory) for the city as well as the state government (Mahurkar 2010). It is important to recognize that the AJL steering committee is predominantly made up of state level institutions (Urban Development and Urban Housing Department, Finance Department, GIDB and GUDC).

As Indian cities expand, and suburban areas develop, Regional Development Authorities are beginning to flourish. The proposed Ahmedabad Metropolitan Region Development Authority (AMRDA) would have an administrative area of 11,548 sq km and would encompass parts of five adjacent districts connecting the region with extensive highways and additional rail links. However, legislation required to officially establish The Authority and the Ahmedabad Municipal Region (AMR) has lingered (Times of India 2010).

In theory, the Planning Commission develops short range (Annual, 5 year) plans, creates a long-term strategic vision, then works with Central and State governments to implement the plans and vision. However, in practice, the three jurisdictional levels (Central, State, Metropolitan region) share various planning and implementation responsibilities related to transportation services and infrastructure. This process follows a highly fragmented decision-making structure that is without effective coordination (World Bank 2007). The degree of power that each jurisdictional level wields over transportation varies city to city. For example, the Indian Railway, a state-owned enterprise operated by the Ministry of Railways, controls the Mumbai Suburban Rail which carries approximately 7 million passengers daily over 465 km of rails (Rangwala 2007). Thus, one central government ministry has a significant impact on Mumbai's local transportation system and urban development. Transportation systems in Ahmedabad, on the other hand, are greatly impacted by state level institutions.

MoUD, JNNURM AND URBAN TRANSPORT

In my work I focus on the MoUD's role in supporting urban transportation. It is important to note that the MoUD also has the responsibility for formulating policies, supporting and monitoring programs in the areas of urban development and urban water supply and sanitation. While these are primarily administered by state and local governments, the Government of India coordinates and monitors these programs centrally. The MoUD also coordinates the activities of various central ministries, state governments and other authorities in so far as they relate to urban development issues in the country.

While it was approved in 1961, MoUD wasn't fully entrusted with the responsibility for planning and coordination of urban transport systems until 1986 (Mahadevia 2006). Previously, urban transport was not the responsibility of any specific ministry. The transport needs of urban areas were split by modes between the MoRTH and Indian Railways. The MoUD is responsible for the coordinating and planning of urban transport systems not including road-based systems (subject to the Ministry of Road Transport and Highways) and rail-based systems (subject to the Ministry of Railways). The role of the MoUD[5] was solidified with the publishing of the National Urban Transport Policy in 2006 that recognized that at the state level, the subject of urban transport was split between different Ministries / Departments. As such, MoUD plays an essential role in ensuring that urban transport was an integral component of urban planning and development at the national, state and local levels.

The MoUD is responsible for the large-scale urban advancement initiative, the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). Launched in December 2005, the JNNURM was envisioned as a 7 year, $20 Billion effort to improve quality of life and update urban infrastructure through making available capital funding for water supply and sanitation, waste management, road network, urban transport and central city redevelopment and slum upgrading projects. Per JNNURM guidelines, a total of 65 select cities are eligible for grants, which depending on the city size, fund from 50% to 80% of project costs. To accommodate a broad set of goals ranging from making cities "investor friendly" to upgrading slum facilities, the JNNURM has been split into two sub-missions, Urban Infrastructure and Governance (UIG) and Basic Services to the Urban Poor (BSUP).

Since the launch in 2005, the UIG mission approved 515 projects, of which 132 were for Roads / Flyovers / Road over-bridges (95), Mass rapid transport system (19), other urban transport (15), or parking initiatives (3). Of those projects sanctioned, $425 Million worth of central assistance flowed to projects that were actually completed. Approximately 30% has been to support roads / flyovers / RoB (20%), mass rapid transport systems (5%), and other urban transport (5%). JNNURM has also become a

[5] Prior to 1985, urban transport was not a ministry responsibility. Interstate bus policy was the responsibility of the Ministry of Surface Transport, while the Ministry of Railways claimed exclusive responsibility for planning and constructing intra urban rail systems anywhere in the country. Following an attempt by the Railway Ministry to develop an underground subway line in Kolkatta that was much maligned for poor implementation and slow pacing and inefficiency (the initial 17km single line took more than 15 years for completion and was 12 times over budget), responsibility for planning and coordination of urban transport was assigned to the MoUD (Rangwala 2007). Thus, for planning and implementing Delhi's Metro Rail, a special purpose corporation was established and administered by the MoUD.

primary source for funding the procurement of modernized public transit vehicles. Thus, the MoUD developed a set of urban bus standards to ensure that agency resources are spent on modern vehicles that are safe, comfortable, and energy efficient (JnNURM, Sivaramakrishnan 2010).

The JNNURM is a realization that Indian cities were unable to undertake renewal on their own. The required city development plans (CDPs) are shaped by consultants without public input. Thus, there is a significant need to democratize urban plan-making and development processes (Mahadevia 2006). The most contentious components of JNNURM are the conditions and prerequisites necessary for accessing central funds. There are mandatory and optional financial, property rights, and decentralization reforms at the urban local and state for grant recipients to accomplish during the funding period. These reforms will include requirements for data collection of key service level benchmarks and performance parameters (SLBs), and it is envisioned that the SLBs will become an integral part of city development and planning processes. However, this policy objective has not yet been implemented.

With the next section, I will look at the Indian transport sector and explore how people are mobile in Indian cities.

TRANSPORT IN INDIA

In India, the transport system consists of a wide variety of modes and services (from heavy goods carriers, to ox-carts and pedestrians). In India from 1950 to 1970, less than 20% of the population was in urban centers. Thus efforts were focused on rural development via transportation connections and master planning in some cities, where non-motorized modes were responsible for approximately 60% of urban transport trips (Pucher et al. 2004) Between 1981 and 2001, the population of India's major metropolises effectively tripled. State investments in highways, urban ring roads and state road transport undertakings (SRTU) – intercity and intracity bus systems sought to address the population shift and increased demand for travel (Singh 2005). Since 1981, Indian cities have seen a tremendous growth in registered motor vehicles (See Figure 11 below) thanks in part to government policies that facilitated an open and productive vehicle manufacturing sector (for motorized two wheeled and four wheeled vehicles), investments in roads, and popular loan schemes that made vehicle ownership increasingly possible (Tiwari 2011, Singh 2005). India's economy has been booming and growing urban incomes have also been an important factor in the rapid increase in motor vehicle ownership (Pucher et al. 2005). The mismatch between public transport infrastructure and services in urban areas and the growing demand for urban mobility is also another factor in the growth (World Bank 2007). Also contributing to the growth are urban land market and development patterns in Indian cities that force people to live in areas poorly served by public transportation (Tiwari 2011).

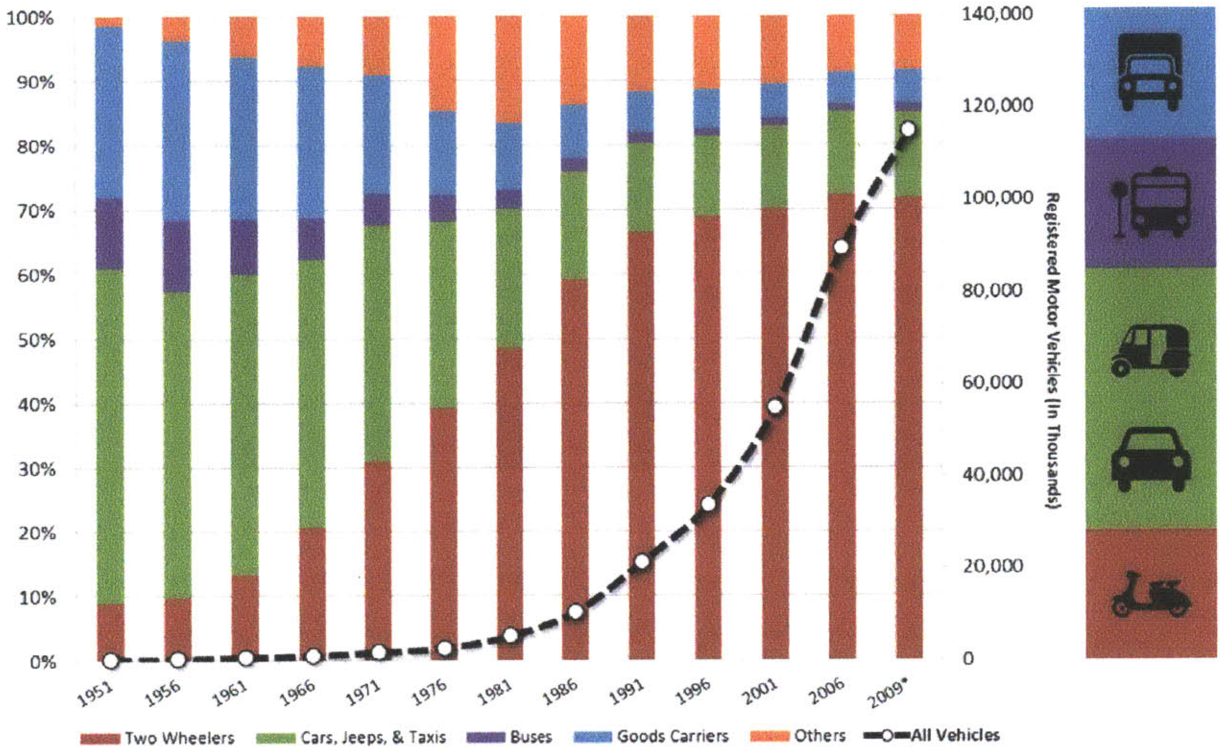

Figure 11: Total Number of Registered Motor Vehicles in India - 1951-2009 (MORTH 2011)

Motorized two wheelers have dominated the overall increase, comprising more than 70% of all registered vehicles (Figure 11). In India, motorized two wheelers (including scooters, motorcycles and mopeds) have been a boon to personal mobility. However, this common motorization pattern in many countries in South and East Asia has been shown to negatively impact air pollution and traffic safety (World Bank 2007).

While the dramatic increase in motorization is important, India's transport sector is still dominated by NMT and public transport. Non-motorized modes of transportation, including bicycles and rickshaws are an integral part of transport in Indian cities. It is important to note that while India's reputation is of megacities, 53% of India's urban population lives in small cities with a population less than 500,000 people (See Figure 12 - Red dashed rectangle). In contrast, 15% live in megacities, with a population greater than 8 Million people (Wilbur Smith Associates 2008).

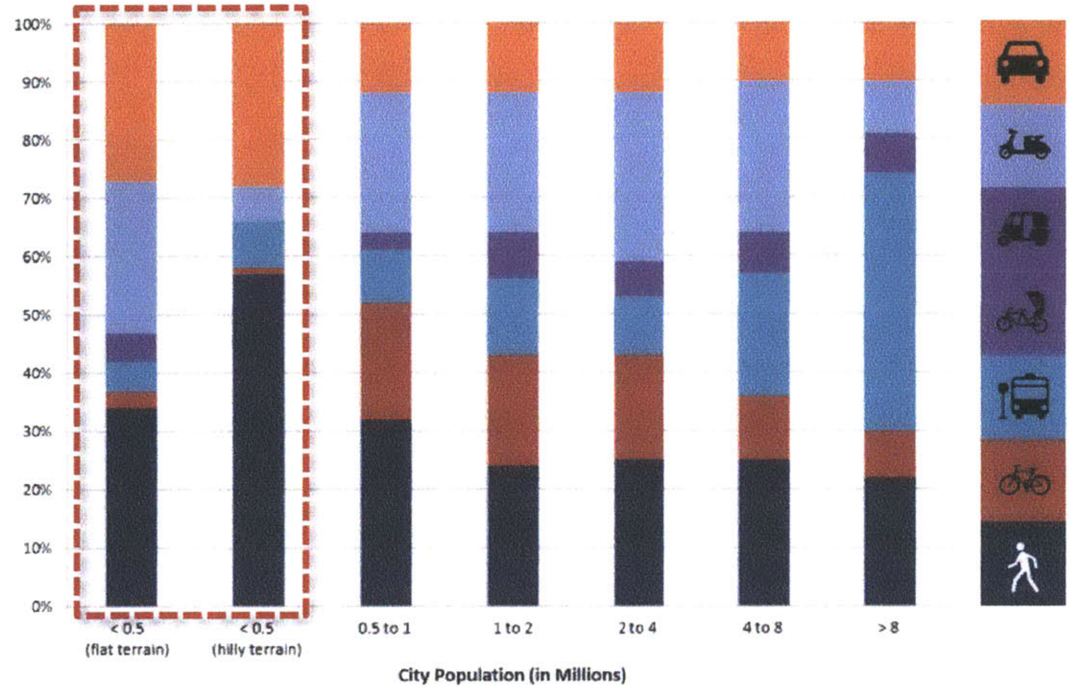

Figure 12: 2007 Modal Split in Indian Cities by Population (MoUD 2008)

Across Indian cities, from small to mega, 22% to 55% of the trips were completed by walking (See Figure 12). This is an important figure to keep in mind, when thinking of how transportation developments often prioritize vehicle movement over bicycle and pedestrian movement. Also of importance is that the above data does not include the pedestrian trips that are essential to each public transit journey. From the same 2007 data, the average urban mode share was the following:

- **28 %** by public transport (bus and rail)
- **28 %** by walking
- **16 %** by motorized two wheeler (including scooters and motorcycles)
- **12 %** by motorized four wheeler (automobile/jeep/van)
- **11 %** by bicycle
- **6 %** by intermediate public transport (including auto and bicycle rickshaws)

Thus, modal shares in Indian cities typically favor NMT and public transport, despite hostile conditions towards public transport and increased safety hazards for pedestrians and bicycles (Tiwari 2011). This may point to the degree that India's economic growth has left a significant number of people behind, and public transport and NMT users simply do not have other choices. India's new wealth has deepened inherited inequalities, or created new ones as migrants from rural areas come to the city in search of potential opportunity. The lowest income poor reside in informal settlements on the urban periphery, squat on vacant lands or dwell in inner city slums of pavements (Tiwari 2011, World Bank 2007). Indians of different income strata will have different expectations of the urban transportation system, and different degrees of access to transportation decision-makers. Thus, it is important that transportation plans include the needs of those at the low end of income distribution with the least political access - primarily pedestrians, bicyclists, who also may be public transport users for longer distances.

In the last decade, larger Indian cities have made significant progress in modernizing bus fleets and planning Mass Rapid Transit Systems (MRTS). Following the success of the Delhi Metro starting in 2002, Indian development ministers and municipal planners have seen MRTS as a panacea against congestion and have recommended them for most cities with over 2 million in population (Badami et al 2004). As a result, Metros have been planned (or are in construction) for Mumbai, Chennai, Bangalore, Hyderabad, Ahmedabad, Jaipur, Kochi and others. However, urban poor are not expected users of the MRTS (Tiwari 2011). Systems are priced higher than existing bus or tempo services that are often displaced when a MRTS is implemented. In general, Indian planners have much affection for rail-based modes. This resulting bias towards rail[6] and Metro Rail in particular has hindered exclusive right of way developments for urban bus systems (World Bank 2007). While there has been a predisposition to rail in transportation plans, buses account for most public transport services and for virtually all public transport services in cities with less than 5 million residents (Tiwari 2011). Municipal bus services are known to operate in at least 17 cities with a population of over one million. Bus Rapid Transit systems have been explored in several Indian cities with limited degrees of success. Most notably, Ahmedabad's Janmarg BRTS, which opened in 2009, provides 45 km of bus service to approximately 1.3 Million passengers per day at an implementation cost of $1.9 million per km (SUTP 2011).

India has rich conditions for supporting Intermediate Public Transport (IPT) modes. IPT requires the availability of both areas that are left poorly served by formal public transport, and an ample labor pool of low-skilled young men (Cervero 2011). Indian IPT is usually provided by rickshaws (pedicabs), autorickshaws (three-wheeled motorized vehicles) that serve individual customers, or groups, chakdas / tempos (shared small vans), or traditional taxis. These vehicles are typically designed very small to access narrow passageways, vacant spaces on roadways, and serve urban forms where conventional buses are physically unable to penetrate. In India, IPT is necessary to fill mobility gaps and act as a feeder system for public transportation in large cities (ITDP 2009). IPT plays an important role in

[6] This bias may be due to the mythical role that Indian Railways has played in country's popular history, or it may be the influence that the consulting wing of India Railways (RITES) has held in developing city transportation studies (World Bank 2007).

allowing those who cannot afford motorized vehicles to get to work, or travel for their work (such as buying and selling produce), as well as access health care services. IPT is especially valuable in smaller cities that do not have extensive formal public transport. India's National Urban Transport Policy (NUTP) developed by the MoUD in 2005 ignores IPT. Similarly, there are few mentions of IPT in other MoUD documents or Ministry of Road Transport and Highways guidelines (ITDP 2009). This is a common problem in many developing cities, as governments are hesitant to formalize or regulate what tend to be largely informal IPT services. Standardization of IPT often accompanies rising incomes (Cervero 2011). Thus, current suggestions for Indian policy improvements include regulatory reforms that prioritize radio dispatch over "walk up" services, standardize vehicle emissions and ensure vehicle road safety performance (Mani et al. 2010).

LAND USE AND TRANSPORT

Understanding patterns and dynamics of land use across a metropolitan region is essential to effectively providing transportation infrastructure. How activities are distributed over an urban area influences the demand for travel that the transportation system must accommodate. Similarly, the transport system itself can significantly impact the shape of the future land use pattern. In this way, transport planning that is based on land use may be more valuable in developing countries (Gakenheimer 2011). Most Indian cities follow a pattern of mixed land use. Because NMT has such a high modal share (See Figure 13; Tiwari 2011), a wide variety of destinations must be within a close distance to residential areas. There are no clear-cut concentric zones for different activities. Central core areas of cities are comprised of both commercial development and high-concentration housing. Working-class developments are found in the core and periphery of the city. .Manufacturing activity is not limited to specific zones, but is spread throughout the city (Tiwari 2003). Thus, an appropriate land use plan should reflect the demands of people with low incomes (shorter distances to travel and high-density mixed land use) as well as the demands of people with higher incomes (low-density large residential plots, infrastructure for private vehicles, etc.).

Several challenges exist to effectively integrating land use and transportation in Indian cities. First, land Use planning is for the most part a local practice - the responsibility of smaller units of government that enact plans in a piecemeal fashion: plot by plot. In contrast, transportation infrastructure is implemented in much larger, and in much less isolatable pieces. This incongruity in implementation scales makes integration difficult (Gakenheimer 2006). Second, the effects of land use decisions are not immediately visible. Even forceful land use policies are only apparent after a few decades. Finally, municipal governments are not significantly empowered to effectively integrate both land use and transport plans as most decision-making power remains with the states. As Gakenheimer (2011) notes in developing countries in general, land use and transportation are not likely to be planned together unless instruction and assistance are provided by a higher authority.

In practice, India's planning is esoteric rather than applied. Land use plans are rarely followed - If they are followed, they are thick with exemptions (McKinsey 2010). The systemic reliance on exemptions results in a weak relationship between what plans prescribe and the decisions that occur at the local level. Despite the existence of planning authorities, and of state and municipal-level agencies that are responsible for preparing and implementing the land-use transport master plans, the zones envisioned by urban master plans are generally not implemented (Tiwari 2003). Consultation with and active participation of neighborhood communities is rarely present, and there is a lack of coordination between the various agencies responsible for planning, construction, and maintenance of the city's infrastructure.

Effective indicators for India's transport performance must reflect the realities of motorization trends, the distinct needs for NMT and public transport modes, IPT effects, municipal planning practices, land use and transportation integration, as well as other factors. The next section will review the efforts by government institutions to measure transportation performance.

MEASURING TRANSPORT

India has a long history of gathering transportation statistics. Starting in 1870, India's Department of Railways utilized a system of detailed surveys to evaluate colonial India's railroad projects. Indicators such as Agricultural income, Price of salt, Crop specific rainfall shock, or Exports per trade block, as well as construction costs (down to the estimated number of bricks required to build each bridge) were utilized to compare potential routes (Donaldson 2010). While the projects were evaluated against economic performance indicators, early railway alignments were based primarily on political, security or humanitarian reasons. Since the 1950s, Indian Railways has gathered extensive data on the characteristics its finances, personnel assets, infrastructure network, rolling stock, safety record as well as key economic data (GDP, Agriculture, Industry, Infrastructure, etc.) for sectors where railway performance had significant impact (Indian Railways year book 2009). Similarly, the Ministry of Road Transport & Highways (MoRTH) has also collected specific data related to roads, road transport and road accidents in India (MoRTH year book 2009). Indian Railways and the MoRTH both release annual year books of the data that has been collected.

As introduced in the previous chapter, the MoUD is developing a pilot initiative to compile urban data for purposes of information management, performance measurement and benchmarking. The Service Level Benchmark pilot initiative is being implemented in 28 cities, across 14 States and one union territory. In 2010, the MoUD's "Databook on Service Level Benchmarking" was first released. It was initially planned to include benchmarking indicator data on urban transport, as well as water supply, wastewater management, storm water drainage, and solid waste management (SWM) services. However, the urban transport benchmark data was *not* included in the inaugural databook.

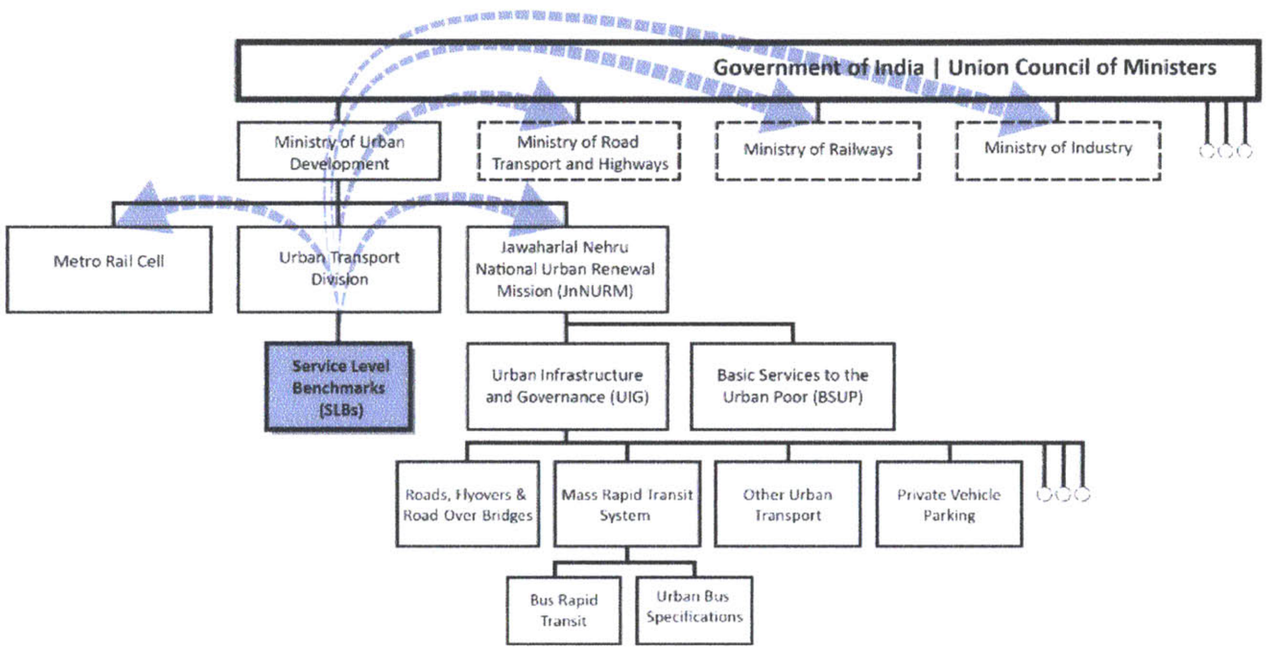

Figure 13: MoUD's SLBs within the National Level Transportation Framework (MoUD 2010, Mahadevia 2006, JNNURM)

The above figure 13 shows the organizational structure of the various central government departments that focus on transportation issues. The Service Level Benchmarks for urban transportation are administered by the Urban Transport Division of the MoUD. SLBs are part of a larger pilot initiative developed to promote transparency, public disclosure, and financial accountability in state and municipal public offices. The SLB framework is one of nine conditions by which the effectiveness of public service delivery at the state level might be judged (MoUD 2009). The urban transport SLB project is located at a lower hierarchical level than other Ministries dealing with transportation concerns. Indeed, the mission of the MoUD specifically notes the boundaries of its responsibilities in regard to the other departments. To make sure that the SLBs are fully utilized as a policy analysis tool, it is most likely that they will first be deployed across the Metro Rail Cell and the JnNURM.

CHAPTER FOUR: SERVICE LEVEL BENCHMARKS

EXISTING SERVICE LEVEL BENCHMARKS FOR URBAN TRANSPORTATION

India's urban development ministers and municipal administrators are challenged to accurately measure the performance of transport systems as well as their social and economic effects on communities. This section presents a review of the SLBs with a strong focus on concepts of mobility (an individual's capability to move through space-time) and accessibility (the extent to which land-use and transport systems enable individuals / groups to reach activities or destinations) as discussed in Chapter 2. As proposed by the MoUD, the Service Level Benchmarks (SLBs) for urban transport represent an important first step in the process of measuring the effectiveness of India's recent investments in sustainable transportation infrastructure. The MoUD has organized the SLBs via the following categories:

I. Public transport facilities
II. Pedestrian infrastructure facilities
III. NMT[7] facilities
IV. Level of usage of intelligent transport system (ITS) facilities
V. Travel speed (motorized and mass transport) along major corridors
VI. Availability of parking spaces
VII. Road safety
VIII. Pollution levels
IX. Integrated land use transport system
X. Financial sustainability of public transport by bus

For each category, a number of performance measurement indicators are designated. The indicator data collected is compared using an idealized performance metric, where a level of service (LoS) between 1 and 4 (1 being the optimal performance) is assigned for each indicator. For example, with Public Transport Facilities (See Table 4.1), six indicators are designated and each has a specific range within which performance is valued. The available documentation (MoUD 2009) provides no explicit derivation, or discussion defining how each indicator's values are tied to its LoS.

[7] For this section of the document, it is confusing to utilize the terminology "nonmotorized transport" (NMT). To maintain a clear comparison, I will use "NMT [sic]" to describe what is essentially bicycle, cycle-cart, or cycle rickshaw transport.

Table 4.1: Public Transport Facilities - Indicators and Level of Service

LOS	INDICATORS 1. Presence of Organized Public Transport System in Urban Area (%)	2. Extent of Supply Availability of Public Transport	3. Service Coverage of Public Transport in the city	4. Average waiting time for Public Transport users (mins)	5. Level of Comfort in Public Transport	6. % of Fleet as per Urban Bus Specification
1	>= 60	>= 0.6	>= 1	<=4	<= 1.5	75 - 100
2	40- 60	0.4 - 0.6	0.7- 1	4 - 6	1.5 - 2.0	50 - 75
3	20 - 40	0.2 - 0.4	0.3 - 0.7	6 - 10	2.0 - 2.5	25 - 50
4	< 20	< 0.2	< 0.3	> 10	>2.5	<= 25

The individual indicator LoSs are combined and a category-wide overall LoS is calculated. For example, if there are six indicators for a certain category, the category LoS would be as follows:

$$\text{Category Level of Service} = (LOS_1 + LOS_2 + LOS_3 + LOS_4 + LOS_5 + LOS_6)$$

Tables 4.2 through 4.11 provide a review of the existing benchmark categories, with detailed descriptions provided for each indicator, including aspirational LOS values.

Table 4.2: MoUD SLB Indicators: Public Transport Facilities

	Indicator	Description	Desired Performance
1.	Presence of organized public transport system in Urban Area (%)	Defines "Organized public transport" as systems operated by a company, special purpose vehicle (SPV) or under a concession agreement. Indicator = ratio of number of buses operated by "organized system" to total number of buses operating.	60% or greater of the area's public transport fleet should be considered organized
2.	Extent of Supply Availability of Public Transport (per 1k people)	Determine total daily number of transport vehicles measured in buses (1 train = 3 buses) operating in an urban area. Indicator = ratio of number of transport vehicles to the current population of the urban area.	Greater than or equal to 0.6 buses and trains are available for every 1k people.
3.	Service Coverage	Find length of road used for public transport operating (where operating at least once per hour). Indicator = ratio of public transport road length to the area of the urban limits of the city.	At least one km of service coverage for each square kilometer of urban area
4.	Average Waiting Time for Public Transport Users	Identify and plot (via GPS and GIS) all of the bus stops and bus routes. Determine a random sample of bus stops (depending on city size). At each of stops selected, the average headway should be collected for each of the bus routes serving the selected stops. Average waiting time = ½ Average headway. Identify frequency distribution of average wait times. Indicator = mean average wait time	Mean average wait time should be under or equal to 4 minutes.
5.	Level of Comfort	Identify "Key routes" of public transport in the city. Measure ridership and available seats for each route (as well as each bus type if there is more than one type of bus) for AM and PM peak time periods, travel in both directions. Load factor for each route = ratio of passengers per available seats. Indicator = average load factor	The average load factor is at most 1.5 passengers to available seats.
6.	Fleet per Urban Bus Specifications (UBS) (%)	Indicator = ratio of the UBS[8] compliant buses to the total number of buses in an urban area.	More than 75% of the area's bus fleet is UBS compliant.

[8] The UBS require (along with other specifications): safety features such as minimum door widths, and emergency exits; passenger comfort features such as access for passengers with disabilities, seat and interior path of travel dimensions, maximum floor height, and destination signage; vehicle life cycle performance metrics, such as drive train, and body structure durability; as well as ITS features such as smartcard, and vehicle tracking (MoUD 2008).

Table 4.3: MoUD SLB Indicators: Pedestrian Infrastructure Facilities

	Indicator	Description	Desired Performance
1.	Signalized Intersection Delay	Identify total number of signalized intersection in an urban area. Per each intersection, measure the total wait time for pedestrians waiting to cross each intersection arm. If foot over-bridge / pedestrian subway is at any arm, then waiting time for arm = 0. Determine average wait time per intersection. Indicator = % of total intersections with average wait time > 45 seconds.	A maximum of 25% of the intersections in an urban area will have average wait times greater than 45 seconds.
2.	Street Lighting	Determine the total length of the road network (consisting of arterial / sub arterial roads). Measure lighting intensity (lux) for every arterial / sub arterial road, at 10 locations per each km (presumably do this at night). Create frequency distribution of the lighting measurements. Indicator = where cumulative frequency crosses 50%.	A cumulative frequency of lighting levels greater than 8 lux.
3.	% of City Covered	Determine total length of the road network. Determine total length of streets with pedestrian footpaths that are at least 1.2m wide (multiply the length by two if there are compliant footpaths on both sides of the street). Indicator = ratio of length of streets with complaint footpaths to 2 x (length of road network)	At least 75% of the road network with footpaths

Table 4.4: MoUD SLB Indicators: NMT [sic] Facilities

	Indicator	Description	Desired Performance
1.	% of network covered	Indicator = ratio of total length of bicycle lanes to the total length of the road network for a given urban area.	at least 50% of the network length should include bicycle lanes
2.	Encroachment on NMT [sic] roads by vehicle parking (%)	Measure the total length of bicycle lanes (NMT [sic] roads) that are encroached upon by vehicle parking over the entire urban area. Indicator = ratio of encroach upon length to total length of bicycle lanes	A maximum of 10% of the bicycle lanes would be encroached upon by parked vehicles.
3.	NMT [sic] parking facilities at Interchanges (%)	Indicator = ratio of public transit interchanges (major bus stops, terminals, and railway stations) with bicycle parking within a 250m radius to the total number of public transit interchanges.	75% or more interchanges will have bicycle parking.

Table 4.5: MoUD SLB Indicators: Level of Intelligent Transportation Systems (ITS) Usage

	Indicator	Description	Desired Performance
1.	Availability of Traffic Surveillance System	Count bus stops, terminals, metro stations and signalized intersections Survey for CCTVs. indicator = % of bus stops, terminals, metro stations and signalized intersections that have CCTVs for municipal use (Security, incidence management, traffic conditions, etc.)	75% or more bus stops, terminals, metro stations, and signalized intersections will have CCTV surveillance.
2.	Passenger Information System (PIS)	Count bus stops, terminals, and metro stations Survey for PISs. Indicator = % of bus stops, terminals, and metro stations that use PIS to display real-time arrival, departure times, departure gate locations	75% or more bus stops, terminals, and metros stations will have PIS.
3.	Usage of Global Positioning System (GPS)	NOTE: This indicator is collected only for cities with at least 200,000 in population. Count all public transport vehicles and intermediate public transport vehicles (taxis, chakdas, rickshaws, etc.) Survey for onboard GPS connected to a common control center. Indicator = % of transport vehicles that utilize GPS.	75% or more public transport vehicles and intermediate public transport vehicles (taxis, chakdas, rickshaws, etc.) will utilize GPS.
4.	Signal Synchronization	Count signalized intersections Survey for signal synchronization technology (designed to reduce congestion, minimize waiting time at each intersection, and improve the flow of traffic along road networks) Indicator = % of signalized intersections with synchronization technology	75% or more signalized intersections will be synchronized.
5.	Integrated Ticketing System	Count modes and operators of public transport and survey for common ticketing system Indicator = % of public transport modes and operators that utilize common ticketing system.	75% or more public transport modes and operators will utilize integrated ticketing.

Table 4.6: MoUD SLB Indicators: Travel Speed (Motorized and Mass Transport) Along Major Corridors

	Indicator	Description	Desired Performance
1.	Travel speed of Personal vehicles along key corridors	Identify "key corridors" using motorized transport moving radially outwards or within the city. Measure travel speeds for vehicles on each corridor during peak hours on working days. Calculate peak hour average speed. Determine corridor LoS between 1 and 4: • 1 = avg. personal vehicle speed > 30 kmph • 4 = avg. personal vehicle speed < 15 kmph Indicator = Citywide average LoS per key corridor (weighted by corridor length)	Average travel speed is greater than or equal to 30 kmph.
2.	Average Travel speed of Public Transport along key corridors	Follow the same methodology for public transport vehicles. Adjust corridor LoS ranges: • 1 = avg. public transport speed > 20 kmph • 4 = avg. public transport speed < 10 kmph Indicator = Citywide average public transport LoS per key corridor (weighted by corridor length)	Average travel speed is greater than or equal to 20 kmph.

Table 4.7: MoUD SLB Indicators: Availability of Parking Spaces

	Indicator	Description	Desired Performance
1.	Availability of paid public spaces	Survey all on street parking locations for arterials, sub-arterials, and service roads. Count parking spaces in equivalent car spaces (ECS) - motorized two wheeler parking requires approximately ¼ ECS. Indicator = % on-street parking spaces that are paid.	Greater than 75% of the on-street parking spaces are paid.
2.	Ratio of Maximum & Minimum parking fee in the city	Survey parking fees for all paid parking locations in the city. Indicator = ratio maximum fee / minimum fee	The maximum fee will be greater than 4 times the minimum fee.

Table 4.8: MoUD SLB Indicators: Road Safety

	Indicator	Description	Desired Performance
1.	Fatality rate per 100,000 population	Determine total number of annual fatalities from police records Estimate developed area population with census Indicator = ratio of fatalities per population	Less than or equal to 2 fatalities per 100,000 people.
2.	Fatality rate for Pedestrian and NMT [sic]	Determine total number of annual fatalities from police records Determine the number of pedestrian and NMT [sic] (such as bicycles, cycle-carts, cycle-rickshaws) fatalities Indicator = % of fatalities that were Pedestrians or NMT [sic] users.	At most 20% of the total fatalities were pedestrian and NMT [sic] deaths.

Table 4.9: MoUD SLB Indicators: Pollution Levels

	Indicator	Description	Desired Performance
1.	SO_2	Indicator = average mean concentration range of SO_2 taken from India's Central Pollution Control Board (CPCB)	Annual mean concentration range of $SO_2 < 40\ \mu g / m^3$.
2.	Oxides of Nitrogen (NO_X)	Indicator = average mean concentration range of NOx taken from India's Central Pollution Control Board (CPCB)	Annual mean concentration range of $NO_X < 40\ \mu g / m^3$.
3.	SPM: Total Suspended Particulate Matter	Indicator = average mean concentration range of SPM taken from India's Central Pollution Control Board (CPCB)	Annual mean concentration range of SPM < 180 $\mu g / m^3$.
4.	RSPM (Size less than 10 microns): Ratio of SPM less than or equal to 10 microns in diameter (PM 10) to SPM	Indicator = average mean concentration range of RSPM taken from India's Central Pollution Control Board (CPCB)	Annual mean concentration range of RSPM < 40 $\mu g / m^3$.

Table 4.10: MoUD SLB Indicators: Integrated Land Use Transport System

	Indicator	Description	Desired Performance
1.	Population Density	Determine the developed area in hectares via mapping software. Estimate developed area population using the most recent census. Indicator = Population / Estimated developed area	Persons per Ha. should be greater than 175.
2.	Mixed Land Use Zoning (% of non--residential area)	Determine the total number of Ha. adjacent to major transport corridors (within 500 m) from Municipal Master Plan. Create inventory of land uses from selected area. Indicator = % of non-residential area across all transport corridors selected.	Greater than 30% of non-residential land use along transport corridors.
3.	Intensity of Development	Indicator = The floor space index (FSI) applicable to "Most of the city" per the master plan.	The FSI is greater than 2.
4.	Intensity of development along transit corridor (Ratio)	Indicator = a ratio of the FSI in areas 500 m adjacent to key transport corridors over "most of the city."	Greater than 3 FSI along transport corridors per every 1 FSI in the most of the city.
5.	Road Network Completeness	Examine form of the city to approximate road pattern and "Degree of completion" of network Indicator = "Road network pattern and completeness"	A "clear pattern (ring-radial or grid-iron)" and a "complete network" is present.
6.	% Area under roads	Measure the developed area of the city as described above. Determine the area under the road network. Indicator = % of area under roads	Greater than 15% of the developed area is under roads.
7.	% Network with Exclusive Right of Way (ROW) for transit	NOTE: This indicator is collected only for cities with at least 1 Mil in population. Calculate the total length of roads (arterial and sub-arterial) with a ROW greater or equal to than 9m. Add the urban rail network is added to the road length. Determine total length of dedicated or exclusive ROW for public transport. Indicator = % network w/ exclusive ROW for public transport.	Greater than 30% of the transit network has exclusive right of way for public transport.

Table 4.11: MoUD SLB Indicators: Financial Sustainability of Public Transport By Bus

	Indicator	Description	Desired Performance
1.	Extent of Non-fare Revenue (%)	Determine non-fare related sources of revenue (such as advertising on vehicles or stations, or commercial rentals at terminals) from all government and private public transport service providers. Calculate the total revenues for providers. Indicator = non-fare revenue / total revenue	Non-fare revenue is greater than 40% of the total revenue.
2.	Staff / Bus ratio	Determine total number of staff (drivers, conductors, supporting staff and operations officials) for bus transport provider. Determine total number of transport vehicles Indicator = Number vehicles / number of staff	Staff to bus ratio is less than or equal to 5.5 staff per each vehicle.
3.	Operating Ratio	Determine total costs (such as depreciation, operation, maintenance, labor, etc.) for bus transport provider Determine total revenues (all fare and non-fare sources) Indicator = costs / revenue	Operating ratio is less than 0.7.

In the next section I will analyze the SLBs and offer specific recommendations, based on my observations of conditions on the street in many Indian cities and informed by the indicator regimes that I've highlighted in Chapter 2. It is important to recognize my role as an outsider in shaping the critique and recommendations, especially in light of the patterns of use (and misuse) of technocratic indicators in global governance. My hope is that the following recommendations will serve as a catalyst for examining and potentially modifying the MoUD's practices (MoUD 2009).

ANALYSIS OF THE SLB INDICATORS

Tables 4.12-4.23 analyze the existing SLB indicators, including implementation challenges, degree of relevance to urban transportation system performance (no, low, medium, high) and recommended adjustments.

Table 4.12a: MoUD SLB Indicators: Public Transport Facilities

	Indicator	Analysis	Relevance	Recommendations
1.	Presence of organized public transport system in Urban Area (%)	Comparing public to private ownership of transport vehicles does not indicate a lack of organization.	Low	Remove indicator
2.	Extent of Supply Availability of Public Transport (per 1k people)	The "Extent of supply availability of public transport" and the total number of public transport vehicles per capita do not appropriately address the issue of access to public transport vehicles.	Low	Remove indicator.
3.	Service Coverage	Simply comparing the length of public transport roadways to the area of the city is not a meaningful metric.	Medium	Use The Local Index of Transit Availability (LITA) $LITA = \frac{v * c * r}{tsa}$ *v* = no. of vehicles, *c* = capacity (seated plus standing) / vehicle, *r* = route kilometers of public transport network, and *tsa* = public transport service area population (Rood, 1998)

Table 4.13b: MoUD SLB Indicators: Public Transport Facilities

	Indicator	Analysis	Relevance	Recommendations
4.	Average Waiting Time for Public Transport Users	"Average waiting time" step is challenging to follow in consistent / meaningful way. The sample sizes are too small to eliminate bias. AWT formula should be more nuanced to provide an accurate and comprehensive measure of performance.	High	Transport agency should develop official data collection program (point checks) Average waiting time, defined as: $AWT = \frac{1}{2}\,\sigma_h^2/\mu_h + \frac{1}{2}\mu_h$ Where σ_h^2 is the variance (std. deviation squared) and μ_h is the mean of the bus headway
5.	Level of Comfort	"Passenger comfort" step is challenging to follow in consistent / meaningful way. The sample sizes are too small to eliminate bias. "Key Routes of public transport in the city" step is vague. Easily misunderstood. Does not specify collecting multiple sets of required measures to reach a higher degree of statistical certainty.	High	Transport agency should develop official data collection program (point checks, ride checks) Average Load Factor: $\frac{\text{pkm}}{(\text{tdkm}) * (\text{acb})}$ *pkm* = passenger-kilometers *tdkm* = total daily kilometers *acb* = average capacity of each bus Passenger –Kilometers: • Conduct a sample boarding and alighting survey • Multiply the occupancy between any two stops by the stop distance (route length / number of stops) (Urban Bus Toolkit 2006)
6.	Fleet per Urban Bus Specifications (%)	Indicator only notes a vehicle's compliance with the urban bus specifications (UBS) at the time of purchase. Old or poorly maintained vehicles may not be UBS-compliant even if they were at the time of purchase.	Medium	A more appropriate measure would reflect the vehicle's current condition at the time of the actual use or indicate what % of the UBS-compliant fleet is actually in revenue service.

Table 4.14: MoUD SLB Indicators: Pedestrian Infrastructure Facilities

	Indicator	Analysis	Relevance	Recommendations
1.	Signalized Intersection Delay	Most intersections in Indian cities are not signalized. Signalized intersection delay does not reveal meaningful information about pedestrian access. Recommended methodology to collect the average waiting time per intersection may be challenging for municipalities.	No	Remove indicator
2.	Street Lighting	Recommended methodology requires significant resources (labor and technology) and does not yield meaningful information about pedestrian facilities.	Low	Replace indicator with a measurement of operational public street lighting per km. Adjust scale of indicator so that it is part of a ward-level survey.
3.	% of City Covered	Minimum pedestrian pavement width is in conflict with the Indian Road Congress (IRC).[9] The simple presence of facilities is not meaningful here. It is the quality of the footpath that makes it usable to pedestrians. The existing indicator ignores issues such as footpath obstructions and encroachments.	High	Indicator should be replaced with % of city covered by IRC compliant pedestrian facilities. Additional indicators should be constructed that measure qualities of pedestrian pavement such as obstructions, surface consistency, access features for people with disabilities.

[9] Indian Roads Congress (IRC) recommends providing 1.5 m of clear space plus a 0.5 m buffer (or 1.0 m next to commercial uses), for a total clear width of 2 m (IRC 1988). Tree pits, light posts, street furniture, utility boxes, and other obstructions must be placed outside of this clear width. Thus footpaths will be significantly wider than 2 m (SLBs recommend 1.2m)

Table 4.15: MoUD SLB Indicators NMT [sic] Facilities

	Indicator	Analysis	Relevance	Recommendations
1.	% of network covered	Indicator does not differentiate between types of bicycle facilities such as physically separated lanes, dedicated lanes or shared lanes. Indicator does not indicate if a bicycle lane is well maintained or unobstructed.	High	Indicator should be replaced with % of city covered by IRC compliant[10] bicycle facilities.
2.	Encroachment on NMT [sic] roads by vehicle parking (%)	Vehicle parking is only one way that bicycle facilities can be encroached upon.	Medium	Replace indicator with one that denotes % of bike lanes that are obstructed (whether by vehicle parking, garbage, rubble, cows, etc.).
3.	% Interchanges with NMT [sic] parking facilities	Ok.	High	No changes.

[10] Indian Roads Congress (IRC) specifies that when the number of motor vehicles using the route is more than 200 per hour, separate, cycle tracks is justified even if the cycle traffic is only 100 per hour. The movement of bicycles and cycle rickshaws should be made safe and comfortable by providing separate tracks, with tough and uniform paving, easy gradients, and trees.

Table 4.16: MoUD SLB Indicators Level of Intelligent Transportation Systems (ITS) Usage

	Indicator	Analysis	Relevance	Recommendations
1.	Availability of Traffic Surveillance System	The availability of traffic surveillance equipment does not ensure efficient utilization or benefit transport performance.	No	This specific ITS indicator should be removed.
2.	Passenger Information System (PIS)	This type of technology can benefit the popular perception of public transport by making arrival times more concrete and reliable. Calculating the number of bus stops, terminals and metro stations with PIS seems too broad a scale of analysis. It is not very likely that PIS will be deployed at every bus stop.	Medium	Shift indicator to Public Transport Real time arrival information has been used to increase the public transport mode ridership in the US, but has a significant implementation challenges and ongoing maintenance costs. As result, most US transport agencies do not include this technology at all bus stops (TCRP 2003). Modify scale of analysis to be "at transport interchanges, BRT terminals, and metro stations."
3.	Usage of Global Positioning System (GPS)	Combining all public transit and intermediate public transport vehicles into one indicator is not meaningful. Public transport operations benefit much more than do IPT and there are much more IPT vehicles in a metropolitan area.	Medium	Create indicator category specific to IPT. Split into two indicators that focus on public transport and IPT and locate them in their perspective categories.
4.	Signal Synchronization	Presence of signal synchronization is not a helpful measurement of junction performance Proper signalization and junction control is helpful, but synchronization tends to give priority to private vehicles.	No	Remove this indicator
5.	Integrated Ticketing System	Ok.	Medium	Shift indicator to public transport.

Table 4.17: MoUD SLB Indicators Travel Speed (Motorized and Mass Transport) Along Major Corridors

	Indicator	Analysis	Relevance	Recommendations
1.	Travel speed of Personal vehicles along key corridors	Indicator premise: "Improving the speed of movement of private vehicles" is inappropriate for Indian context where pedestrians and cyclists comprise an overwhelming majority of transport users. Travel speed measures: Biased by the mid-block speeds. No throughput increase for any mode & negative externalities (compromised road safety).	Low	Remove this indicator.
2.	Average Travel speed of Public Transport along key corridors	Indicator is a measure of average speed of buses in "city center" at peak traffic periods. Indicates maximum potential for impact of traffic congestion on public transport performance. Most cities have multiple CBDs.	Medium	Average commercial speed should be measured at each of the CBDs and the lowest average speed should be used. Modify indicator to: "Minimum average speed of buses in central business districts (CBDs) during peak traffic periods (km/h)." Shift indicator to public transport.

Table 4.18: MoUD SLB Indicators Availability of Parking Spaces

	Indicator	Analysis	Relevance	Recommendations
1.	Availability of paid public spaces	Indicator is limited to on street parking. Off street parking is ignored.	High	Include all parking spaces within the scope of analysis.
2.	Ratio of Maximum & Minimum parking fee in the city	Ratio not meaningful. Private vehicle demand may be reduced through parking pricing strategies, but the existence of a high ratio does not indicate that the highest priced parking space is actually being used.	Low	Remove indicator.

Table 4.19: MoUD SLB Indicators Road Safety

	Indicator	Analysis	Relevance	Recommendations
1.	Fatality rate per 100,000 population	Fatalities recorded in road accidents taken from police measures.	High	No changes.
2.	Fatality rate for Pedestrian and NMT [sic]	Indicator measures fatality rates for all NMT users.	High	Indicator should be split into two. One indicator for pedestrian fatalities and one for bicyclist / cycle rickshaw / hand cart fatalities. Add fatality indicators for other modes: Public Transport, IPT, etc.

Table 4.20: MoUD SLB Indicators Pollution Levels

	Indicator	Analysis	Relevance	Recommendations
1.	SO_2	Ok.	High	No changes.
2.	Oxides of Nitrogen (NOx)	Ok.	High	No changes.
3.	SPM: Total Suspended Particulate Matter	Ok.	High	No changes.
4.	RSPM (Size less than 10 microns): Ratio of SPM less than or equal to 10 microns in diameter (PM 10) to SPM	Ok.	High	No changes.

Table 4.21a: MoUD SLB Indicators Integrated Land Use Transport System

	Indicator	Analysis	Relevance	Recommendations
1.	Population Density	Definition for total developed area is not specific. Different municipalities may have different definitions of what this area constitutes. Density is an input to mobility and accessibility performance. It is not necessarily an outcome.	Low	Remove indicator. Replace with: • Gross residential density • Employment density Modify methodology to include clear definition. "Total developed area" = Largely continuous and should capture locations where a majority of all transport trips occur.
2.	Mixed Land Use Zoning (% of non-residential area)	Non-residential use does not mean mixed-use. For example, high population density What we care about is how people are getting what they want. How could we know what is the "right" level?	Medium	Develop more concise definition for Mixed Land Use. "Mixed land use" = Combination of residential and commercial areas Many municipal regions have GIS-based land use data available that can be analyzed at the ward level. Diversity Index (Bhatt et al. 2003), or a Dissimilarity Index (Cervero and Kockelman 1997) can be calculated to develop set of "land use mix" measures to compare across zones or urban areas.
3.	Intensity of Development	Gross approximation of floor space index (FSI) is problematic: "Most part of the city." In general, FSI is a poor predictor of physical form. Similar FSI values may result in drastically different land uses: luxury apartments (large setback with few units per floor) or low income blocks (no many units per floor).	Low	Remove indicator.

Table 4.22b: MoUD SLB Indicators Integrated Land Use Transport System

	Indicator	Analysis	Relevance	Recommendations
4.	Intensity of development along transit corridor (Ratio)	Gross approximation of FSI is problematic: "Most part of the city" and "Transit Corridors." Even if city-wide average FSI could be determined that would be weighted by area, this measure is not meaningful at such a broad scale.	Low	Remove indicator.
5.	Road Network Completeness	Gross approximation of urban form is not a meaningful measure of land use or transportation.	No	Remove indicator.
6.	% Area under roads	Methodology describing the measurement of overall area under road network is lacking. Poor description may make it difficult to effectively complete of this measurement task.	Medium	Modify indicator to include very specific methods for determining: • Area under roads. Utilize additional indicator to better characterize built environment: "4-way intersections per kilometer of roads"
7.	% Network with Exclusive Right of Way (ROW) for transit	Ok.	Medium	No Changes.

Table 4.23: MoUD SLB Indicators: Financial sustainability of public transport by bus

	Indicator	Analysis	Relevance	Recommendations
1.	Extent of Non-fare Revenue (%)	All areas of transport system should be financially sustainable – Not just public transport.	Low	Remove indicator.
2.	Staff / Bus ratio	Ok.	High	Shift indicator to public transport.
3.	Operating Ratio	Ok.	High	Shift indicator to public transport.

RETHINKING URBAN TRANSPORT BENCHMARKS

Urban Transport SLB's are an important first step for the MoUD. Creating indicators is an iterative, collective process that takes time – The European Environmental Agency's TERM indicators have been refined over the last 13 years. With this process in mind, I offer the following analysis[11] of the existing SLBs and propose an alternate set of indicators.

POINT #1: Indicators should be structured to reflect on the ground transport realities.

These realities should in turn shape priorities and policies. It is important that the benchmark categories reflect the needs of the existing transportation users, as well as policies of the MoUD's National Urban Transport Policy (NUTP) (MoUD 2006). It is surprising that this policy is not explicitly referenced by the SLBs. Specifically, the SLB categories should be re-ordered and adjusted. Figure 14 shows my proposed new indicator categories. Some of the categories are modified from the existing, while some categories have been eliminated. Two additional categories have been created. The justification for these modifications will be detailed further below.

	EXISTING CATEGORIES		PROPOSED CATEGORIES
I.	Public transport facilities	I.	Accessibility and Urban Form
II.	Pedestrian infrastructure facilities	II.	HPT infrastructure (Pedestrian and Bicycle facilities)
III.	NMT facilities	III.	Public Transport Facilities & Operation
IV.	Level of usage of intelligent transport system (ITS) facilities	IV.	Parking management
V.	Travel speed (motorized and mass transport) along major corridors	V.	Pollution levels
VI.	Availability of parking spaces	VI.	Equity and Transport
VII	Road safety	VII.	Public Engagement / Transparency
VIII.	Pollution levels	VII.	Intermediate Public Transport
IX.	Integrated land use transport system		
X.	Financial sustainability of public transport by bus		

Figure 14: Existing SLB Indicator Categories and Proposed Category Modifications

[11] This analysis draws from a report completed by the author in 2011 for ITDP entitled "Measuring Progress on Sustainable Transport."

POINT #2: Good transportation maximizes accessibility.

My review of the SLBs has a strong focus on the concept of *accessibility*: the extent to which land-use and transport systems enable individuals and groups to reach activities or destinations. Understanding the level of accessibility to essential sources for human existence, such as jobs, food, health and social services (as well as the potential for social interactions), is necessary to prioritize urban investments. Meanwhile, an equitable mobility strategy will provide *all* population groups (regardless of caste, religion, sex, disability, income, etc.) the potential to have equal levels of accessibility, which may or may not imply equal levels of mobility.

POINT #3: Be strategic about indicator selection and data collection.

Establishing appropriate and meaningful indicators is especially important as public transport agencies, public works departments and municipal corporations have little experience collecting and analyzing transport system data. Training will be absolutely necessary and helpful to a certain extent, but the data collection methods and thus the indicators themselves should be simplified to make the process operational. Recognizing concerns about benchmark validity, the indicators should realistically reflect capacity of local institutions. Indicators that are impractical to measure will be promptly ignored, or worse, incorrectly measured. Incomplete or inconsistent data gathering may compromise the entire benchmarking process.

POINT #4: Pedestrians and Bicyclists are both HPT (Human Powered Transport)

Non-motorized Transportation (NMT) is an important term to conceptualize. Its definition specifically includes pedestrian activity. The SLBs refer to NMT facilities as "Dedicated cycle track / lane with a minimum of 2.5 m width." Ultimately, the two categories pedestrian infrastructure facilities and NMT facilities should be combined to a single category. However NMT explicitly defines a category by what it is lacking – Motors. I feel that a more appropriate descriptor for this set of like items would be a trait that all elements have in common – They are both human powered. Hence the category: Human Powered Transport (HPT).

POINT #5: Integrate ITS into other indicator categories.

Regarding Intelligent Transportation Systems (ITS), it is inappropriate to create a category specific to technology for its own sake. While ITS may be a means towards improving public transport, it is not an end in itself. It is misleading and dangerous to position ITS as a comparable transport component to the others (e.g. land use, pedestrian infrastructure, bicycle facilities) as ITS is only one of many techniques for improving the function of public transport networks.

POINT #6: Develop a realistic measurement framework - Stick to it.

In general, the scope of measurement for many of the existing indicators is too poorly defined to be reliably measured across an entire metropolitan area. Typically, Indian cities are broken into administrative divisions of urban agglomerations, zones and wards that are managed by a municipal corporation. For example, the urban agglomeration of Chennai, managed by the Chennai Corporation, consists of ten zones and 155 wards. To make these measurements meaningful, a simple methodology that incorporates the *urban agglomeration* (meso), *zone* (micro), and *ward* (nano) level scales should be utilized. Data for the urban agglomeration scale are collected for the entire developed urban area. They require access to town planning, transport, and public works records. Ward-level indicators rely on a representative sample of local streets rather than attempting to cover the entire city.

Ward-level surveys should be conducted on streets with a right-of-way (ROW) of greater than 18 m. An exception to this minimum ROW should be made in corridors in city centers that function as arterials in spite of their narrow width. Each survey location consists of at least a 1 km long road stretch. The surveys should explore places with critical failures in the transport system. Measuring at these difficult locations will provide additional data about system performance so that a public transport agency can correct. It also provides a balanced look at how the system functions.

Once the survey locations have been selected, data should be collected and an indicator values should be calculated for each location. A zone level indicator value should then be calculated by averaging the corridor results. Indicators are marked at the level where data from the survey locations is necessary (ZONE, WARD). Where not specified, urban agglomeration data should be utilized.

POINT #7: A benchmark process is only as good as its implementation.

Thus, a national MoUD-sponsored benchmarking initiative should facilitate consistent application across urban agglomerations. As data are compared across municipalities, agencies, and administrative divisions it is especially important to ensure that the data collection methods are consistent. In the context of consistency, the involvement of the central government is crucial. It is the only body capable of funding and coordinating this complex effort across different regions and states. The data collected in Ahmedabad must actually be comparable to those collected in Kolkata.

A national coordination body will be necessary to ensure that survey methods are identical and survey instruments are utilized in a similar manner. Once data are collected it must be consistently formatted and submitted to a national urban transport performance database. These are all essential tasks for a national benchmark initiative to function. Thus, it is recommended that such a benchmarking framework be housed at the MoUD.

Regional and local level resources will need to be created, supported and nurtured. It is very important to establish a network at the state level for data collection so that metropolitan areas may share state--wide measurement resources. Designated measuring agencies must be determined and specific funding must be channeled to these agencies to pay for additional staff members and resources to provide a consistent performance measurement process. It is likely that most agencies will be unfamiliar with transport performance measures and will require extensive and on--going support from local planning resources (such as universities, research centers, etc.).

SLBs 2.0 ALTERNATIVE INDICATORS

Based on the above analysis I present the following set of indicators as a starting point for updating the MoUD's Service Level Benchmarks. My overall vision is for the indicators to guide metropolitan areas in providing transportation outcomes that are equitable and that expand the set of capabilities and choices for a diverse group of users.

Intervention by indicators may be especially powerful in India, where a landscape of rapid motorization has arisen through rapid industrialization and investments in infrastructure that favor mobility (especially of automobile users) over accessibility. Because the numbers and needs of the economically disadvantaged are so great, the goals of CST (2002) in particular, provide an apt focus. It is important that government investments in transportation systems allows the non-declining accessibility needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations. That includes transport services that are affordable; operate efficiently, offer choice of transport mode, and that support a vibrant economy. As well, systems must limit emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

With these high minded equity, economic, and environmental goals in mind, I present the following set of transportation performance categories, objectives and indicators. Specifically, the sub-category "objective" I use to describe what each indicator is meant to support in relation to transportation performance. For example, "Land Use Diversity Index" indicator gives an understanding of ward or zone accessibility.

Table 4.24: Alternative Indicator Category / Objective

	CATEGORY	OBJECTIVE
I.	Accessibility and Urban Form	Density Diversity of Opportunities Suitability for Transport Design
II.	HPT Infrastructure (Pedestrian and Bicycle facilities)	Overall performance Convenience Traffic Safety Physical Comfort Personal Comfort Institutional Structure
III.	Public Transport Facilities & Operations	Overall Performance Service Performance Institutional Structure Financial Performance Convenience Safety
IV.	Parking Management	Institutional policy Performance Enforcement
V.	Pollution Levels	Air Quality Long Term Public Health Vehicle Emissions
VI.	Transport and Equity	Equity Outcome Income Gender Disability Access
VII.	Intermediate Public Transport	Performance Convenience Public Safety Regulation
VIII.	Public Engagement / Transparency	Participatory Planning Community Engagement Consensus Building Data Transparency

ACCESSIBILITY AND URBAN FORM

The existing Transport and Land Use indicators are a good start for approaching the subject of physical accessibility. However, there are two issues that make this set of measurements problematic. First, they are very difficult to measure. It is hard to imagine a municipal planning agency that would be able to operationalize these indicators. Second, if the agency is capable of gathering this data, I feel that there are more specific measurements that can capture the impacts of land uses on transport system performance. This section includes an alternative set of Accessibility and Urban Form indicators.

Land use patterns themselves have a modest but often statistically significant effect on transportation behaviors (Cervero and Ewing 2010). Employment related land-use patterns are especially important for support public transport systems - Proximity to transport is more important for workers than for residents (Kolko 2011). Design attributes of street networks, such as short blocks and many intersections, can encourage walking and transit ridership. While transport stations by themselves are not associated with job growth, they should be paired with zoning changes that permit increased density and encourage commercial development in relation to residential development near stations (Kolko 2011). Transport investments should be especially encouraged in high employment and residential density areas.

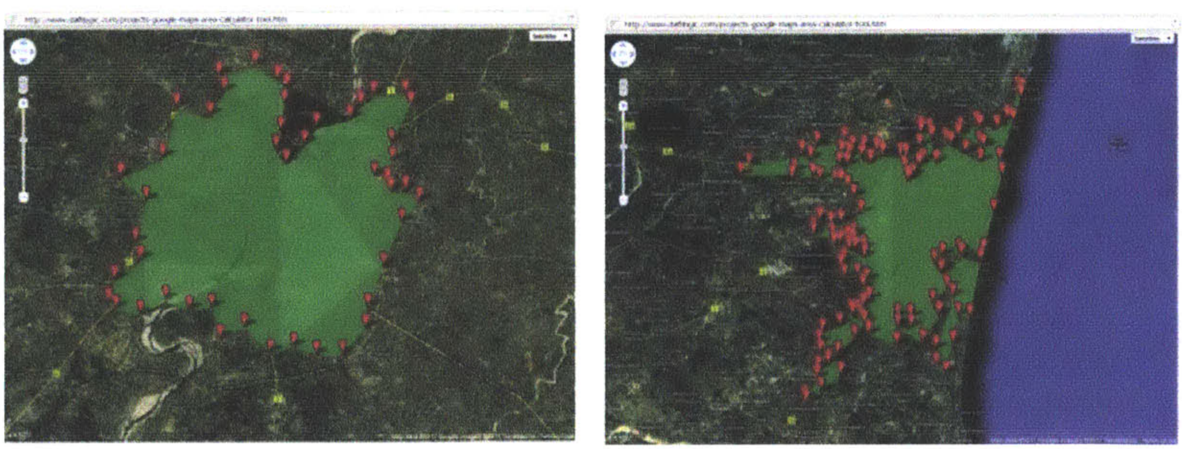

Figure 15: Identification of the "built-up urban area" in Ahmedabad (left) and Chennai (right). The developed areas total 257 sq km and 584 sq km, respectively.

An important requisite of accessibility-based transportation planning is a focus on current problems instead of predicting future problems. Look at actual travel behavior does not tell us much about accessibility per se. It is more helpful to focus on opportunities (such as employment, health care, or education) than behavior. It is also important to differentiate between who or what experiences accessibility. For this set of indicators, the administrative **WARD** (and specifically the WARD population center) is what experiences accessibility.

Regarding density indicators, it is important to define a methodology for determining the built-up urban area because different municipalities have different definitions of what this area constitutes. A possible definition is the area encompassed by the political boundaries of urban development authorities. However, the jurisdictions of many development authorities include disparate satellite developments and encompass large swaths of undeveloped area. Thus, the "built-up urban area" should be largely *continuous* and should capture locations where *a majority of all transport trips* occur. The area for this region should be collected using an area calculation tool and satellite imaging software such as Google maps.[12] (See Figure 15 above). The agency's rationale for identifying the region should be well documented. Alternative methods for excluding undeveloped land include using weighted density[13], or calculating net density[14].

The SLB definition of "mixed land use" as non-residential is too limiting. For the purpose of clarity and consistency, we define "mixed land use" to mean the co-location of multiple land uses in a way that eases access and reduces travel. Typically, mixed-use development means the combination of residential and commercial uses. It can also refer to a mix of housing types and affordability; a mix of civic, institutional, and commercial facilities; or a mix of public spaces to cater for a range of users (e.g. children through to older adults) with a diversity of needs.

Table 4.25 presents my alternative indicators for Accessibility and Urban Form to address the objectives of: <u>Density</u>, <u>Diversity of Opportunities</u>, <u>Suitability for Transport</u>, and <u>Design</u>: "Indicator / Type" refers to the indicator name as well noting whether the indicator is an Input, Output, Outcome, or Process indicator. This field also indicates if the scope of the evaluation requires **WARD** level data.

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[12] For example, see Google Maps Area Calculator Tool (http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm).

[13] Weighted density is the weighted average of Census ward population (or employment, residential, etc.) density (ward population divided by ward land area) for all wards in the metropolitan area, where the weight is each ward's % of metropolitan population. Wards without population are weighted zero (Glaeser and Kahn 2004).

[14] Total population, employment, or residential dwelling numbers are divided by land area excluding farmland, public lands, and other undeveloped areas. Net density requires detailed data on land uses in order to identify and exclude undeveloped land, whereas weighted density requires only on tract population (or employment) and land area.

Table 4.25: Accessibility and Urban Form Indicators

	Indicator / Type	Operational Definition	Objective
1.	Gross Residential Density / Input	$\frac{[\text{number of residential units}]}{[\text{built} - \text{up area}]}$	Density
2.	Employment Density / Input	$\frac{[\text{number of jobs}]}{[\text{built} - \text{up area}]}$	Density
3.	% Jobs within 30 minutes travel time by transport modes and income quartiles / Output **WARD**	Develop GIS-based map that includes locations of residence, employment, administrative wards and transportation network. Determine population center of Ward by residential distribution. Calculate % of jobs reachable within 30 minutes travel time from ward center by mode and by income quartile.	Diversity of Opportunities
4.	% Health Care Facilities (including doctors, clinics and hospitals) within 30 minutes travel time by transport modes and income quartiles / Output **WARD**	Develop GIS-based map that includes locations of residence, health care facilities, administrative wards and transportation network. Calculate % of health care facilities reachable within 30 minutes travel time from ward center by mode and by income quartile.	Diversity of Opportunities
5.	% Secondary Schools within 30 minutes travel time by transport modes and income quartiles / Output **WARD**	Develop GIS-based map that includes locations of residence, secondary schools, administrative wards and transportation network. Calculate % of secondary schools reachable within 30 minutes travel time from ward center by mode and by income quartile.	Diversity of Opportunities

	Indicator / Type	Operational Definition	Objective
6.	Land Use Diversity Index / Input **WARD**	Use the following land use diversity index (Rajamani 2003) to represent on a map the mix of land uses for each ward (or zone): The index includes six different land uses, measured by built floor space, where:	Diversity of Opportunities
	$$DI = 1 - \left[\frac{\left|\frac{r}{T} - \frac{1}{8}\right| + \left|\frac{c}{T} - \frac{1}{8}\right| + \left|\frac{i}{T} - \frac{1}{8}\right| + \left|\frac{e}{T} - \frac{1}{8}\right| + \left|\frac{h}{T} - \frac{1}{8}\right| + \left|\frac{rec}{T} - \frac{1}{8}\right| + \left|\frac{t}{T} - \frac{1}{8}\right| + \left|\frac{a}{T} - \frac{1}{8}\right|}{\frac{7}{4}} \right]$$		
		DI = diversity index *r* = square meters of residential floor space *c* = square meters of commercial floor space *i* = square meters of industrial floor space *e* = square meters of educational floor space *h* = square meters of health facilities floor space *rec* = square meters of recreational space *t* = square meters of transport infrastructure space and a = square meters of agricultural space *T* = r + c + i + e + h + rec + t + a This index aims to capture the mix of uses relative to a "perfect" distribution of uses. A value of 0 for this index means that the land in the area has a single use and a value of 1 indicates perfect mixing among the eight uses.	
7.	Fraction of built-up area with access to the dedicated ROW public transport network. / Input	Develop GIS-based map that includes locations of dedicated ROW public transport stations $$n * \left[\frac{(r^2 * \pi)}{a}\right]$$ *n* is number of stations with dedicated ROW *r* is walkshed[15] radius (1 km) *a* is built-up area (sq km)	Suitability for transport

[15] Walkshed refers to the walkable area around a particular point of interest. Walkshed's are variable depending on trip purpose and physical barriers, such as transportation infrastructure (urban freeways) or topography (steep hills). This area is indicative of a pedestrian tolerance, and is typically estimated at 500 m / 5 minutes for low frequency public transport (such as buses) or 1 km / 10 minutes for rapid transport (such as rail or BRTS).

	Indicator / Type	Operational Definition	Objective
8.	Fraction of central business districts (CBDs)[16] with access to the public transport network / Input	$\frac{\text{[number of CBDs with access to the public transport network]}}{\text{[number of CBDs]}}$	Suitability for transport
9.	Fraction of built-up area with access to the public transport network / Input	Develop GIS-based map that includes locations of all bus stops along with dedicated ROW transport stations. $$(n+b) * \left[\frac{(r^2 * \pi)}{a}\right]$$ *n* is number of stations with dedicated ROW *b* is number of bus stops *r* is walkshed radius (1 km) *a* is built-up area (sq km)	Suitability for transport
10.	Fraction of area within 1 km of stations that have mixed land uses / Input	Develop GIS-based land use map of built-up area that includes locations of dedicated ROW transport stations Use GIS software to isolate areas within 1 km walking distance of dedicated ROW transport $$\frac{a}{(r^2 * \pi)}$$ *a* is area of designated "mixed land use" within walkshed (sq km) *r* is walkshed radius (1 km)	Suitability for transport

[16] Most Indian cities are polycentric and do not have a single CBD. Thus, a transport system planned to carry a large number of people to a single CBD (monocentric form) will need to be supported by smaller networks connecting multiple business districts.

	Indicator / Type	Operational Definition	Objective
11.	Employment density near public transport / Input	Develop GIS-based map that includes public transport walksheds and all places of employment. Determine the total area of land that is within public transportat walkshed. Determine the number of employment locations that are within transport walksheds. Indicator = employment opportunities within walkshed / total area within all transport walksheds.	Suitability for transport
12.	Development intensity near public transport / Input	Determine the average floor space index (FSI) for areas within 1 km walking distance of dedicated ROW transport stations, weighted by area.	Suitability for transport
13.	Fraction of built-up area with mixed land use / Input	$\frac{[\text{area with mixed land use}]}{[\text{total built} - \text{up area}]}$	Design
14.	Road Network Extent / / Input	Determine total length of road network (km) $\frac{[\text{Total length of road network}]}{[\text{total built} - \text{up area}]}$	Design
15.	Setback requirements / Input	Determine the setback requirement (m) on all roads (with ROW > 18m) Calculate the average setback, weighted by road length.	Design
16.	Intersection Density / Input **WARD**	$\frac{[\text{number of intersections}]}{[\text{total road length}]}$	Design

HUMAN POWERED TRANSPORT (HPT) INFRASTRUCTURE

This indicator category includes measurements for pedestrian and bicycle activity. For the purposes of clarity and consistency in this document, "Obstructed" is defined as any length of pedestrian path where a 2 m clear width is unavailable due to the following:

- Permanent obstacles (e.g. construction, landscaping, lighting columns, bollards, or signposts)
- Mobile obstacles (e.g. vending stands, trash bins, vehicle parking)
- Trash (i.e. removable debris)
- Rubble (i.e. heavy duty maintenance required)
- Abrupt changes in level without beveled edges or ramps (i.e. vertical changes greater than 12 mm) [17]
- Pinch point occlusion by barriers (e.g. lighting columns, bollards, signposts)

In general, pedestrian footpaths should have a continuous, unobstructed minimum width of 2 m in clear width (Per IRC Standards). Additional buffers along the carriageway for street furniture (such as lighting, bus stops and access ramps) and along the building frontage for side street activities (such as plantation, commercial activity) are also required. Where greater demand for pedestrian space exists, 5 m plus width footpaths are recommended to accommodate street vendors and larger seating areas.

Beyond the presence of facilities or maintenance of existing infrastructure, HPT users may experience social barriers that prevent safe movement in public. Based on my conversations with women friends and acquaintances, I've included four **WARD**-level indicators under the rubric of Eyes on the Street. "Activity level," "Street Vendors," "Compound Walls," and "Hazards for women" all refer to specific conditions that may support or detract from personal comfort (and expectations of safety). Ideally the four would be aggregated into an index that would take the following form:

$$P_S = \alpha(AL) + \varepsilon(SV) - \gamma(CW) - \delta(HW)$$

P_S = Perception of Safety

CW = % of corridor fronted by compound walls / km

AL = Activity Level

SV = Number of Street Vendors / km

HW = Hazards for Women (such as Wine shops, Bars, B-Movie Houses) / km

[17] National Building Code / Bureau of Indian Standards (BIS) Indian Accessibility Standard - 2009 DRAFT

Baseline data must be collected to determine weighting coefficients ($\alpha, \varepsilon, \gamma, \delta$) and acceptable ranges for each of the indicators. This measure would want to be closely compared to a qualitative survey that queried degrees to which women "felt safe" to walk / bicycle / reach public transport in various parts of the city. These are only the most obvious of factors that contribute to the perception of safety. There are many, many more (like the actual numbers of crimes towards women over a particular corridor), but I feel that this simplistic indicator would be a step towards collecting more complete public safety data, and providing all users (regardless of gender or orientation) accessibility by walking or bicycle.

The following set of alternative indicators is recommended for HPT Infrastructure to address objectives of Overall performance, Convenience, Traffic Safety, Physical Comfort, Personal Comfort, and Institutional Structure:

Table 4.26: Human Powered Transport (HPT) Indicators

	Indicator / Type	Operational Definition	Objective
1.	HPT Mode share / Output	Percentage point change in HPT mode share over a recent recording period (e.g. last five years)	Overall Performance
2.	Progress in creating HPT Infrastructure / Output	[length of IRC compliant pedestrian paths] / (2 * [total km of roads constructed or reconstructed over previous year])	Overall Performance
3.	Complete HPT coverage / Output **WARD**	[length of IRC compliant pedestrian footpaths **AND** bicycle tracks on 18+ m ROW streets] / (2 * [km of 18+ m ROW streets]	Overall Performance
4.	Pedestrian Infrastructure Utilization / Output **WARD**	% of pedestrians observed using footpaths on 18+ m ROW streets	Overall Performance
5.	Bicycle Infrastructure Utilization / Output **WARD**	% of cyclists observed using bicycle lanes on 18+ m ROW streets.	Overall Performance
6.	Pedestrian Footpath Width / Input **WARD**	Average clear width on pedestrian footpaths on 18m + ROW streets	Convenience

	Indicator / Type	Operational Definition	Objective
7.	Bicycle Lane Width / Input **WARD**	Average width of cycle tracks on 18m + ROW roads	Convenience
8.	Pedestrian Footpath Quality / Input **WARD**	[number of obstructions on IRC compliant footpaths on 18+ m ROW streets] / (2 * [length of 18+ m ROW streets]	Convenience
9.	Cycle track quality / Input **WARD**	[number of obstructions on standard cycle tracks on 18+ m ROW streets] /(2 * [length of 18+ m ROW streets]	Convenience
10.	Crossing opportunities / Input **WARD**	[Intersections + median barrier breaks - foot overbridges)] per km of roads with median barriers	Convenience
11.	Crossing distance / Input **WARD**	Average crossing distance per intersection	Convenience
12.	Access for Disabled and Seniors / Process **WARD**	[number of street corners with pedestrian ramps in compliance with National Building Code/Bureau of Indian Standards Accessibility standard] / [length of 18+ m ROW streets]	Convenience
13.	Bicycle parking / Process **WARD**	[number of major public transport interchanges with protected public cycle parking] / [total number of major public transport interchanges]	Convenience
14.	Annual number of pedestrian fatalities per capita (100,000 people) / Output	[number of pedestrian fatalities] / [population]	Public Safety
15.	Annual number of cycling fatalities per capita (100,000 people) / Output	[number of cyclist fatalities] / [population]	Public Safety
16.	Traffic Calming per capita (100,000 people) / Process	Annual number of traffic calming interventions	Public Safety

	Indicator / Type	Operational Definition	Objective
17.	Intersection Signalization / Process **WARD**	[number of intersections with at least three arms of 18m + ROW that are signalized] / [number of intersections with at least three arms of 18m + ROW]	Public Safety
18.	Crossing safety / Process **WARD**	[number of table top (raised) crossings (minimum elevation of +150 mm above carriageway)] / [km of road]	Public Safety
19.	Seating provision / Input **WARD**	[number of government provided seats] / [length of 18+ m ROW streets]	Physical Comfort
20.	Shade / Input **WARD**	[number of trees in the public ROW with > 30 cm circumference] / [length of 18+ m ROW streets]	Physical Comfort
21.	Encroachment on Pedestrian Facilities / Output **WARD**	[number of vehicles (equivalent car spaces [ECS])] / (2 * [length of 18+ m ROW streets])	Physical Comfort
22.	Encroachment on Bicycle Facilities / Input **WARD**	[number of vehicles (equivalent car spaces [ECS])] / (2 * [length of 18+ m ROW streets])	Physical Comfort
23.	Personal crime / Output	[incidents of crime against pedestrians] / [population]	Personal Comfort
24.	Lighting / Input **WARD**	[number of operational public streetlights] / [length of 18+ m ROW streets]	Personal Comfort
25.	Eyes on the Street: Activity level / Output **WARD**	Fractions of road length falling in pedestrian activity categories: crowded (some pushing and shoving); active (moderate numbers of people but not too dense); or inactive (street is devoid of pedestrians)	Personal Comfort
26.	Eyes on the street: Street Vendors / Input **WARD**	[number of street vendors] / (2 * [length of 18+ m ROW streets])	Personal Comfort

	Indicator / Type	Operational Definition	Objective
27.	Eyes on the street: Compound Walls[18] / Input **WARD**	[length of compound wall frontage] / (2 * [length of 18+ m ROW streets])	Personal Comfort
28.	Eyes on the street: Hazards for women / Input **WARD**	[number of bars, wine shops, or B-movie houses] / (2 * [length of 18m + ROW streets])	Personal Comfort
29.	HPT Planning Process / Process	Existence of formal HPT planning / safety / public awareness program that stresses the environmental and social benefits of NMT modes located within the municipal corporation or planning agency.	Institutional Capacity

PUBLIC TRANSPORT FACILITIES & OPERATIONS

This set of indicators is concerned with public transport facilities and operations. Most of the data collected through these indicators should be collected by municipal corporations. Ideally, public transport agencies will utilize a ride-check and point-check manual data collection program to collect vehicle arrival time frequency, ridership, and load factor data. Manually collected load factor data should focus on the most crowded segment (the maximum load segment) of each trip. This is necessary, because if half the trips measured are empty and half are overcrowded, then only 50 per cent of the trips are considered overcrowded, yet 100 per cent of the passengers experience an overcrowded trip.

To reduce confusion regarding the variety of buses and trains utilized in urban public transport services, I define a "vehicle" as carrying 72 people. Trainsets can be treated as multiples of this 72-passenger "vehicle." Also, dedicated ROW public transport is defined as rail based or if road-based services that meet the following conditions:

[18] In India, "Compound walls" refer to a common practice of building high security walls to protect European-style bungalows. As Indian cities expanded to encompass what was previously countryside, estate walls become key features that define urban forms and demarcate space available for circulation. In modern Indian cities, the presence of compound walls can be seen as important indicator of street activity. They tend to be used extensively as public urinals, or for political graffiti. Their ubiquity and lack of transparency creates environments that can be unsafe for women.

- Private and non-public transport vehicles are not allowed to enter the lanes used by the public transport vehicles
- The lanes used by the public transport vehicles are physically separated from other roadways (not painted)

Collecting revenue is an ongoing problem for most urban transportation systems. Assuming that the public transport entity is not significantly subsidized, the higher level of non-fare revenue may imply lower fares. Public transport organizations are often fraught with decision-averse bureaucracy and unnecessary large and underproductive administrative staff (Sreedharan 2012).

My proposed set of alternative public transport indicators appears below in support of Overall Performance, Service Performance, Institutional Structure, Financial Performance, Convenience, and Public Safety:

Table 4.27: Public Transport Facilities and Operations Indicators

	Indicator / Type	Operational Definition	Objective
1.	Public Transport Mode share / Output	Percentage point change in public transport mode share over a recent recording period (e.g. last five years)	Overall Performance
2.	Public Transport to Private Vehicle (M2W, M4W) Mode Share Ratio	(public transport mode share) + (intermediate public transport mode share)] / [(motorized two-wheeler mode share) + (motorized four-wheeler mode share)]	Overall Performance
3.	Transport service reliability per ward (calculated separately for each mode and agency) **WARD**	Develop system of ridership data collection (via transport agency method described above) Average waiting time, defined as: $AWT = \frac{1}{2}\sigma_h^2/\mu_h + \frac{1}{2}\mu_h$ Where σ_h^2 = variance (std. deviation squared) and μ_h = mean of the bus headways	Overall Performance
4.	Public transport speed in CDBs	Minimum "commercial speed" of buses in CBDs during AM and PM peak traffic periods in both directions (km/h)	Overall Performance

	Indicator / Type	Operational Definition	Objective
5.	Service Coverage	Local Index of Transit Availability $LITA = \frac{v * c * r}{tsa}$ *v* is the number of vehicles, *c* is the capacity (seated plus standing) per vehicle, *r* is the route kilometers of the public transport network, and *tsa* is the public transport service area population	Overall Performance
6.	Load factor / Level of Comfort per Municipal area	[daily passenger-km] / ([daily vehicle seats + daily vehicle standees] * daily km traveled)	Service Performance
7.	Average Route Load factor / Level of Comfort per ward (calculated separately for each mode and agency) **WARD**	Develop system of ridership data collection (via transport agency or crowdsourcing method described above) Determine ward-wide average load Factor by determining load factor per each route in each ward surveyed.	Service Performance
8.	Fraction of Public Transport Ridership using dedicated ROW	[daily public transport bus boardings on dedicated ROW] / [total daily public transport bus boardings]	Service Performance
9.	Fraction of Public Transport Vehicle-Km on dedicated ROW	[daily vehicle-km on dedicated ROW] / [total daily vehicle-km]	Service Performance
10.	Fraction of Intersections with Public Transport Signal Priority **WARD**	[number of junctions where signal or manual control gives priority to public transport] / [total number of signalized intersections]	Service Performance
11.	Fleet utilization (calculated separately for each mode and agency)	[daily public transport bus boardings] / [total number of public transport buses in active fleet]	Service Performance
12.	Fleet age (calculated separately for each mode and agency)	Median age of the public transport bus fleet	Service Performance

	Indicator / Type	Operational Definition	Objective
13.	Population per each 72-passenger vehicle	[Urban area population] / [daily number of buses in service (buses not sitting at depot during the peak hour)	Service Performance
14.	Fleet condition	[number of public transport buses in the in service fleet that in their current condition are compliant with UBS] / [total number of public transport buses in the active fleet]	Service Performance
15.	Data Collection Cell /Process	Existence of data collection department within public transport agency (e.g. capable of rider check and point check collection schemes to determine headways, loading factor, etc. per individual routes within the agency's network).	Institutional Structure
16.	Cost efficiency (calculated separately for each mode and agency)	[annual operating cost] / [annual ridership]	Financial Performance
17.	Staff ratio (calculated separately for each mode and agency)	[number of staff] / [number of in-service vehicles]	Financial Performance
18.	Annual operating ratio (calculated separately for each mode and agency)	[annual costs (depreciation, operation, maintenance, manpower, etc.)] / [annual revenues (all fare & non-fare revenue)]	Financial Performance
19.	Fraction of City with High Frequency Coverage	[area within 0.5 km of bus stop where service frequency is greater than 12 buses per hour] / [total urbanized area]	Convenience
20.	Electronic fare collection (calculated separately for each mode and agency)	[number of boardings paid with passes or smartcard ticketing system] / [total number of boardings]	Convenience
21.	Integrated fare collection (calculated separately for each mode and agency)	[number of boardings paid with integrated passes or smartcard ticketing system] / [total number of boardings]	Convenience

	Indicator / Type	Operational Definition	Objective
22.	Off-board fare collection (calculated separately for each mode and agency)	[number of boardings paid via off-board sales points] / [total number of boardings]	Convenience
23.	Integration	[number of interchange stations with formal facilities for feeder services] / [total number of interchange stations]	Convenience
24.	System Reliability	[number of vehicle breakdowns] / [total vehicle-km]	Convenience
25.	Span of Service (calculated separately for each mode and agency)	Average daily number of hours that public transport services are in operation.	Convenience
26.	Presence of public safety officers (calculated separately for each mode and agency)	[daily number of uniformed, dedicated transport security officers] / [number of in-service vehicles	Public Safety
27.	Personal crime	[daily incidents of crime against public transport users] / [daily boardings]	Public Safety
28.	Crime against Women	[daily incidents of crime against female public transport users] / [daily boardings by women]	Public Safety
29.	Annual number of public transport user fatalities per capita (100,000 people)	[number of public transport fatalities] / [urban area population]	Public Safety

PARKING MANAGEMENT

The section title has been changed from "Availability of parking spaces" to "Parking management" as the availability of parking is not necessarily a positive attribute. Parking can be a powerful tool to manage travel demand. However, in many cities parking policy is either non-existent, poorly coordinated, or used as a way to encourage more people to travel by personal vehicles (ITDP 2011). If parking is too plentiful, people are encouraged to buy more cars and use them more often, and more cars leads to the demand for more parking spaces. For cities to provide on-street parking spaces for free is hugely inefficient use of urban space and municipal resources. Limiting the provision of parking to create disincentives to automobile travel and reduce negative externalities (such as congestion and air pollution) is growing in popularity (ITDP 2011). Using the price of parking to ensure turnover at the curb, and distribute scarce parking space to those who need it most, is becoming the standard practice in the US and Europe. Thus, the role of parking management is recognized as integral to successful cities.

With parking's growing importance in cities, the following indicators expand on the original SLBs to address parking management goals of Institutional policy, performance, and enforcement. These indicators refer to private motor vehicle parking spaces as equivalent car spaces (ECS), where motorized two wheeler parking requires approximately ¼ ECS.

Table 4.28: Parking Management Alternative Indicators

	Indicator / Type	Operational Definition	Objective
1.	Maximum Parking Minimum Requirement Commercial	Highest minimum number of parking spaces required per 100 sq. m of commercial area	Institutional Policy
2.	Maximum Parking Minimum Requirement Commercial	Highest minimum number of parking spaces required per 100 sq. m (or per unit) of residential area	Institutional Policy
3.	Off-Street Parking Maximum Policy	Existence of off-street parking maximums as per zoning anywhere in the city	Institutional Policy
4.	CBD Parking Freeze Policy	Existence of a freeze on new parking spaces in CBDs	Institutional Policy
5.	Existence of a market for off-street parking	Ratio of average monthly parking fee to average monthly rent in most expensive commercial area	Institutional Policy
6.	Travel Demand Reduction Fee	[total revenue from municipal parking facilities] / [number of per registered vehicles]	Performance
7.	Fee coverage	[length of 18+ m streets with paid on-street parking] / [length of 18+ m ROW streets]	Performance
8.	Fee level efficiency **WARD**	Occupancy of on-street parking spaces	Performance

	Indicator / Type	Operational Definition	Objective
9.	Parking fees as a travel demand management tool	Ratio of 1 hr parking fee to average public transport fare	Performance
10.	Illegal Parking Fine - Pedestrian Impacts	Minimum fine for parking on pavements and impeding pedestrian access	Enforcement
11.	Illegal Parking Fine - Bicycle Impacts	Minimum fine for parking on bicycle track.	Enforcement
12.	Parking Impeding Pedestrian Access (ECS / km) **WARD**	[number of vehicles illegally parking in pedestrian paths in ECS] / [length of 18+ m ROW streets in km)]	Enforcement
13.	Parking Impeding Bicycle Access (ECS / km) **WARD**	[number of vehicles illegally parking in cycle tracks in ECS] / [length of 18+ m ROW streets in km)]	Enforcement

POLLUTION LEVELS

The relationship between transport systems and the natural environment is a complex one. Transport activities often result in economic benefits that generate increasing mobility demands for passengers and freight (ranging from urban areas to international trade). However, increased demands for mobility mean increased levels of motorization and congestion. Thus, the transport sector is becoming increasingly linked to environmental problems. The negative externalities of transport systems can be examined from economic, social and environmental dimensions. The basic types of transport externalities attributed to the environment fall within air pollution, water pollution, noise, and hazardous materials.

Transport noise not only impacts the quality of life, it affects physical as well as mental wellbeing. Noise management schemes typically involve noise barriers or buffers that require adding to road ROW and specific physical modifications (acoustic walls, berms, etc.). These barriers may pose significant challenges to pedestrians as they demand large swaths of land and and built structures adjacent to transport corridors. In India, the use of noise reduction techniques is very uncommon. While noise emitted from traffic contributes about 55 % of total

India's noise pollution (Mishra et al. 2010), noise volume is often related to traffic speed, which is reduced through congested roads.

With the help of government initiatives, some Indian cities have cleaned up fleets (UNEP 2009). However, these gains have been short lived as they were only interested in reducing one type of particulate matter. These gains were not partnered with significant efforts to control the growth of the private vehicle fleet. Thus, the increased size of India's private vehicle fleet has overwhelmed the reductions due to fleet improvements. These indicators should be retained and I suggest expanding the scope of the air pollution measurements.

Alternative pollution level Indicators for parking management serve goals of Air Quality, Long Term Public Health, and Vehicle Emissions. They include the following:

Table 4.29: Pollution Levels Indicators

	Indicator / Type	Operational Definition	Objective
1.	SO_2	India's Central Pollution Control Board (CPCB) reports on air pollutants for particular urban areas in annual amounts (µg / m^3). CPCB data should be utilized for the following seven indicators.	Air Quality
2.	Oxides of Nitrogen (NO_X)	See #1	Air Quality
3.	SPM: Total Suspended Particulate Matter	See #1	Air Quality
4.	RSPM (Size less than 10 microns): Ratio of SPM less than or equal to 10 microns in diameter (PM 10) to SPM	See #1	Air Quality
5.	Carbon Monoxide (CO)	See #1	Air Quality
6.	Hydrocarbons (HO)	See #1	Air Quality
7.	Ozone	See #1	Air Quality
8.	Exposure to transport noise (> 55 dB) **WARD**	Perform Wayside Ambient Noise Survey: • Via noise meter measure noise (Leq) every 15 sec for 15 min / h (point check) • Ldn may be determined by averaging Leqs over a 24	Long Term Public Health

	Indicator / Type	Operational Definition	Objective
		hour period. • Nighttime between 22:00 and 07:00 10dB should be added to each Leq[19] Indicator = % Ldn points > 55dB	
9.	Fraction of Public Transport Fleet in Compliance with Indian air quality standards	[number of public transport equal to or above Bharat Stage IV -Euro 4 standards] / [number of public transport vehicles per metropolitan area]	Vehicle Emissions
10.	Vehicle emissions enforcement	Existence of municipal level emission inspection and maintenance program	Vehicle Emissions

TRANSPORT AND EQUITY

The traditional concept of equity is an economic one: everybody should pay for what they get. An alternate application of equity is as a social concept: everyone should receive what they need[20]. It is with the latter definition in mind that I present the following set of indicators addressing issues of equity and social justice in the provision of urban transport systems. In evaluating transportation planning, it is important to differentiate between equity and equality. *Equality* does not necessarily imply conditions that are *equitable*. The goals of equality may be *too complex* to be realistically accomplished in the context of urban transportation interventions (Fainstein 2011). Equity does not imply that all people are treated the same. Equity implies fairness – This is a more broadly accepted and politically strategic term. Applying the criterion of equity in urban transport planning may elevate the standing of weaker, poorer groups in terms of the impacts of specific decisions without implying that policies are sufficient enough to actually bring about equality (Fainstein 2011). Equity-based transportation planning schemes would ask that project performance be measured in terms of: Who benefits? and To what extent do they benefit?

Equity issues in transport are aggravated by traditional approaches to the urban transport solutions that focus on improving operational efficiency of transport systems and benefitting only

[19] It is also possible to feed this data into an online Lden calculator: http://www.noisemeters.com/apps/ldn-calculator.asp

[20] A challenge of this approach is in how societies define *need*, and how they determine which needs are public responsibilities.

selective sections of the community (Dimitriou 1992). Traditional economic development is often in conflict with concepts of equity and political realities. In many Indian cities, the poorest can often only afford to walk. Formalized concepts of optimization, standardization and evaluation criteria used by engineers or economists do not feature strongly in the analysis of equity planning. Overly technical approaches to transport systems have favored the interests of the affluent who depend on private transport modes at the expense of the mobility needs other transport users (such as pedestrians, bicyclists and public transport users).

Individual characteristics such as income, age, gender, disability, race, or ethnicity / religion all have crucial impacts on travel choices. The distribution and impacts of these characteristics varies by country and society. An equity-based approach to transport planning would ask how current mobility conditions meet the specific needs of the above individual characteristics. Vasconcellos (2011) suggests the following questions so that the mobility needs of all urban inhabitants are considered:

- How is access to space distributed among different categories of people?
- How do different social classes and groups use space?
- What are the related conditions of equity, safety, comfort, efficiency, environment and cost that conform to people's mobility?

An important application of an equity-based approach to transportation planning is in providing services and infrastructure that meet the needs of seniors and disabilities. The MoUD SLBs ignore these important urban transport requirements. Per the Persons with Disability (PWD) Act passed in 1995, the eleventh 5-Year Plan passed in 2007 and the United Nations Convention for the Rights of People with Disability (UNCRPD) ratified in 2007 call for modifications to vehicles, facilities, and services to make them inclusive for all potential users. I define public transport facilities that are "Accessible for wheelchair users" as being compliant with the draft National Building Code/BIS Indian Accessibility Standards (2009). BIS accessibility characteristics include the following:

- Unobstructed entrance with a clear width of at least 1.5 m
- At least one ramped access point with a slope that does not exceed a 1:12 (or 1:20 depending on platform height), and handrails on both sides
- Level boarding to transport vehicles
- A consistent horizontal gap between the vehicle and boarding platform of no greater than 10 cm.

My proposed set of transport and equity indicators appears below in support of Equity Output, Income, Gender, and Disability Access:

Table 4.30: Transport and Equity Indicators

	Indicator / Type	Operational Definition	Objective
1.	Transport System impact on Development / Output **WARD**	Indicator = Human Development Index (HDI)[21] $I_{Health\ \&\ Longevity}{}^{1/3} + I_{Knowledge}{}^{1/3} + I_{Income}{}^{1/3}$	Equity Output
2.	Transport System impact on Inequality / Output **WARD**	Indicator = Gini coefficient index $Inequality = \sum_j p_j f(r_j)$ $r_j = \frac{x_j}{\bar{x}}$ P_j = Weights units by population share $f(r_j)$ = function of the deviation of each unit's r_j from 1	Equity Output
3.	Transport System impact on GDP per capita / Output	Indicator = GDP per capita	Equity Output
4.	% of people who cannot afford public transport (HPT captive)	Determine minimum annual cost of public transport Indicator = % of urban area population whose annual income < minimum annual cost of public transport	Income
5.	Fare per km (calculated separately for each mode and agency)	Minimum passenger fare per km	Income
6.	Monthly fare (calculated separately for each mode and agency)	Passenger fare for one month of public transport use	Income

[21] HDI measures a country's average achievement in population health and longevity (life expectancy at birth), knowledge (Adult literacy rate – two-thirds weighting - and the combined gross enrollment rate of primary, secondary and tertiary schools - one-third weighting) and standard of living (natural log of the GDP per capita at purchasing power parity).

	Indicator / Type	Operational Definition	Objective
7.	Expenditure on Transport (as % of Income) **WARD**	Determine total annual income per **WARD** Determine total annual expenditure on transport per **WARD** Indicator = [Total annual transport expenditure] / [Total annual Income] per **WARD**	Income
8.	Average Travel distance by Income Quartile / Output **WARD**	Indicator = frequency distribution of Average Travel Distance ROW station by income quartile	Income
9.	Vehicle Kilometers Traveled (VKT) by Income Quartile /Output **WARD**	Indicator = frequency distribution of VKT by income quartile	Income
10.	Access to dedicated ROW Public Transport Stations (Rail, BRTS) by Income Quartile **WARD**	Use GIS to identify administrative wards, residential locations, and dedicated ROW public transport stations Approximate location of **WARD** population center Determine avg. distance to ROW public transport stations for each **WARD** Determine avg. income quartile by **WARD** Indicator = frequency distribution of average distance to dedicated ROW station by income quartile	Income
11.	Fraction of seating designated "Women's only" on public transport vehicles	[daily number of dedicated seats for women] / [daily number of vehicle seats in revenue service]	Gender
12.	Women public transport users	[daily public transport boarding by women] / [daily boardings]	Gender

	Indicator / Type	Operational Definition	Objective
13.	Disability Access per Vehicle	Daily number of in service transport vehicles (buses and trains) that are accessible for wheelchair users * wheelchair capacity per vehicle / daily transport capacity	Disability Access
14.	Disability Access per Bus	[number of bus boarding events that are accessible for wheel chair users] / [total number of bus boarding events]	Disability Access
15.	Passenger Information	Daily number of in service transport vehicles (buses and trains) with functioning auditory announcements * vehicle capacity / daily transport capacity.	Disability Access
16.	Disability Access per Station	[number of dedicated ROW public transport stations accessible for wheelchair users] / [number of dedicated ROW public transport stations]	Disability Access
17.	Disability Access per Bus stop	[number of bus stops accessible to wheel chair users] / [number of bus stops]	Disability Access

INTERMEDIATE PUBLIC TRANSPORT

Returning to what was described earlier: Autorickshaws, tempos, chakdas, cycle rickshaws, taxis, and other intermediate public transport modes play an essential role in bridging accessibility gaps and providing mobility to populations and locations that are excluded from other transport options. Intermediate modes help to create an integrated and affordable public transport system. In addition, intermediate transport itself provides an important means of livelihood for low-income, uneducated, and migrant populations (Cervero 2011). Thus, the SLBs should not ignore this critical component of India's urban transport networks. Prioritizing IPT will especially make the SLBs more sensitive to conditions in smaller cities that cannot support formal public transport (Dhingra 2011).

Intermediate public transportation can support the urban transportation objectives such as: Performance, Convenience, Public Safety, and Regulation. The following indicators can be explored as a way of assessing IPT performance:

Table 4.31: Intermediate Public Transport Indicators

	Indicator / Type	Operational Definition	Objective
1.	Change in IPT mode share	Percentage point change in IPT mode share over a recent recording period (e.g. last five years)	Performance
2.	Change in bicycle rickshaw mode share	Percentage point change in bicycle rickshaw mode share over a recent recording period (e.g. last five years)	Performance
3.	Fraction of owner-operated IPT vehicles	[number of owner-operated IPT vehicles] / [total number of IPT]	Performance
4.	Fraction of dead kilometers (on the road but not in use)	[number of dead km] / [total number of IPT km traveled]	Performance
5.	Percentage of IPT vehicles that utilize radio dispatch	[number of IPT that utilize radio dispatch] / [total number of IPT]	Convenience
6.	Fraction of public transport interchanges with dedicated rickshaw parking	[number of public transport interchanges with IPT parking] / [total number of public transport interchanges]	Convenience
7.	Provision of designated lay-bys and terminals per capita	[number of IPT lay-bys and terminals] / [metropolitan area population]	Convenience
8.	Annual number of IPT user fatalities per capita (100,000 people)	[number of IPT user fatalities] / [metropolitan area population]	Public Safety
9.	Municipal Bicycle Rickshaw Maximum Policy	Existence of bicycle rickshaw maximums anywhere in the city	Policy
10.	Percentage of motorized IPT that pass state emission standards	[number of IPT vehicles that pass state emissions standards] / [total number of IPT vehicles]	Regulation

	Indicator / Type	Operational Definition	Objective
11.	Vehicle licensing fee	Fee for annual motorized IPT license	Regulation
12.	Educational prerequisites for obtaining a license	Minimum requirement for obtaining motorized IPT operator license.	Regulation

PUBLIC ENGAGEMENT / TRANSPARENCY

Public engagement in community decision-making can be traced as far back as Plato's Republic. Plato's concepts of freedom of speech, assembly, voting, and equal representation have evolved through the years to form basic pillars of representational democracy. It is difficult to effectively engage the community when planning large scale transportation interventions. Flyvberg (2003) indicates the following general challenges for participation:

- General public, citizens who are impacted, and other concerned groups are usually not involved in project appraisal or selection.
- Planning agencies or developers provide information at a stage late in the process where key decisions and agreements have already been reached.
- When they are denied inclusion and access to project information, public interest groups may act destructively and try to shoot the project down.

Thus it is not surprising that citizens who bear the risk of public investments feel left out when decisions regarding major infrastructure are taken without public involvement. Typical transportation performance measurements have focused attention on the impacts of government policies, but in a narrow way, emphasizing efficiency indicators as the only vantage point from which to assess program performance. While much attention is devoted to questions of waste, fraud, abuse, and managerial accountability, there is little mention of values such as equity, transparency, and citizen participation.

Participation should not be an empty exercise. While pressure from below forces both official participatory bodies and governments to be more aware of public interests, it is equally important to recognize that meaningful justice may only be obtainable through "Better representation," not broader participation (Fainstein 2010). Participation in public programs and broader political activity can be considered both as an intermediate process outcome, and an end outcome in which participation impacts public policy. That is, program participation leads to end outcomes by helping individuals acquire civic skills and develop social and political networks.

Citizens need not constantly reflect upon the impact of transport on their lives, but transparency efforts that facilitate municipal monitoring and accountability are essential to ensure that decision-makers are responsibly governing. For marginalized populations, citizen activism and protest movements are especially crucial to develop policies that are sensitive to a greater number of potential outcomes. Similarly, effective public participation and pressure from below is necessary for successful transport outcomes. Participation efforts are best suited for contributing to municipal-level initiatives.

Public participation can potentially be utilized to augment the capacity of transportation institutions to effectively monitor their operations. Crowdsourcing – or the act of outsourcing tasks performed by an individual to a group – has been shown in some instances (Steinfeld 2011, Ching et al. 2013) to support public transport performance measurement. With appropriate technological support, local participants may utilize GPS enabled feature phones with an appropriately design crowdsourcing app (Steinfeld 2011) to capture data such as: bus stop locations, transport vehicle arriving times, and their total times in transit, then submit this data to a database for analysis and public review. Asking local participants to complete full ridership surveys is not effective; however they should be able to indicate general categories related to vehicle load: (such as, Empty, Seats Available, Standing, Full). The GPS and time tracking capacity of feature phones allows the participants to collect multiple vehicle load readings as their ride progresses

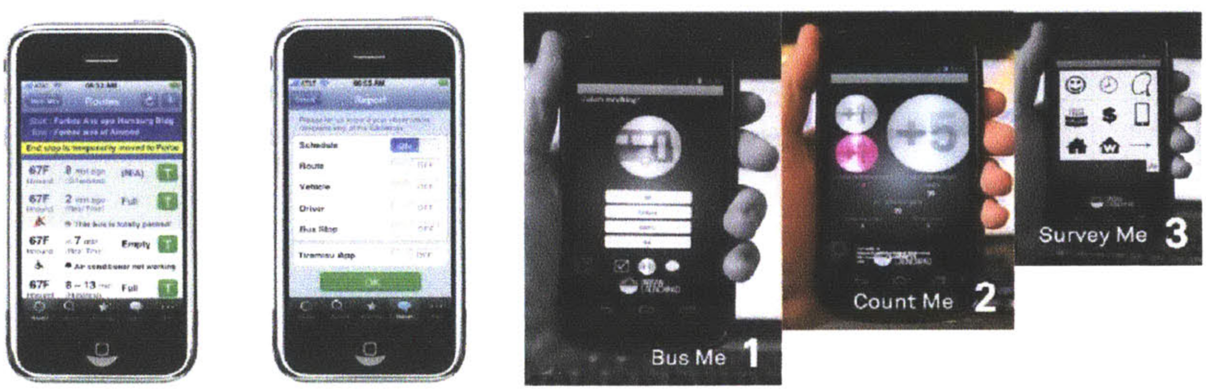

Figure 16: Examples of crowdsourced transportation measurement apps: Tiramisu & Share My Bus Dhaka (Steinfeld 2011, Ching et al. 2013)

An important benefit of performance measurement and indicator initiatives is making data sources open and sharing measurement results with the public. Via such initiatives of data transparency, government bodies can benefit the public by alerting them to key project benefits and long-term planning goals (World Bank 2003). Making public the indicator data has the potential to assist in building participant capacity and thus creating more capable partners in program development. Currently planning processes in India are predominantly influenced by either vested state institutional or NGO interests (Rajagopal 2003), thus there is great potential for political distrust and discrediting. Making project reports and performance indicator data transparent and readily available can reduce the public fear of monied influence and corruption. Finally, making the data available will allow planning projects to benefit from crowdsourced data collection. India has approximately 27 Million smartphone users[22] in cities with greater than 100,000 people (Neilsen Informate 2012). Having access to GPS data, high quality digital cameras, internet access, and custom designed reporting apps could prove to be a vital step in collecting transportation performance data. In a country that has recently been extremely active in protesting corruption of public officials (such as activist Ana Hazare's movement to strengthen and pass anti-corruption legislature) and demanding public transparency (Aruna Roy's Right to Information Act), crowdsourced transport data collection may be worthy of political support.

The following proposed indicators address engagement and transparency through objectives of Participatory Planning, Community Engagement, Consensus Building, and Data Transparency.

Table 4.32: Public Engagement / Transparency Indicators

	Indicator / Type	Operational Definition	Objective
1.	Fraction of annual Municipal level projects that utilize **community transport planning meetings**[23] to gather public input and advise the public on project progress.	[annual number of projects that utilize community transport planning meetings] / [annual number of planning projects initiated]	Participatory Planning

[22] Albeit this group may not share the goals of the HPT user. There may prove to be enough interested that a meaningful cross-section of data may be collected and shared. I feel that transportation performance improvements are not guaranteed, but they are possible.

[23] In this context, "Community planning meeting" refers to meetings that are widely advertised and open to the public, where agency transportation projects are introduced and key stakeholders (general public, local NGO groups, resident welfare associations) who would be impacted by the projects' implementation are invited to ask questions and provide feedback. These open public meetings should follow a specific agenda, and discussion notes and minutes should also be distributed (online or on request) to interested parties.

	Indicator / Type	Operational Definition	Objective
2.	Fraction of municipal level transportation institutions and planning initiatives (such as BRT, Metro, or flyover projects) that have designated citizen advisory bodies including representatives of the public.	[number of municipal institutions and initiatives that have designated advisory bodies] / [total number of number of municipal institutions and initiatives]	Community Engagement
3.	Municipal level transportation indicators created through public negotiations and consensus	Specifically related to the societal validation step of the indicator construction process in Chapt. 1. Existence of transportation indicator collections produced via consensus process and societal validation	Consensus Building
4.	Current and past performance measurement data is made available to the public via online municipal transportation "Dashboard / Scorecard[24]".	Existence of open indicator database and municipal transportation	Data Transparency
5.	Municipal level program for facilitating public crowdsourcing of transportation performance data collection.	Existence of crowdsourcing program to collect performance data.	Community Engagement

AREAS FOR FURTHER STUDY

In this section I describe one particular area of institutional management of urban transportation systems that should be considered in future efforts to refine the SLBs.

Soil and Water Quality

More attention must be paid to soil and water pollution

[24] Such as Boston's MBTA Scorecard which lists Ridership, Vehicle and System Maintenance, On-Time Performance, etc. (MBTA 2012)

- Runoff pollution from transport infrastructure
- Annual Polluting transport accidents per capita

These indicators document important negative side effects of transportation systems with regard to environmental systems. However, the data for these measurements is not as readily available as the typical air pollution measurements.

Contract Sustainability

Increasingly, municipal governments are turning to the private sector to build and operate public transport systems. The private sector can contribute much-needed capital and expertise. Yet with all the promise of public private partnerships (PPPs), efficiency and quality improvements in the public transport sector are often elusive. Many PPPs prove to be a more costly financing option than traditional financing of public transport (Flyvbjerg 2003, Fainstein 2001). An overarching problem is the pace at which so many privatizations occur. While proper implementation often requires years of planning, important steps are often rushed and implemented out of sequence. Hasty privatization can be especially problematic considering that the public sector often has little or no previous privatization experience.

The effectiveness of transport systems operated by the private sector is a function of the structure of contract agreements and the management capacity of the public sector. If a municipal government is sophisticated, transparent and reasonably free of graft, many of the potential problems with PPP can be contained. This is accomplished through careful contracting, sufficient public scrutiny and oversight and transparent competitive bidding procedures (ITDP 2007). Implementing agencies require sufficient and well-qualified staff to oversee private operators. Contracts need to include Service Level Agreements with quantitative metrics to assess contractor performance. These metrics need to be measured by the implementing agency on a regular basis, and specific financial penalties should be applied in the case of non-compliance. Thus, I feel that these indicators should be included to maximize public benefit and fully measure public-private sector performance.

To work towards measuring the effectiveness of the PPP process, I suggest developing indicators that can begin to measure performance in the following areas.

Contract structure and stability

- Is there a competitive bidding process?

- Are there multiple capable firms or was the contract awarded to a sole bidder?
- Does the contract include joint public-private ownership structures?
- How much can the system charge for its services?
- Are fares linked to the cost of inputs, such as fuel?
- How much capital must the concessionaire invest to fulfil requirements?
- Competitive process for subcontracts (such as financing, vehicle procurement, and construction)
- Do clauses about the "fair rate of return on capital" offer excessive guaranties to private firms?
- Is the payment method per km or per passengers?
- Is there transparency in financial transactions?

Institutional Capacity

- Does the staff have the relevant skill sets to write and enforce contracts and related processes?
- Experience with public transport regulation?
- Legal and administrative commitment to regulation?
- What is the government's capacity for enforcement?
- To what extent has control been ceded to private interests?
- Is there adequate representation of users on the regulatory body overseeing the project (including in the project-planning phase)?

SERVICE LEVEL BENCHMARK CONCLUSIONS

Through the previous recommendations, I've presented a large number of indicators (more than 100 in total). In the spirit of my focus on indicator production and participation, I offer these indicators more as a starting point to such a dialogue/process, not an endpoint.

Effective monitoring and benchmarking is critical to the success of transport systems in Indian cities. This process offers a mechanism to tie funding to project performance. Benchmark indicators may be utilized to assess whether a project has been implemented properly and if it is meeting its original goals. Benchmarking may help cities and public transport agencies assess and improve service quality. Collecting and sharing system performance data may offer a mechanism for citizens and community groups to call for improvements and changes, and thus hold transport system decision-makers accountable for policies and projects.

Municipal governments and public transport agencies will need support in rolling out effective benchmarking systems. The Ministry Of Urban Development has a key role to play in the following activities:

- **Establishing an transportation data clearing house** that can serve as a repository for indicators, benchmarking data and analysis. City-level data should be made available free-of-charge via annual online reports and a publically searchable database.
- **Identifying organizations and institutes that can serve as benchmarking resource centers** for municipal governments and public transport agencies. These organizations can offer support in survey techniques and data analysis methods.
- **Tie transport project funding to demonstrated improvement in transport indicators.** Unless, cities demonstrate progress in improving the quality and patronage of sustainable modes, central funding for private vehicle infrastructure should be put on hold.
- **Nationally sponsored house hold travel behavior surveys.** A survey of the travel behavior of households in urban areas should be undertaken at least every two years. It is especially important to capture essential transport data such as VKT, Average trip lengths, transport modes, etc. The survey should include a household survey (demographic information), a vehicle survey (description of vehicle ownership and use), a person survey (typical travel behavior), and a travel day survey (detailed travel diary). The survey components could be collected via internet form, mobile phone, or GPS enabled smartphone (especially helpful for travel diary); however, a certain percentage of surveys should be collected in person to assist respondents who would have difficulty reading or understanding survey forms.

Together, these efforts can help ensure that benchmarking becomes a useful tool for cities that are working to make their transport systems more environmentally sustainable, socially equitable, and economically sound.

Next, I would like to demonstrate how a specific set of proposed Service Level Benchmarks may be applied in Ahmedabad.

CHAPTER FIVE: INDICATORS FOR AHMEDABAD

Keeping in mind the history of applying universal indicators to the problem of transportation and sustainable development, I now focus on indicator efforts at the local scale. Informed by local priorities and international best practices for urban transportation measurements, I will contrast specific characteristics of Indian streets through the lens of the SLBs as well as the previously defined alternative set of indicators.

AHMEDABAD BASICS

Modern Ahmedabad is the cultural capital of and the largest city in the western Indian state of Gujarat. With a population of 5.5 million spread over 475 sq. km, Ahmedabad is India's 8th most populous city. Initially considered the "Manchester of India," with the largest share of employment in cotton textile industry, Ahmedabad has transformed its economic base to include pharmaceutical, automobile manufacturing, food processing, textile and apparel, chemicals and dyes and IT industries (Mahadevia 2012). Based on investments in infrastructure, institutional capacity and "market friendly reforms" the city has been held aloft as an example of the shining new India. However, that image corresponds to only one half of the City. The wide channel of the River Sabarmati splits the city in two: East and West, walled and modern. Ahmedabad's history is also marked by significant episodes of communal violence between Hindus and Muslims.

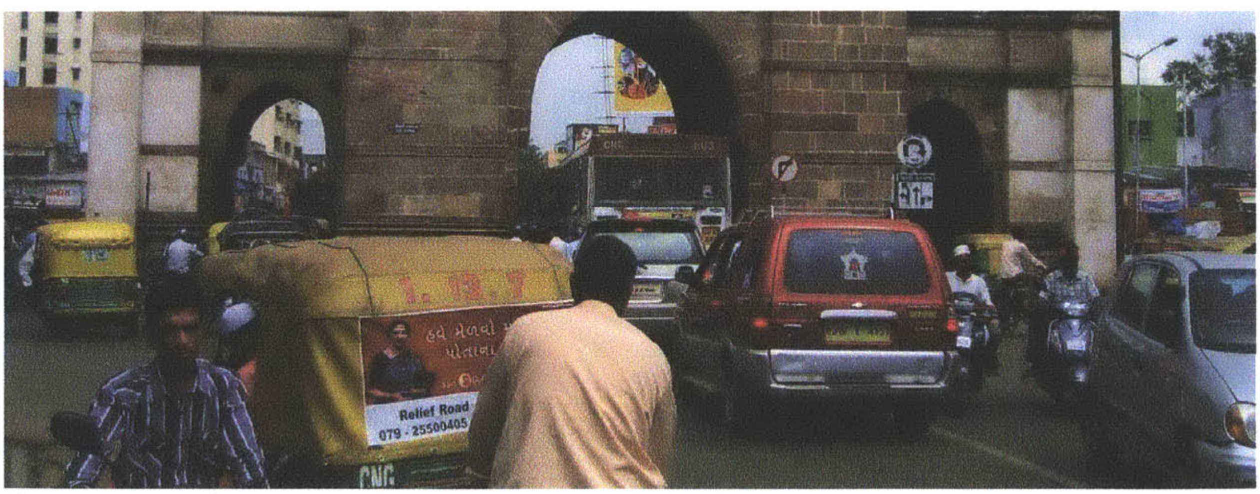

Figure 17: Tension between Old Ahmedabad's traditional urban form and modern transportation modes

While I had heard much about Ahmedabad's 600-year old history, and recent accomplishments in urban governance, I was especially interested in the city's relationship with the west and its mid-20th century efforts seeking design and planning expertise. In the mid 1990's, urban designers Alan Jacobs and Elizabeth MacDonald were asked to redesign a main commercial thoroughfare as a multi-way boulevard. Ahmedabad continues to engage with international design and planning initiatives. Most recently in 2010, Ahmedabad's Bus Rapid Transport System (BRTS) was recognized with a "Sustainable Transportation Award" by a consortium of experts and organizations working internationally on sustainable transportation.

Besides the recent public transport improvements, urban transport planning in Ahmedabad has tended to concentrate on improving private motor vehicle mobility (such as road widening, flyovers at intersections, ring roads, etc.). In general, Indian street design standards vary only slightly from those of highways (Pucher, et al. 2004). While this rings true in Ahmedabad, using highway-focused measurements to gauge the performance of city streets seemed ill-suited to describe the events of conflict, asymmetry, and negotiation that I observed everyday on my bicycle commutes. Ahmedabad has the following transportation mode share characteristics (ITDP 2009):

- **14%** Pedestrian
- **14%** Bicycle
- **11%** Public Transport (bus)
- **9%** Intermediate Public Transport
- **6%** Automobile
- **46%** Motorized Two Wheelers

The current mode share statistics represent the following trends from previous transportation data collected (Figure 17).

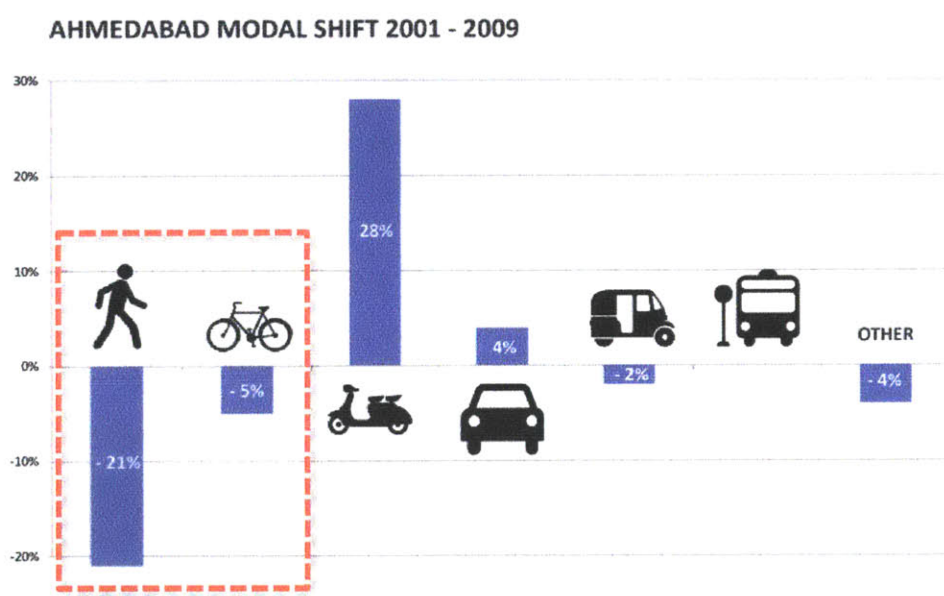

Figure 18: Ahmedabad Modal Shift 2001-2009 (Louis Berger 2001, ITDP 2009)

In examining the modal shift since 2001, the drop in bicycling and walking of a combined 26% is notable (See red dashed rectangle). This just about matches the increase in motorized two-wheelers

(28%). It is also important to note that although the mode share of public transport did not change, Ahmedabad made significant improvements in public transport infrastructure.

MEASURING IN THE CITY

I use the Ahmedabad case to illustrate some of the problems of the MoUD SLBs and how my proposed alternative indicators (see Chapter 4) offer an improvement. Given the scale of the full suite of indicators elaborated in the previous Chapter and the general importance of pedestrian and bicycle modes in Ahmedabad, I focus on a sub-set of the indicator categories, namely those that measure the SLB indicators for "Pedestrian Infrastructure" and "NMT [sic] Facilities." To collect this data a sampling of the city's corridors was necessary. I classified arterials that had a ROW of at least 18m by age, income and dominant land use, so that I would be sure to get a diverse mix of Ahmedabad's unique features.

Table 5.1: Mix of ages, incomes, and land uses utilized to select representative corridors

AGE	Historic
	Modern
INCOME QUARTILE	Economically Weaker (EWS)
	Upper
	Middle
	Lower
DOMINANT LAND USE	Commercial
	Residential
	Institutional
	Industrial

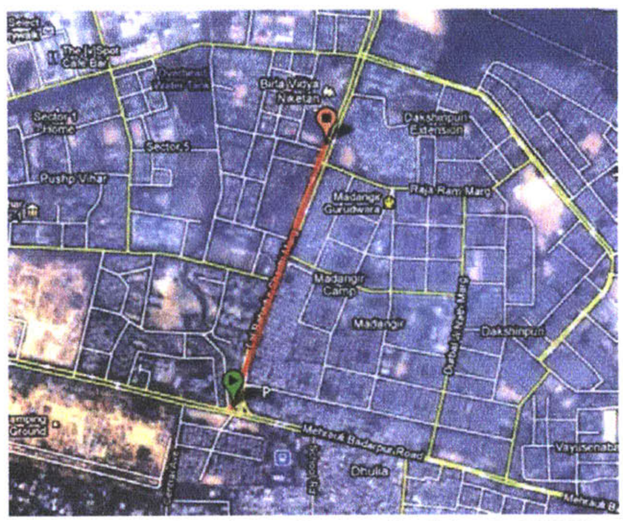

Figure 19: A 1 km of sample stretch of the Delhi BRT

It is important that the corridors chosen provide an adequate sample of the city's wards and developed areas. These locations should include a mix of dominant land uses, income levels, and ages (See Table 5.1). Examples of appropriate urban places to capture include: historic districts, modern enclave developments, superblocks, public transport corridors, important transport interchanges, institutional blocks, and urban highways. For example, choosing the southern stretch of Delhi's bus rapid transit (BRT) corridor at the Ambedkar Nagar Depot (Delhi Metropolitan Area, South Zone, Ambedkar Nagar Ward) as a survey location would provide: *modern* age, *middle* income, and *residential* land use (see Figure 18).

After informal interviews with planners and planning academics at CEPT University, I visited approximately 12 key corridors that were identified as indicative of Ahmedabad's typical transportation conditions. Next, I identified four study areas (Figure 18) that I felt were are representative of city transportation corridors that I visited. Finally, I observed the way that each corridor was being used and counted the number of people moving through space via each mode of transport.

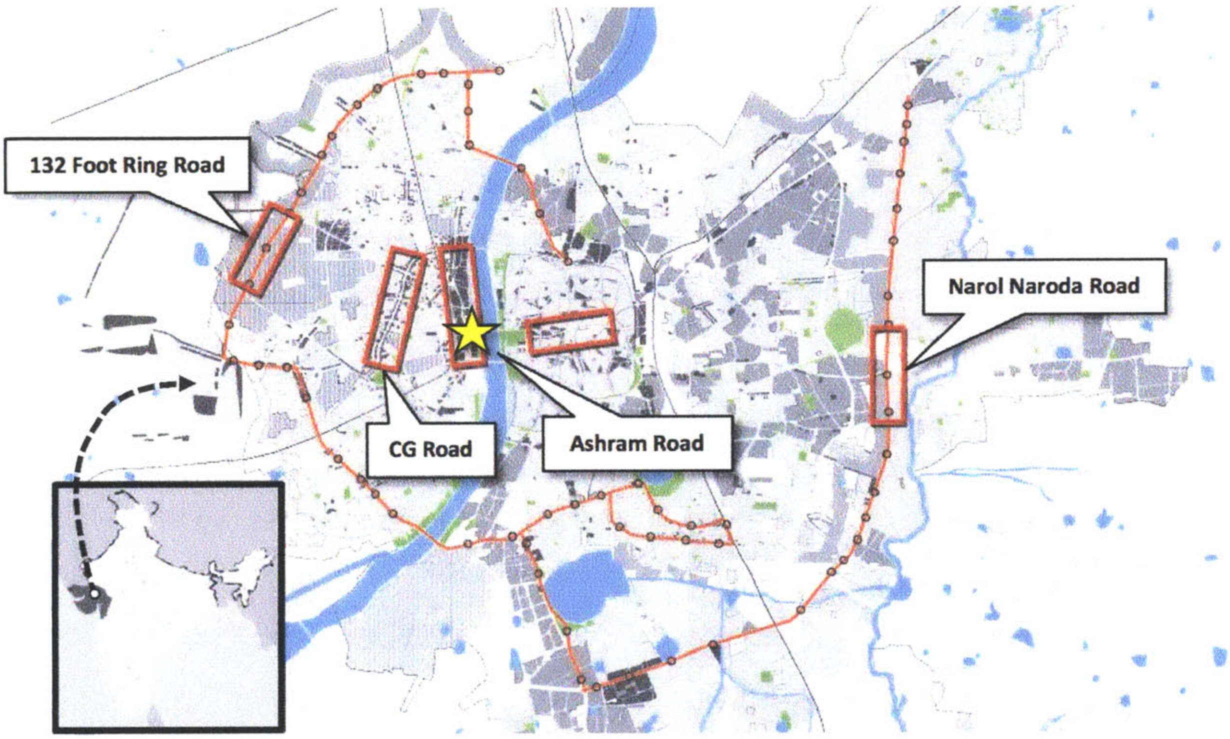

Figure 20: Context of India, Gujarat, and Ahmedabad showing CBD (yellow star), survey locations and BRT route(in red)

The time that I had available to engage with the work was not enough for me to fully survey all of the potential locations. I was unable to resurvey or return to locations for gathering additional data at different times. While I did try to get a somewhat representative even mix of the city's uses and urban forms in selecting corridors, and consulted planning professionals and residents, a more rigorous approach might have entailed that multiple corridors for each type be identified and then randomly chosen to eliminate bias. In addition, the spatial resolution of the data collected was is relatively crude as I did not spatially identify most of the data that I collected beyond attributing it to a particular corridor. To simplify the process, I used bulk tallies for footpath obstructions, numbers of street vendors, trees, or lengths of unbroken median / compound wall / etc.

For the four corridors, two types of surveys were completed: short point measurements (every 200 m) and longer traffic surveys (every 600 m). Measurements were completed on both sides of the corridor. This study included the following corridors, as described below.

Figure 21: Ashram Road / Corridor Survey

Ashram Road is a commercial / institutional arterial that recently has been redesigned by the Ahmedabad Municipal Corporation (in the mid-2000s). There are three lanes in each direction with access lanes, vehicle parking facing the outside, a landscaped and fenced center median, wide pedestrian islands and benches at consistent intervals. The road well served by public transport and has clearly marked shelters with inlets

Figure 22: CG Road / Corridor Survey

CG Road is a mixed commercial / residential multi-way boulevard that was designed by Jacobs and MacDonald in 1996. It features two lanes of traffic in each direction with a fenced center median, as well as access lanes with diagonal parking towards the center.

Figure 23: 132 Foot Ring Road / Corridor Survey

132 Foot Ring Road is an institutional arterial serving the Indian Institute of Management Ahmedabad campus, a convention center and several wide open greenbelt fields with 2 lanes of traffic in each direction and 2 lanes in the center dedicated to BRTS vehicles and stations. Recently opened in 2009, this road includes protected bicycle lanes and wide footpaths as well as infrequent benches.

Figure 24: Narol Naroda Road - NH 8 / Corridor Survey

Narol Naroda Road is a mixed industrial / commercial urban highway with three lanes in each direction, 2 lanes of BRTS facilities, as well as protected bicycle lanes. This road was redesigned to accommodate BRTS and also a portion of the Bombay-Ahmedabad-Delhi Highway (NH 8).

Table 5.2: Physical and Operational Characteristics for Ahmedabad Corridors

	Characteristics	ASHRAM ROAD	CG ROAD	132 FOOT RING RD.	NAROL NARODA RD.
PHYSICAL	Survey Length (km)	2	2	1.4	1
	Roadway width (m)	34	26	40	55
	Avg. Sidewalk width (m)	2.14	1.37	2.08	1.48
	Intersection Density (/km)	3.5	4	2.86	2
	% Compound wall frontage	45%	28%	95%	5%
OPERATIONAL	Land Use	Commercial, Residential, Institutional, Recreational	Commercial, Residential, Institutional, Recreational	Institutional, Recreational	Industrial, Commercial
	Configuration	3 lanes / direction, median barrier, service lane, off-street parking: 45° facing out	2 lanes / direction, median barrier, service lane, off-street parking: 45° facing in	3 lanes / direction, median alignment BRT	4 lanes / direction, median alignment BRT, service lanes, parallel parking
	Bike Lane Direction / Avg. width (m)	0	0	Each direction, 1.35	Each direction, 0.76
	Seating (/ km)	38	6.5	10	24

Table 5.3: Weekday PM Peak Traffic Counts / Min

	ASHRAM ROAD	CG ROAD	132 FOOT RING RD.	NAROL NARODA RD.
	5.1	5.9	1.63	5.5
	3.6	2	2.33	5.3
	1.1	0	0.3	0.75
	5.8	3.8	2.93	10.45
	19.8	24.9	14.30	25.4
	5	6.9	8.13	3.3
	0.4	0.7	0.6	4.15

Table 5.3 presents the traffic counts, which reinforce the modal data listed above with motorized two wheelers (M2W) contributing the majority share of the vehicles. Of course public transit would for all of the corridors where it was present be responsible for moving the most people. While all of the corridors had pedestrian footpaths, only two of those surveyed had dedicated bicycle facilities (132 Foot Ring Road and Narol Naroda Road). With the provision of bicycle lanes, Narol Naroda Road had the highest bicycle counts (5.3 bicycles/minute), but only 1.7 bicycles per minute more than Ashram Road (3.6 bicycles / minute). Also interesting is the relationship between BRT routing and public transport service provided. Ashram Road saw the highest frequency of buses despite not having dedicated ROW for buses. Of course this may be due to its proximity to the CBD and RTO interstate bus terminal which is located approximately 3 km to the North (See Figure 18). Ahmedabad BRT system does not directly enter the city core – which I would approximate as being across the river from the walled city (Figure 19).

The next set of diagrams (Figure 24) shows the four survey areas in context with their adjacent city blocks. It highlights the survey extent (red dashed line) and also documents the urban form and approximate land uses of each corridor. Taken with the traffic count data, the conditions of each corridor comes into focus. For example, the lack of built form and large block sizes of 132 Foot Ring Road may explain the low pedestrian levels observed.

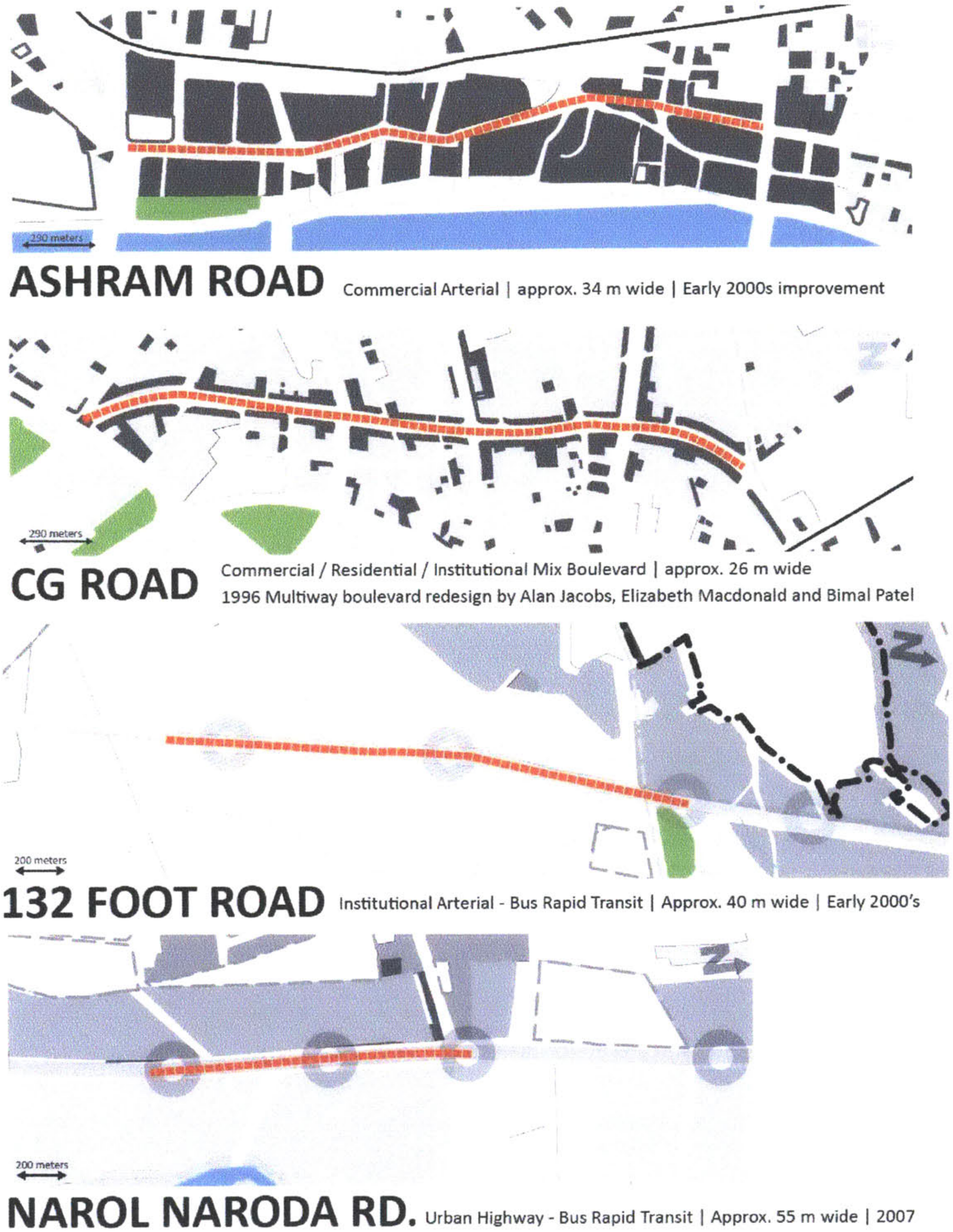

Figure 25: Four study areas existing conditions with study areas

SLBs APPLIED

As described in Chapter 4, the following SLB indicators are concerned with HPT (bicycle and pedestrian) movement:

1. Signalized Intersection Delay
2. Street Lighting
3. % of City Covered
4. % of network covered
5. Encroachment on NMT [sic] roads by vehicle parking (%)
6. NMT [sic] parking facilities at Interchanges (%)

Table 5.4 presents my estimated calculations for each of the HPT indicators in the existing SLBs.

Table 5.4: SLB Indicators for Ahmedabad Corridors

	SLB indicator	ASHRAM ROAD	CG ROAD	132 FOOT RING RD.	NAROL NARODA RD.
PEDESTRIAN	Signalized Intersection Delay (% intersections with delay > 45 seconds)	0% LoS = 1	0% LoS =1	0% LoS = 1	0% LoS = 1
	Street Lighting	Not measured	Not measured	Not measured	Not measured
	% of City (Survey Area) Covered [by 1.2 m footpaths]	100% LoS = 1	50% LoS = 2	70% LoS = 2	70% LoS = 2
NMT [sic]	% of network covered	0% LoS = 4	0% LoS = 4	100% LoS = 1	75% LoS = 1
	Encroachment on NMT [sic] roads by vehicle parking (%)	No NMT [sic] roads N/A	No NMT [sic] roads N/A	0% LoS = 1	4% LoS = 1
	NMT [sic] parking facilities at Interchanges	No Interchanges N/A	No Interchanges N/A	0% LoS = 4	0% LoS = 4

For the pedestrian infrastructure facilities indicators, I did not measure the indicator for Street Lighting. Assuming that street lighting at night was between 4 and 6 lux, resulted in a sub-category level of service (LoS) = 3 (From the SLB LoS descriptions). Approximately 73% of the corridors surveyed had a footpath that was greater than 1.2 m wide (LoS = 1). Also, 100% of the signalized intersections had required a waiting time for pedestrians that was less than 45 seconds (LoS = 1). Combining these three indicator categories, the Overall category LoS for Pedestrian is 1. Thus, per the benchmarks: "The city has adequate barrier free pedestrian facilities along overall road network."

The Bicycle facilities level of service was similarly calculated. 32% of the length of the two corridors surveyed had bicycle facilities (LoS = 2). Less than 10% of the bicycle facilities were encroached by vehicle parking (LoS = 1). However, 0% of the major interchanges had bicycle parking (LoS = 4). Therefore the overall category LoS for Bicycle facilities is 2. Per the benchmarks: "The city has NMT [sic] facilities which may need some improvements in terms of encroachments, parking facilities at interchanges, etc. as some parts of the city are note served by it. The system provided is comfortable and sustainable." Thus, if the SLBs were utilized as actual indicator of system performance by the city, a healthy picture of the city's HPT infrastructure on the corridors analyzed would be presented.

Developing LoS for these modes is uncharted territory for Indian cities. Thus, great care should be placed to set aspirational goals that are in sync with actual conditions. If the goal behind the exercise is to create a set of comparable benchmarks for cities to compare transportation practices, it is important that several cycles of performance evaluation be completed to get a firm understanding of the conditions on the ground. It is troubling that the MoUD would assign aspirational value to performance ranges without have evidence that such ranges represent positive changes (as well as possible conditions), for Indian cities.

ALTERNATIVE INDICATORS APPLIED

I now turn to applying the alternative HPT indicators, that I proposed in the previous Chapter, to the same four corridors. The following indicators were utilized:

1. Complete HPT Coverage
2. Pedestrian Infrastructure Utilization
3. Bicycle Infrastructure Utilization
4. Pedestrian Footpath Width
5. Bicycle Lane Width
6. Pedestrian Footpath Quality
7. Bicycle lane quality
8. Crossing opportunities
9. Crossing distance
10. Access for Disabled / Seniors
11. Bicycle parking
12. Intersection Signalization
13. Crossing safety
14. Seating provision
15. Shade
16. Encroachment on Pedestrian Facilities
17. Encroachment on Bicycle Facilities
18. Lighting
19. Eyes on the Street: Inactivity
20. Eyes on the street: Street Vendors
21. Eyes on the street: Compound Walls
22. Eyes on the street: Hazards for women

Table 5.5 presents the HPT indicator values that were measured across the sample corridors.

Table 5.5: Alternative HPT Indicators for Ahmedabad Corridors

	Alternative Indicator	ASHRAM ROAD	CG ROAD	132 FOOT RING RD.	NAROL NARODA RD.
OVERALL PERFORMANCE	Complete HPT Coverage (% of roads with IRC compliant sidewalks **AND** bicycle facilities)	0%	0%	21%	9%
	Pedestrian Infrastructure Utilization (% of peds using designated footpath)	33%	17%	76%	11%
	Bicycle Infrastructure Utilization (% of cyclists using designated footpath)	N/A	N/A	11%	3%
CONVENIENCE	Pedestrian Footpath Width	2.14 m	1.37 m	2.08 m	1.48 m
	Bicycle Lane Width	N/A	N/A	1.35 m	0.76 m
	Pedestrian Footpath Quality (obstructions per km)	94	154	94	192
	Bicycle lane quality (obstructions per km)	N/A	N/A	68	52

	Alternative Indicator	ASHRAM ROAD	CG ROAD	132 FOOT RING RD.	NAROL NARODA RD.
	Crossing opportunities (opportunities per km)	10	10	6	8
	Crossing distance (Maximum)	30 m	26 m	40 m	55 m
	Access for Disabled / Seniors (curb ramp per km)	0	0	0.38	0
	Bicycle parking (% of interchanges with bike parking)	N/A	N/A	0%	0%
PUBLIC SAFETY	Intersection Signalization (% intersections signalized)	71%	63%	75%	100%
PUBLIC SAFETY	Crossing safety (tabletop crossings / km)	0	0	0	0
PHYSICAL COMFORT	Seating provision (public seating / km	38	7	10	24
PHYSICAL COMFORT	Shade (trees in ROW / km)	66	43	2	3
PHYSICAL COMFORT	Encroachment on Pedestrian Facilities (parking ECS / km)	7	38	1	31
PHYSICAL COMFORT	Encroachment on Bicycle Facilities (parking ECS / km)	N/A	N/A	0	32
PERSONAL COMFORT	Lighting	Not measured	Not measured	Not measured	Not measured
PERSONAL COMFORT	Eyes on the Street: Inactivity (% of road length described as inactive - street is devoid of pedestrians)	0%	18%	93%	36%
PERSONAL COMFORT	Eyes on the street: Street Vendors (street vendors / km)	31	36	3	32
PERSONAL COMFORT	Eyes on the street: Compound Walls (% of frontage that is compound walls)	45%	28%	95%	5%
PERSONAL COMFORT	Eyes on the street: Hazards for women (Wine shops & B-Movie Halls / km)	0	0	0	0.5

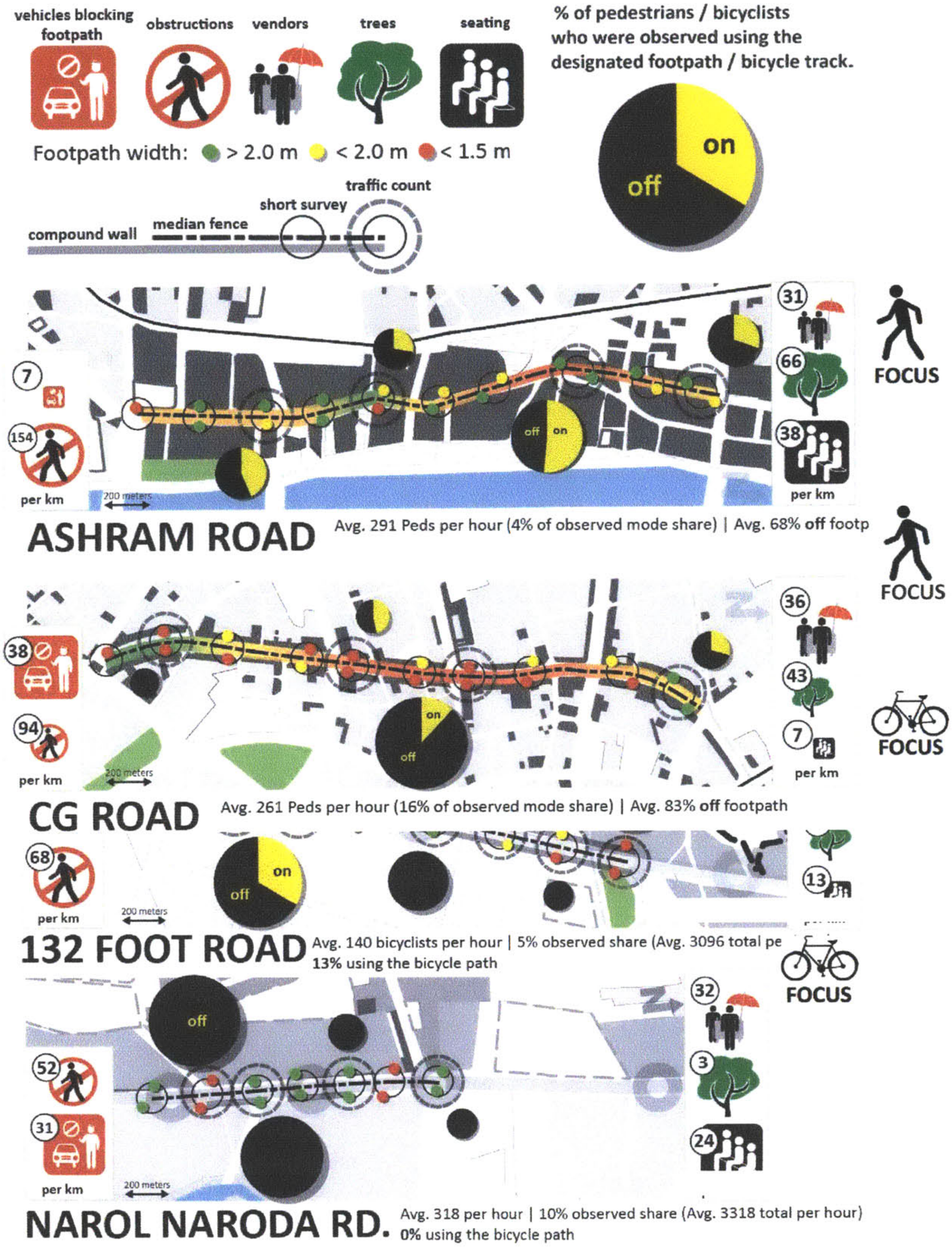

Figure 26: NMT Indicators / Observations (Pedestrian data in the top two, bicycle data in the bottom)

The above diagrams (Figure 26) demonstrate the specific locations of high or low activity and infrastructure utilization. For Ashram Road and CG Road, the figure highlights alternative indicators focusing on pedestrian access, while for 132 Foot Ring Road and Narol Naroda Road, the bicycle-focused indicators were highlighted. The black circles indicate the different types of surveys (small black lines indicate 200 m locations, dotted lines indicate the 600 m surveys with traffic counts) and their locations. The red, yellow and green dots indicate specific ranges of sidewalk and bicycle lane width. The black and yellow pie charts note the degree of infrastructure utilization and are scaled by the total number of pedestrians or cyclists counted. The icons capture a limited set of the alternative indicators, and are scaled in size to represent absolute numbers.

The data suggest correlations between areas of low sidewalk width and low degrees of sidewalk usage. However, the same relationship does not hold for the width of the cycle tracks and their use. This may say more about the design or maintenance of the bicycle lanes, than the abilities or perceptions of the users. Collecting indicator data on the quality of NMT facilities (such as average widths, degrees of encroachment and obstruction) will help associate design characteristics with actual performance, measured by user preferences and observed mode share. Thus, in comparison to the 6 SLBs the 22 alternative indicators paint a more detailed picture of the performance of Ahmedabad's streets for pedestrians and bicyclists. Ahmedabad's streets are much more complex than the simple frame of the SLBs portrayed. The alternative indicators are also more sensitive to local conditions. While the level of service according to the pedestrian and bicycle SLBs was excellent (LoS = 1), the actual uses show that pedestrians were not using the facilities designated for their benefit. The lack of use was especially apparent for the bicycle lanes on Narol Naroda Road and 132 Foot Ring Road. The facilities at present were in poor condition with many obstructions. These important specifics were lost to the SLB indicators.

In reviewing the four corridors through the lens of HPT, I was able to show key differences between the SLBs and the alternatives that I propose. First, the SLB pedestrian indicators were narrowly focused on transportation details that were not inclusive of all the potential users of Ahmedabad's streets. From the three SLB indicators presented, the first, Signalized Intersection delay (which asked the surveyor to measure how long a pedestrian would have to wait to get a green light to cross the street) seems to represent the gap between policy and practice most aptly. Most pedestrians were not at all concerned with the timing of traffic signals. In regard to bicycle indicators, they were focused on an ideal vision of what a street should look like – While this is slowly changing, segregated bicycle lanes are a new experiment for Indian planners and designers. In Ahmedabad, I conducted observations at two locations that utilized these lanes, and found them not utilized. Conducting audits at the street level allows a finer degree of transportation performance detail to be collected. Understandably, benchmarks are designed for comparison, not local specificity. However, from my application of the HPT indicators to different conditions and corridors in other Indian cities (such as New Delhi and Bangalore) the SLBs were equally not meaningful.

CHAPTER SIX: CONCLUSION

I'd like to end with a broader reflection on the indicator development and production process, and the role of community. I believe this is particularly important given my own role (as a foreign visitor) in the indicator elaboration for India and application to Ahmedabad put forth in this thesis. In this thesis, I have reviewed the technical details and institutional framework of the MoUD's Service Level Benchmarks. My analysis of these benchmarks shows that while they represent an important program for the Ministry, they are lacking in several areas. They are narrowly focused on measurements, such as ITS, parking availability or traffic speed that do not reveal essential performance data. In other places they are missing important methodological details, thus resulting in indicators that are difficult to follow or do not produce reliable measurements. Indeed, my study of the four corridors in Ahmedabad highlights this.

In light of historical transportation performance and development indicator practices, I have analyzed and developed an alternative set of indicators which attempt to reset the focus on the transportation needs of India's urban population. These alternative benchmarks attempt to be mindful of what I feel are the real goals of transportation systems: providing current and future generations with physical mobility and access to opportunities. Through observing actual conditions of streets and transportation infrastructure, I sought to gauge the efficacy of India's transport performance initiatives. From my observations and discussions with Amedabadis (including planning academics, professional planners, transportation engineers and bureaucrats, and local NGOs), I constructed an alternative collection of indicators, and sought four locations where I could explore a subset of Human Powered Transport (HPT) indicators. In measuring and walking through targeted corridors of the city, I attempted to observe and measure what I felt were key features. Through capturing this kind of information first-hand, I hoped to identify potential gaps between envisioned policies and daily practices.

Ultimately my objective was to determine which indicators and which processes would be the most technically efficient and appropriate for the Indian context. After completing the processes of indicator analysis, creation, measurement and reflection, I recognize that it is far more important that indicators can be produced locally, and be flexible to multiple uses and users. Creating indicators has the potential to be an iterative and reflective process. I now see the full potential for indicators to be used as a collaborative learning tool to transform policy.

LEARNING BY INDICATORS

While it is important to develop a set of indicators that coincides with actual street conditions and public practices, it is equally important to recognize that there is no one closed set of uses and/or users of indicators. While indicators should be aligned with the goals of the central and state government, they should be more nuanced to address the needs of local stakeholders. Now I want to return to the key concept of indicator *production*. I see the development of valid, effective indicators for transportation performance as much an art, as they are a science. Technical facts are produced. And the production of technical facts, such as indicators, is a collective social enterprise that works through involving multiple interests (Blomley 2011). Therefore, the alternative indicators as described above are presented as a starting point for negotiations and a catalyst for an iterative process. They are a starting place for discussion and exploration of potential action.

Indicators can become powerful planning interventions under certain conditions, but to do so they must measure something that is publically valued. The real influence of indicators emerges in the collaborative decision-making process that constitutes of their development (Innes and Booher 2000). The process of group discovery and debating the design of indicators shapes the thinking of the contributors. Indicators by themselves are only useful if they are tied to policies and a possible set of actions. Thus, finding an agreement on indicators is finding an agreement on policy. In this way, an indicator development initiative for Ahmedabad is a vehicle for building consensus around transportation policy and establishing a specific set of values for transportation and urban planning interventions.

As I've made clear in the first chapter, indicators don't measure the world. What they measure are chosen characteristics. This is why it matters how indicators are produced. The characteristics of the MoUD-selected SLBs reflect the MoUD's values and aspirations for Indian cities. Instead of framing the many challenges for transportation in Indian cities, the SLBs tend to emphasize transportation performance goals and planning ideals that prioritize the movement of personal motorized vehicles above other uses of the road. In the context of developing appropriate transportation indicators for Ahmedabad, I feel that the indicator selection / creation process must include a broad cross section of interests, including citizens and members of civil society, transportation and urban planners, as well as municipal and state officials. Especially key to this process is involvement of those that are typically outside of transportation planning decisions (See Figure 26 below). Indicator development processes must carefully balance the stakeholders involved in production. Local NGOs should be approached and asked to designate official representatives. As well, representatives should be chosen from the general public through a transparent process. The Ahmedabad Municipal Corporation (AMC) is perhaps best positioned to be the facilitator and host of these meetings, as they currently influence the widest set of local transportation systems. The MoUD, the Gujarat Infrastructure Development Board (GIDB) , or the Gujarat Urban Development Company (GUDC) should provide support, but ultimately, the power should be delegated to the city. Thus, AMC should be tasked with finding a neutral party to lead and document the consultation sessions, and then ultimately with collect and maintain the data once the indicators are determined.

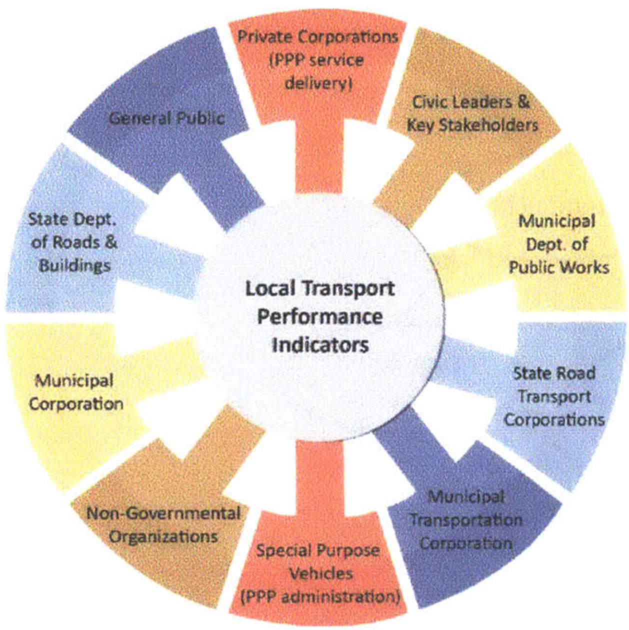

Figure 27: In Ahmedabad, Stakeholders to be part of indicator development / selection

Not only will the group learning process that occurs through indicator deliberation and production influence the greatest number of participants, but the final set of indicators (and policies) will be trusted, and granted legitimacy by the communities involved (Innes and Booher 2000). If the creation involves only a team of experts, then it is less likely to influence action. If the process is done without expert participation, then indicators developed are not utilized. To establish and maintain the trust, I feel that it is essential that indicator production meetings and the indicator measurements be made open and accessible to the public. Cultivating a practice of data and process transparency will ensure that those outside the process will benefit from the group discovery, and contribute to the process by reviewing and analyzing the data (as they are able to do so).

WAY FORWARD

Innes and Booher (2000) reflect on the critical role that indicators play in helping cities become *adaptive learning systems* that can be resilient in the face of unpredictable futures. In the context of good governance, building consensus over indicators is a path to group policy making. Developing a cultural literacy with these types of group learning and problem solving exercises is key to Lindblom's (1990) concept of a robust systems and self-guiding society. Thus, solutions to problems emerge not from design or central authority, but from collaboration, reconsideration of problem definitions and mutual adjustment. This approach embraces Lindblom's model of disjointed incrementalism, where policy making was less a matter of rational decision making than it was of process of mutual adjustment among various actors driven by different self-interests and divergent conceptions of public interest.

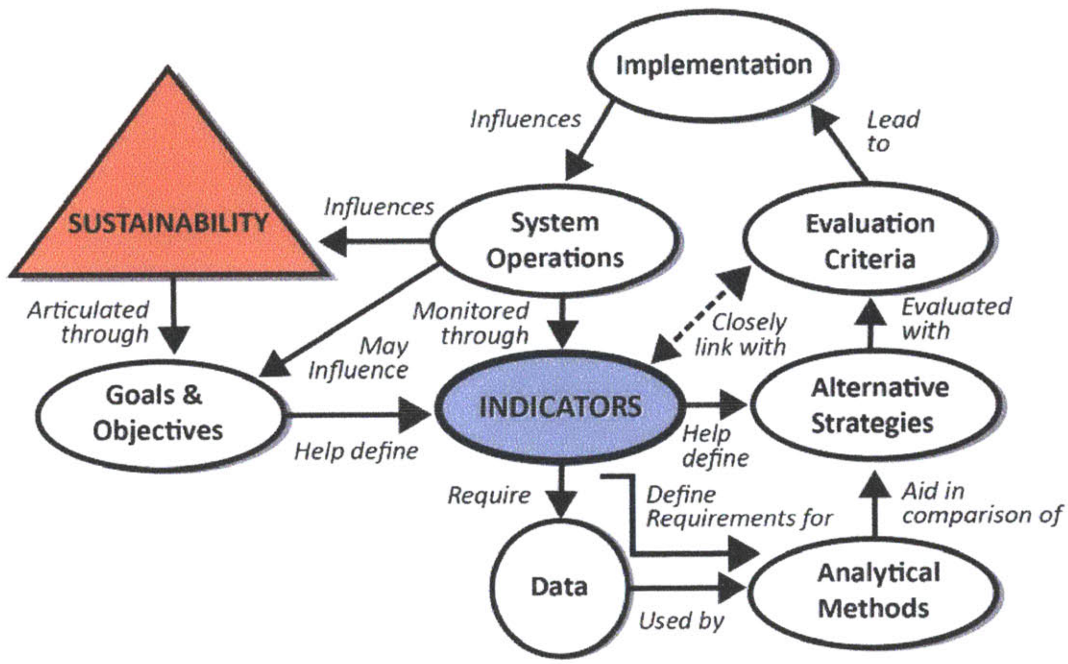

Figure 28: Indicators and Sustainability in Transportation Planning / Adapted from Meyer and Miller 2001, Zegras 2006

Returning to Meyer and Miller's diagram (Figure 27) the importance of the indicators to the practice of reconsidering project definition and mutual adjustment is more obvious. If a city is to transform into a robust self-organizing learning system, the indicators are key to the circulation of new ideas and the modification, or recycling / discarding of outdated, inefficient practices or policies (such as emphasizing mobility through personal motorized vehicles). Challenges to justice or equity could potentially be addressed through the next cycle of indicator review. However, in the context of India, the capacity to implement an ongoing indicator creation and discussion process and maintain consistent indicator quality may prove to be a challenge.

Once indicators are birthed from this process, an interesting potential application is the role of mobile technology in India. Returning to the concept of crowdsourcing, transportation performance measurements such as vehicle locations, load factors and frequencies can be measured using smart phone technologies that are already in place and growing in use in India. Different than ITS applications that are static interventions, and very expensive to implement and maintain, crowdsourcing data collection networks require a different set of resources. The user supplies a bulk of the technology. Instead of equipping a fleet of thousands of buses with GPS units, the end users bring their own GPS in the form of their smart phones. Thus, the agency is responsible for app development, public awareness campaigns, back end database integration, and front end interfaces that allow transport agencies (as well as the public) to analyze indicator data. This is not to say that crowdsourcing programs are inexpensive or easy to accomplish. They simply require a different set of agency resources, and build an institutional familiarity with public collaboration and adaptive learning.

While they have been introduced in several Indian cities, low tech, low investment crowdsourcing frameworks, such as SeeClickFix or FillThatHole have not made sufficient inroads. These web-based applications, allow users to make civic complaints to officials, geo-locate specific claims (such as broken infrastructure, large potholes, etc.), as well as post images. No Indian municipal government has embraced this type of online tool so far; however, I do believe that there is potential for this type of application if interfaces are adjusted to Indian mobile devices, languages, and aesthetic preferences and then marketed to the growing middle class. In India social media tools (such as Facebook, Twitter, Tumblr, Pinterest, etc.) are extremely popular among certain age and income groups. For example, Facebook has approximately 53 Million registered users which makes India the third largest country behind the US and Brazil. In Beijing, the World Bank has recently reported on a pilot project with the Beijing Municipal Government and the Beijing Transport Research Center that allows users to report issues about pedestrian and bicycle infrastructure via the web, feature phone apps, SMS or social media (World Bank 2012). The system is built on the Ushahidi interactive mapping platform, and was originally developed to allow mapping of crisis situations in Kenya. All reports will be mapped, then visualized for others to review and comment on. Using this or a similar platform, I believe that a truly local citizen feedback portal can be developed that is sensitive to Ahmedabad transportation and information context.

Despite the recent flourishes of experimental Governance projects based on applying information and communications technologies in developing countries, most initiatives have failed (Chete et al. 2012). The digital divide is not just about access to technology (such as computers or smartphones), rather it is about access to information and services. While, mobile phone technology in urban India has reached a degree of market saturation - greater than 75% of the population (Nelson 2012) - not all users can purchase data plans that allow them unlimited (or large enough) access to benefit from the crowdsourcing frameworks listed above. Thus, it is important that data transparency efforts must be free to use. Indeed, India's universal ID program will rely heavily on free mobile technology and data services. The government sponsored Har Hath Mein Mobile (A Mobile in Every Hand) campaign hopes to harness cheap Chinese-made mobile phones and "Pay as you go" plans to enable India's poor to access banking (e.g., transfer money and receive payments via text messages) and information services (such as weather forecasts, employment listings, booking services, etc.) (Nelson 2012).

In developing transportation indicator data transparency initiatives, it is important to frame issues in terms of equity, fairness and sensitivity to the needs of the marginalized. So that the benefits of such information transparency efforts in India are not limited to middle and upper classes in a select number of cities, content must be relevant and usable and must vary with regional preferences. Great effort must be made to ensure that a local population is actually aware that the service exists. Finally, systems must reflect the vast diversity of languages and literacy rates to truly be inclusive (e.g., Prioritizing audio and voice input / browsing over text) (Pyati 2010).

What is likely is that unless they are supported and driven by both state and municipal level institutions, Indian municipal government agencies will actively resist efforts led by social movements or NGOs to implement this type of civic data scheme. This is especially true in Ahmedabad, where the most successful transportation planning initiatives have been supported by state corporations and departments. Also, political frictions between the private planners and local NGOs, as well as the between the transnational NGOs and academics and municipal agency representatives may result in such a collaborative system being underutilized. For example, some private planners I spoke with consciously avoided communicating with the local NGOs, whose abilities to collect unbiased data they distrusted. The academics and municipal agency representatives felt that the international NGOs lacked familiarity with local conditions. While this is typical of the competition that I have seen in other Indian cities between private and public sectors as well as local and international actors, I did not expect the degree of contention between groups. It is possible that consensus amongst these competing groups may be difficult to reach. Thus, a strong leader to establish ground rules, facilitate group learning and assist in negotiating over indicators would be a necessity.

Transportation performance indicator schemes that depend too much on mobile technology or social media platforms to collect and review data are not likely to be durable ones. This type of technocratic solution for does run the risk of instituting a model where the poor are asked to "Dig their own sewers" (Roy 2004), thus reducing the demands of local civic institutions to serve their constituents. I do believe that members of the public, agency planners and municipal administrators with whom I spoke with did wish to establish a public dialogue about the performance of their transportation system. Indicator reports by themselves are seldom influential, beyond becoming talking points for speeches and providing a general education for those who know little about an issue. However, this effort focusing on the just impacts of the consensus building process may prove and introductory method to build a public demand to input and access to transportation performance data.

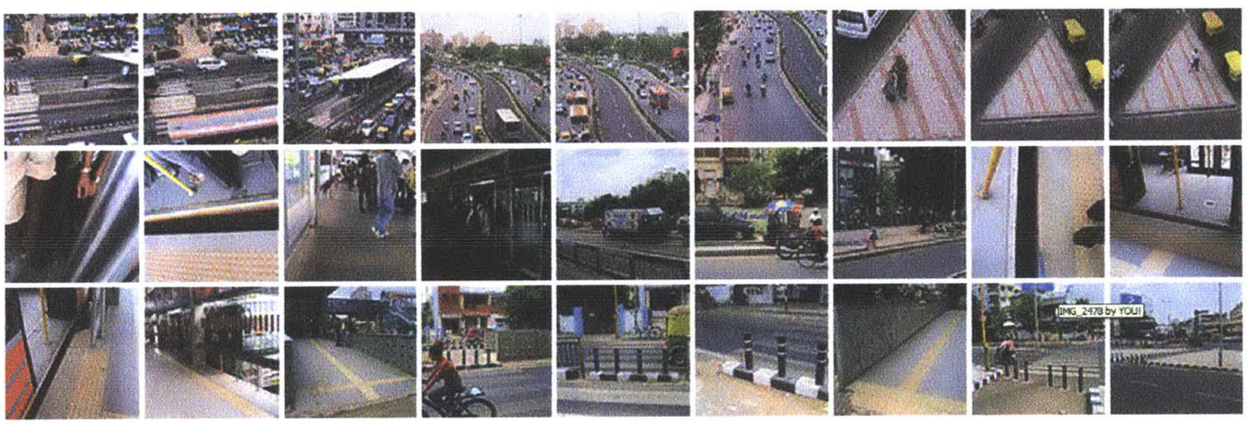

Figure 29: Ahmedabad's Transportation Infrastructures

While the indicator selection process may pose challenges for participation by all stakeholders, the later steps of the process involving making data and reports transparent could allow the public to contribute within their own time frame and means:

- Negotiating over the indicators – group learning,
- Collecting data via their smart phone / mobile device - crowdsourcing,
- Reviewing performance data records to hold transportation providers accountable – good governance, or

- Developing additional apps to improve the collection and querying of the records - providing pressure from below

In conclusion, this project shows the work that needs to be done in order to operationalize mobility practices and policies in India and potentially other developing regions. The observation and research methodology will hopefully support the work of individuals and social movements focusing on transportation and urban development issues. Other cities across India and worldwide may be inspired by Ahmedabad's methodology and findings, and would thus be encouraged to find their own indicators of transportation performance.

REFERENCES

Ackoff, R. L. (1989), "From Data to Wisdom", Journal of Applies Systems Analysis, Volume 16, 1989 p 3-9.

American Public Transportation Association (2012). 2012 Public Transportation Fact Book. Washington DC.

Angel, S., J. Parent, D. L. Civco and A. M. Blei (2010). Atlas of Urban Expansion, Cambridge MA: Lincoln Institute of Land Policy. http://www.lincolninst.edu/subcenters/atlas-urban-expansion/. Accessed on June 26, 2012.

Badami, M.G., Tiwari, G. and Mohan, D. (2004) Access and Mobility For The Urban Poor In India: Bridging The Gap Between Policy And Needs.

Blomley, N. (2010) *Rights of Passage: Sidewalks and the Regulation of Public Flow*. Routledge.

Centre for Sustainable Transportation (2002). *Definition and Vision Of Sustainable Transportation*. http://cst.uwinnipeg.ca/documents/Definition_Vision_E.pdf. Accessed June 2, 2012

Cervero, B. (2011) "Informal Public Transport: A Global Perspective." *Urban Transport in The Developing World: A Handbook of Policy and Practice*. ed. Gakenheimer, R. and Dimitriou, H. Edward Elgar, Cheltenham.

Cervero, R and Ewing, R (2010). "Travel and the Built Environment." Journal of the American Planning Association. 76 (3): 265–94.

Cervero, R. and Kockelman, K.. (1997). Travel Demand and the 3ds: Density, Diversity, and Design. *Transportation Research Part D*, 2, 199-219.

Chete, F., Oyemade, D, Abere, R , Chiemeke, S and Ima-Omasogie, I. (2012). Citizens Adoption of SMS Based E-Government Services In Lagos State, Nigeria. *Journal of Emerging Trends in Computing and Information Sciences*. VOL. 3, NO. 4, April 2012.

Ching, A., Zegras, C., Kennedy, S. and Mamun, M. (2013) "A User-Flocksourced Bus Experiment in Dhaka: New Data Collection Technique with Smartphones" Transportation Research Record: Journal of the Transportation Research Board.

Cortright, J. (2010) Measuring Urban Transportation Performance: A Critique of Mobility Measures and a Synthesis. http://www.ceosforcities.org. Accessed May 1, 2012.

Davis, K. and Kingsbury, B. (2011) Indicators as Interventions: Pitfalls and Prospects in Supporting Development Initiatives. http://www.rockefellerfoundation.org/news/publications/indicators-interventions. Accessed May 20, 2012.

De Certeau, M. (1984) Chapter 7: Walking in the City. *The Practice of Everyday Life*. University of California Press.

Dhingra, C. (2011) "Measuring Public Transport Performance – Lessons for Developing Cities" Sustainable *Urban Transport Technical Document #9*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Dimitriou, H. and Gakenheimer, R. (2011) *Urban Transport in The Developing World: A Handbook of Policy and Practice*. ed. Gakenheimer, R. and Dimitriou, H. Edward Elgar, Cheltenham.

Duchene, F., Journel, C. and Coanus, T. (2002) The forgotten construction process of indicator sets - The social dimension of air pollution measurement in the Greater Lyons area (France). *Ecological Indicators 2*. 187 – 196.

European Environment Agency (2011). Laying the foundations for greener transport — TERM 2011: transport indicators tracking progress towards environmental targets in Europe. http://www.eea.europa.eu/publications/foundations-for-greener-transport Accessed May 20, 2012.

Fainstein, S. (2010) The Just City. Cornell University Press.

Fainstein, S. (2001) The City Builders: Property Development in New York and London 1980-2000. University Press of Kansas.

Flyvbjerg, B. (1991) Rationality and Power: Democracy in Practice. The University of Chicago Press. 1991.

Flyvbjerg, B. (2003) Megaprojects and Risk: An Anatomy of Ambition. Cambridge University Press 2003.

Garrick, N. (2010) *Measuring the Broader Impacts of Transportation.* http://www.planetizen.com/node/46367. Accessed April 16, 2012.

Gakenheimer, R. (2006) Transportation and Land Use in the Developing World: Planning in a Context of Controversy. International Congress on Human Development Madrid 2006. http://www.reduniversitaria.es/ficheros/RalphGakemheimer(i).pdf. Accessed April 24, 2012.

Gakenheimer, R. (2011) Land Use and Transport in Rapidly Motorizing Cities: Contexts of Controversy. *Urban Transport in The Developing World: A Handbook of Policy and Practice*. ed. Gakenheimer, R. and Dimitriou, H. Edward Elgar, Cheltenham.

Gershenkron, A. (1962) *Economic Backwardness in Historical Perspective: A Book of Essays.* Cambridge, MA: Harvard Belknap Press, 5-30.

Glaeser, E. and Kahn, M.. (2004). "Sprawl and Urban Growth." Handbook of Regional and Urban Economics, vol. 4, ed. J. V. Henderson and J. F. Thisse (Amsterdam: Elsevier), 2481–2527.

Goldman, T. and R. Gorham (2006) Sustainable urban transport: Four innovative directions. *Technology in Society, 28.* 261–273.

Gudmundsson, H. (2003), Making concepts matter: sustainable mobility and indicator systems in transport policy. *International Social Science Journal*, 55: 199–217

Gudmundsson, H. (2011) Indicators of Sustainable Transport – Why, What and How to Measure: Results of the European 'COST' Action 356. http://www.ias.unu.edu/sub_page.aspx?catID=159&ddlID=1561. Accessed on April 20, 2012

Gudmundsson, H. (2011) Indicators of Sustainable Transport – Why, What and How to Measure: Results of the European 'COST' Action 356. *Presentation at United Nations University, Institute of Advanced Studies, Yokohama* http://www.ias.unu.edu/resource_centre/HGU_sustainable_transport_UNU-IAS/01_03_2011.pdf. Accessed April 20, 2012.

Geurs, Karst T. and van Wee, Bert (2004) "Accessibility evaluation of land-use and transport strategies: review and research directions" Journal of Transport Geography.

Hess, Paul (2009) Avenues or Arterials: The Struggle to Change Street Building Practices in Toronto. *Canada Journal of Urban Design*. 14(1).

Holzer M. and Kloby, K. (2005) "Public performance measurement: An assessment of the state-of-the-art and models for citizen participation", *International Journal of Productivity and Performance Management*, Vol. 54 Iss: 7, pp.517 – 532

Indian Road Congress (1988) Guidelines for Pedestrian Facilities – IRC 103.

Indian Ministry of Urban Development – Databook on Service Level Benchmarking (2010). http://urbanindia.nic.in/programme/uwss/slb/slbhandbook.htm. Accessed May 24, 2010.

Indian Ministry of Urban Development – Service Level Benchmarks for Urban Transport (2009). http://www.urbanindia.nic.in/programme/uwss/slb/slb.htm. Accessed September 1, 2011.

Indian Ministry of Urban Development – Urban Bus Specifications (2008). http://urbanindia.nic.in/programme/ut/urbanbus_spec.pdf. Accessed September 1, 2011.

Louis Berger Group (2001). *City of Ahmedabad Integrated Public Transport System (IPTS) Feasibility Report.* Amedabad Municipal Corporation.

Innes, J. and Booher, D. (2000) Indicators for Sustainable Communities: A Strategy Building on Complexity Theory and Distributed Intelligence. *Planning Theory & Practice, Vol. 1, No. 2*, 173-186.

Institute for Transportation and Development Policy (2009). Two and Three Wheelers in India. http://www.itdp.org/documents/2_and_3_wheelers_in_India.pdf . Accessed May 2, 2012.

Jawaharlal Nehru National Urban Renewal Mission (JnNURM). Government of India. www.jnnurm.nic.in Accessed February 15, 2012.

Sivaramakrishnan, K. (2010) *The JnNURM Story*. Centre For Policy Research. http://forum.eastwestcenter.org/urbanasiaseminar/files/2010/03/JNNURm-Story_Feb_10_20102.pdf. Accessed on June 4, 2012.

Jenkins, R. and A. Goetz (1999) Accounts and Accountability: Theoretical Implications of the Right to Information Movement in India', *Third World Quarterly* 20.3:603-22.

Jessop, B. (1998) *The Rise of Governance and the Risks of Failure: The Case of Economic Development*. International Social Science Journal. 50 (155). Pp. 29-45.

Joumard, R. and H. Gudmundsson (2010) COST 356 'EST: *Indicators of Environmental Sustainability in Transport.* http://hal.archives-ouvertes.fr/hal-00492823/fr/. Accessed May 1, 2012.

Kolko, J., Mejia, M., Reed, D., Schiff, E. (2011) Making the Most of Transit Density, Employment Growth, and Ridership around New Stations. Public Policy Institute of California. http://www.ppic.org/content/pubs/report/r_211jkr.pdf. Accessed June 15, 2012.

Krishna, S. (2011, Jan 9) "Gujarat: Combining Sense and Sensibility" *Times of India.* http://articles.timesofindia.indiatimes.com/2011-01-09/special-report/28370384_1_gujarat-accounts-ports-mou. Accessed June 20, 2012.

LaMondia, J., Blackmar, C. and Bhat, C. (2010) Comparing Transit Accessibility Measures: A Case Study of Access to Healthcare Facilities. http://www.ce.utexas.edu/prof/bhat/ABSTRACTS/ComparingAccessibility.pdf. Accessed June 15, 2012.

Leather, J., Fabian, H., Gota, S. and Mejia, A. (2011) Walkability and Pedestrian Facilities in Asian Cities: State and Issues. *ADB Sustainable Development Working Paper Series No. 17.* Asian Development Bank.

Lindblom, C. E. (1990). *Inquiry and change: the troubled attempt to understand and shape society.* Yale University Press and Russell Sage Foundation.

Litman, T. (2007) Developing Indicators for Comprehensive and Sustainable Transport Planning. *Transportation Research Record 2017.* Pp. 10-15

Litman, T. (2012) Evaluating Accessibility for Transportation Planning: Measuring People's Ability to Reach Desired Goods and Activities. Victoria Transport Policy Institute. http://www.vtpi.org/access.pdf. Accessed June 15, 2012.

Loukaitou-Sideris , A. and R. Ehrenfeucht (2009) Sidewalks: Conflict and Negotiation over Public Space. The MIT Press.

McKinsey Global Institute (2010) India's Urban Awakening: Building Inclusive Cities, Sustaining Econcomic Growth.

Mahadevia, D. (2006) "NURM and the Poor in Globalising Mega Cities" Economic and Political Weekly, August 5, 3399-3403

Mahadevia, D. (2012) "Decent work in Ahmedabad: An integrated approach" International Labour Organization. http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_181745.pdf. Accessed on August 1, 2012.

Mahurkar, U. (2010, August 28) "Ahmedabad BRTS Corridor: A Rare Success Story" *India Today* http://indiatoday.intoday.in/story/ahmedabad-brts-corridor-a-rare-success-story/1/110490.html. Accessed July 5, 2012.

Mani, A., Pai, M. and Aggarwal, R. (2010) World Resources Institute. Sustainable Urban Transport in India: Role of the Auto-rickshaw Sector http://pdf.wri.org/sustainable_urban_transport_india.pdf. Accessed June 5, 2012

Marglin, Frederique Appfel and Marglin, Stephen A., (1990), *Dominating Knowledge: Development, Culture, and Resistance*. Oxford University Press.

Mathur, O. P. (2007) Moving forward with the JNNURM reforms. *Business Standard*. www.business-standard.com/india/storypage.php?autono=287623. Accessed on January 20, 2011.

About the MBTA (2012) "MBTA Score Card (2012)" http://www.mbta.com/about_the_mbta/scorecard/. Accessed July 21, 2012.

Merry, S. (2011) Measuring the World: Indicators, Human Rights, and Global Governance, Current Anthropology.

Mishra, R. Parida, M. and Rangnekar, S. (2010) Evaluation and analysis of traffic noise along bus rapid transit system corridor. International Journal of Environ. Sci. Tech., 7 (4), 737-750.

Mitchell, T. (1991) *Colonising Egypt*. University of California Press.

Mitchell, T. (2002) *Rule of Experts: Egypt, Techno-Politics, Modernity*. University of California Press.

Mowbray, C., Holter, M., G.Teague, and Bybee d. (2003) Fidelity Criteria: Development, Measurement, and Validation. *Americana Journal of Evaluation* (2003)

Neilsen Informate Mobile Insights (2012) "27 million Smartphone Users in Urban India says Nielsen Informate Mobile Insights" http://www.nielsen.com/in/en/news-insights/press-room/2012/smartphone-incidence.html. Accessed August 10, 2012.

Nelson, D. (2012, August 10) "India to trigger economic boom by giving mobiles to the poor" The Telegraph. http://www.telegraph.co.uk/news/worldnews/asia/india/9466626/India-to-trigger-economic-boom-by-giving-mobiles-to-the-poor.html. Accessed August 18, 2012.

Paccoud, A. (2011) Cities, Health and Well-being: Methodology for an International Analysis. Discussion Paper – Urban Age Hong Kong Conference. http://lsecities.net/files/2011/11/LSE-Cities-Metropolitan-HDI-and-Density-18-10-11.pdf Accessed on June 26, 2012.

Pai, M. (2009) Transport in Cities: INDIA INDICATORS. EMBARQ. www.indiaenvironmentportal.org.in/files/transport-indicators.pdf Accessed on November 20, 2011.

Pucher, Korattyswaroopam and Ittyerah (2004) The Crisis of Public Transport in India: Overwhelming Needs but Limited Resources. *Journal of Public Transportation*, Vol. 7, No. 4.

Pyati, A. (2010) "Re-envisioning the 'knowledge society' in India: Resisting neoliberalism and the case for the 'public'" *Ephemera: Theory & Politics in Organization Vol. 10 (3/4)* 406-420. http://www.ephemeraweb.org/journal/10-3/10-3pyati.pdf. Accessed August 1, 2012.

Rajagopal, B. (2003) International Law from Below. Cambridge University Press.

Rajamani, J., Bhat, C., Handy, S., Knaap, G. and Song, Y. (2003) Assessing Impact of Urban Form Measures on Non-work Trip Mode Choice after Controlling for Demographic and Level-of-Service Effects. *Transportation Research Record*. 1831.

Rangwala, S. (2007) *Principles of Railway Engineering - Nineteenth Edition*. Charotar Publishing House.

Satterthwaite, M.L. & A. Rosga (2008). The Trust in Indicators: Measuring Human Rights. IILJ Working Paper 2008/12. (Global Administrative Law Series). New York University School of Law.

Scott, J. (1999) Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. Yale University Press.

Shipper, L. (1996) Sustainable transport: What it is, and whether it is. Towards Sustainable Transportation - . OECD Conference. http://www.oecd.org/dataoecd/28/54/2396815.pdf. Accessed March 30, 2012.

Singh, K. (2005) Review of Urban Transportation in India. *Journal of Public Transportation*. Vol. 8, No. 1.

Sreedharan, E. (2012, April 17) "Bureaucrats, not politicians, stalling India's progress: E. Sreedharan" IBN Live http://ibnlive.in.com/news/bureaucrats-stalling-indias-progress-e-sreedharan/249274-3.html

Stapenhurst, T. (2009) The Benchmarking Book: A How-to-Guide to Best Practice for Managers and Practitioners. Elsevier Ltd

Steinfeld, A., Zimemrman, J., Tomasic, A., Yoo, D., and Dar Aziz, R. (2011) "Mobile Transit Rider Information Via Universal Design and Crowdsourcing" http://www.cs.cmu.edu/~astein/pub/Steinfeld_TRB11_final.pdf. Accessed on July 14, 2012.

Stone, Christopher E. (2010) "Indicators in Development Safety and Justice: Problems of Power in the Design of Indicators of Safety and Justice in the Global South" http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers-programs/programs/criminal-justice/Indicators-ProblemsofPower.pdf. Accessed on April 1, 2012

Sustainable Urban Transport Project (SUTP) "Ahmedabad, India Wins 2010 Sustainable Transport Award" http://www.sutp.org/. Accessed on December 2, 2011.

Thedvall, R. (2012) "Negotiating Impartial Indicators: Putting Transparency Into Practice In The EU" Journal of the Royal Anthropological Institute (N.S.) 18, 311-329, Royal Anthropological Institute.

Thomas, A. and Jacobs, G. (2011) "Road crashes and low-income cities: impacts and options" *Urban Transport in the Developing World: A Handbook of Policy and Practice*. Edward Elgar, Cheltenham.

Ahmedabad Metropolitan Region plan gathering dust. (2010, August 9). *Times of India* "http://articles.timesofindia.indiatimes.com/2010-08-09/ahmedabad/28292653_1_sq-km-planning-body-plan-gathering-dust. Accessed May 21, 2012.

Tiwari, G. (2011) Key Mobility Challenges in Indian Cities: Discussion Paper 18 2011 International Transport Forum.

United Nations Economic and Social Affairs (UN ESA) (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition. United Nations, New York. http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf. Accessed May 10, 2012.

Wachs, M. (2010) "Transportation Policy, Poverty and Sustainability: History and Future" *Journal of the Transportation Research Board*.

Weiss, T. (2000) Governance, good governance and global governance: conceptual and actual challenges. *Third World Quarterly*. Vol. 21, No. 5, pp. 795-814.

Whitford, A. and Wong, K. (2009) Political and Social Foundations for Environmental Sustainability. *Political Research Quarterly, Vol. 62, No. 1* (Mar., 2009), pp. 190-204

Williams, D. W. (2003), Measuring Government in the Early Twentieth Century. Public Administration Review, 63: 643–659. doi: 10.1111/1540-6210.00329

The World Bank (2003) Political Institutions and governance. *World Development Report: Building Institutions for Markets.*

The World Bank (2012) China: Online Platform Engages the Public in Urban Transport Planning. http://www.worldbank.org/en/news/2012/05/24/China-Online-Platform-Engages-the-Public-in-Urban-Transport-Planning0. Accessed on August 1, 2012.

United Nations (UNEP) (2009). Cleaning up Urban Bus Fleets: With a focus on developing and transition countries. http://www.unep.org/transport/pcfv/PDF/Retrofit.pdf. Accessed July 1, 2009.

World Commission on Environment and Development (WCED) (1987) Brundtland Report - Our Common Future, Oxford University Press, Oxford.

Zegras, C. (2006) Sustainable Transport Indicators and Assessment Methodologies. Biannual Conference and Exhibit of the Clean Air Initiative for Latin American Cities – *Sustainable Transport: Linkages to Mitigate Climate Change and Improve Air Quality.* Sao Paulo, Brazil.

Zegras, C. (2011) "Mainstreaming Sustainable Urban Transportation: Putting the pieces together." *Urban Transport in the Developing World: A Handbook of Policy and Practice.* ed. Gakenheimer, R. and Dimitriou, H. Edward Elgar, Cheltenham.

Zietsman J. and Rilett L.R., (2002). Sustainable Transportation: Conceptualization and Performance Measures. *Research Report SWUTC/02/167403-1.* Texas Transportation Institute, Univ. of Texas, Austin, USA.