Sustainable transportation for Indian cities: role of intelligent transportation systems

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This article highlights the relationship between sustainability (or maintainability) and efficiency of transport systems. It also outlines some of the problems and issues that exist in providing mobility to urban Indians. Finally, it enumerates some of the ways in which application of (modern) information and communication technologies can help improve the efficiency of the transportation system and ultimately help achieve a sustainable urban transportation system.

Keywords: Intelligent transporation system, sustainability, urban mobility efficiency.

Introduction

SUSTAINABILITY as an important issue in development came into public focus with Carson's book titled *Silent Spring*[1]. Schumacher's thoughts in *Small is Beautiful*[2] brought the issues of sustainability and the then development models into sharper focus. Since then, policy makers, by and large, have been mindful of sustainability while formulating policies.

The *Oxford English Dictionary*[3] defines 'sustainable' as an adjective meaning 'capable of being maintained at a certain rate or level'. *Merriam-Webster Dictionary*[4] defines it as 'of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged'. One of the most oft-quoted definitions of sustainable development appeared in the Brundtland report[5]. According to this definition, sustainable development is that which 'meets the needs of the present without compromising the ability of future generations to meet their own needs'.

From the above definitions few points about sustainability emerge. These and other thoughts on sustainability and sustainable transportation are the subject matter of the next section. The third section provides a brief description of the issues related to urban mobility that are foremost in India. The fourth section suggests how intelligent transportation system (ITS) can help India move towards a sustainable urban mobility plan. The fifth section summarizes the discussions in this article.

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Sustainability and sustainable transportation

The definitions of the word 'sustainable' indicate that the concept of sustainability includes the following features: (i) processes need to be maintained (or carried on with) over a period of time, and (ii) harvesting of resources is inevitable for processes to run. It is the contention of the author that systems which remain efficient over a period of time and over space are the ones which can be maintained and hence are the only sustainable systems. Of course, the word efficient is used in a broader sense than it is generally used while describing efficiency of engineering systems. It must be accepted that engineering interventions (like infrastructure) which affect the society at large and use significant resources cannot be viewed and evaluated in isolation and must be looked at as a part of the habitat; that is, the efficiency of such systems must be defined in a more inclusive manner.

In the particular case of urban transportation one needs to define what this habitat includes, what are the resources that one is dealing with and how one should measure efficiency (in the broad sense that is envisaged here). In the rest of this section these points are expanded.

Urban transportation facilities or the processes of achieving mobility in an urban setting are a part of the urban habitat. The question is: what does this habitat include other than the roads, intersections, bus-stops, rail lines and so on? The urban habitat includes, the people – rich, middle-class and poor, the work places, the services (like the hospitals, the fire services, etc.), the residential areas, the recreational facilities, educational institutions, commercial establishments and the like. The way this habitat is organized creates the transportation demand and supply patterns.

The resources that urban transportation systems deal with are, broadly speaking, as follows: (i) Material resources such as fuel, aggregates, bitumen, etc.; (ii) Space on land, water and air; (iii) Time; (iv) People (and sometimes certain types of animals); (v) Environment and (vi) Opportunity.

Of the six resource classes listed above, opportunity needs a little exposition. It is felt that generally human endeavour with use of other resources creates opportunities which, if utilized improves the quality of life. However, if unutilized, opportunities often perish. This in some sense causes inefficient use of other resources on which

opportunities are built. A definite mandate of any transportation system should be to allow the users of the system to efficiently harvest the opportunities.

What types of demand patterns are created and how they are met (the supply patterns) through the use of the resources have a large bearing on whether the transportation system is sustainable, i.e. whether the transport system will remain efficient for over a period of time and space (i.e. the system must be efficient not only for a restricted area but also regionally). However, as mentioned earlier, how the efficiency is measured is also important.

Efficiency has been a driving force in engineering design. If a system is seen to be inefficient, then effort is expended to improve the efficiency. The problem arises in the way this efficiency is often measured. A couple of examples on how a traditional view of efficiency can lead to non-sustainable development whereas a more inclusive definition of efficiency could have led to sustainable development will highlight this issue better.

Few decades ago, it was felt that good roads should be provided to achieve fast and safe transportation of people and goods. The efficiency of the road system would be measured according to how well it met the stated goals. Hence, when roads became congested one built even more roads, roads without at-grade intersections, limited access roads and so on. Two-lane roads became four-lane highways; four lane highways became six-lane expressways; and this would have continued but for the realization that there is no end to it. If on the other hand, the definition of efficiency was more inclusive and had features like (i) the amount of exhaust that would be created if more people drove (which would happen, and did happen, as the roads provided quicker mobility); and (ii) the amount of fossil fuel that will be consumed, etc., then obviously roads which encouraged more automobile traffic would no longer be thought of as efficient. Planners and engineers would have had to look for other solutions. There are many other such examples.

In the Indian context, many medium-sized cities, like Kanpur, having allowed an uncontrolled growth of jitney services (motorized cabins with capacity of 6–8 persons, which typically ply on a fixed route but on a flexible schedule) today face the problem of a largely inefficient urban transportation system. As a city grew, so did the need for public modes of transport. The few jitneys that were on the roads (when the city was small) were not enough and waiting times for passengers were high; so more of the same were allowed to ply on the roads. For sometime the problems seemed to be solved, but soon there was need for more. As with the previous example, this constant striving to obtain efficiency in the short term eventually created an inefficient transportation system. Had the definition of efficiency included issues like congestion (in the long run), environmental degradation and the like, in addition to issues of waiting time, network coverage, etc. then at some point planners and engineers would have surely moved away from the small cabin based jitney services to larger cabin based bus services, light rail transit systems, and so on.

Thus three aspects are important to the creation of a sustainable urban transportation system. As mentioned before, these are: (i) the habitat of which the transportation system is a part; (ii) the resources that such a system will need to harvest, and (iii) the measure of efficiency that should be employed to evaluate such a system. In this context the definition of sustainable transportation as put forward by the European Union Council of Ministers of Transport is particularly important to note. Hence, this definition, as quoted in 'Sustainable Transportation and TDM'[6] is reproduced here.

'A sustainable transportation system is one that:

(i) Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.
(ii) Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.
(iii) Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.'

Another way of looking at the above definition is that it tries to enunciate, although not exhaustively, the basic principles which will lead to an efficient transportation system over space and time.

Before, discussing how ITS technologies can help in achieving sustainable transportation for urban India, the issues related to mobility in urban India are briefly discussed.

Urban mobility issues in India

This section highlights some of the issues that need to be looked at in order to provide an efficient (in the long run), and hence sustainable, urban transportation system for Indian cities. These issues, which are enumerated in no particular order, are definitely not exhaustive, and there are other issues (often specific to a city) which are also important.

(i) India is a populous country. According to the 2001 census[7], close to 300 million live in urban settlements. If one counted India's urban population alone, even then 'Urban-India' would easily become

the fourth largest country (behind China, 'Rural-India,' and USA)[8] (The word country is used here to indicate that even if we looked at Indian cities as a unit it will be larger, in population, than most other countries. Of course, urban and rural India together is one nation.) Not surprisingly, among other things, Indian cities are teeming with pedestrians. Any transportation system which does not properly account for pedestrian movement is bound to be inefficient in an Indian context.

(ii) Further, a large section of the urban population, especially in medium-sized cities, uses bicycles as the mode of transport. This natural tendency of the population to use non-polluting modes of transport should be encouraged and the urban transportation plan should integrate bicycles into the system.

(iii) Also, a large section of the population in the cities uses public transportation. In fact, by some estimate, the larger the city, greater is the share of public transportation[9]. This implies that the success of urban transportation lies in providing an efficient public transportation network. However, a large percentage of the public transportation users are captive users with meagre income levels; this implies that the cost of public transportation has to be kept low – often artificially so.

(iv) In the last two decades Indian economy has grown at unprecedented levels. This has meant that affordability of the urban population has gone up manifolds. Concurrently, India has produced more affordable vehicles. The net effect has been a brisk increase in the number of vehicles in urban India. Today, urban India also demands good roads and efficient intersections for mobility and adequate parking facilities at the destinations. Although one can argue that improving these facilities will encourage automobile use and hence may hurt the cause of sustainable development, the reality is not that straightforward. The road network currently available in most Indian cities is far from where it should be and does not even come close to a state where questions can be raised as to whether more should be done to improve the network.

(v) Larger number of vehicles on the roads has increased the possibility of accidents; further with improvements in speeds chances of more severe accidents have also increased. Adding to the heightened safety concerns is the fact that Indian cities have a large pedestrian population; this increases the chances of human–vehicle conflict. In short, safety-related issues are important more than before in achieving an efficient and maintainable transportation system.

(vi) Due to cities becoming rich employment sources and because of increased cost of living in the cities, movement of people into and out of the city from and to the suburbs has also increased. Integrating the urban transport system with the regional transport network is now important; consequently multi-modal transportation has also become important.

Role of ITS in achieving long-term efficiency in urban transportation

Solutions to the above problems lie in prudent policies and efficient implementation of these policies. The scope of this paper, however, is limited to discussing how elements of ITS can help in achieving a sustainable urban transportation system. It may be noted here that ITS can help in implementing some policy measures which can lead to sustainability. ITS per se cannot create sustainability, it is the policies (which may use ITS) that can ultimately lead to a sustainable transportation system.

As argued earlier, sustainable development can be achieved through systems which remain efficient over a period of time and over space (or regionally). Hence, in this section the discussion will focus on how ITS can aid in achieving efficient road transportation and efficient public transportation. It may be noted that the word 'efficient' is to be understood in the broad sense envisaged here. Further, it must be understood that sustainability cannot be achieved without an efficient road and public transportation system; however, the converse is not true. Unless one develops a balance between road and public transportation system of a city neither of them will remain efficient in the long run and hence will not create a sustainable system.

For the purposes of this paper, the term ITS will be used to refer to the area of transportation which deals with the application of (modern) information and communication technologies in transportation. It may be noted that information technology is assumed to include sensor technologies also.

Efficient road transportation through ITS

Without going into the details, one can say that efficient road transportation can be achieved through improved travel times, improved safety and improved terminals (parking). Figure 1 provides a general outline of how these can be achieved.

We describe below how ITS can aid in achieving some of the measures enunciated in the lower level boxes of Figure 1.

ITS can help *modify demand* characteristics and *improve capacity* of roads in many ways. Some of these are mentioned here:

(i) Telecommuting (where much of the work can be done from remote locations) can reduce the need to travel, thereby reducing demand.

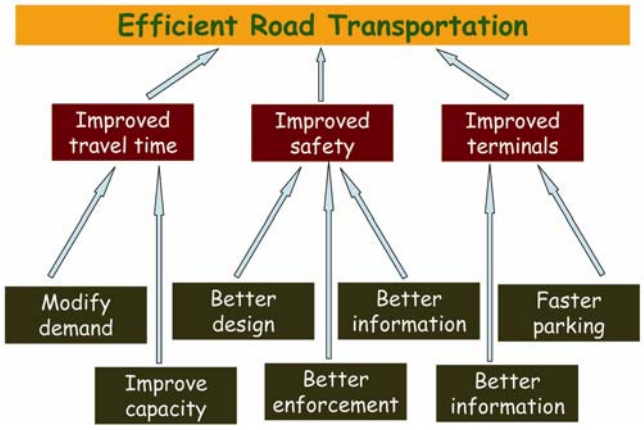

Figure 1. Measures which can improve the efficiency of road transportation.

(ii) Ease of toll collection through ITS makes congestion pricing easy to implement; this allows the engineer the use of an effective tool to modulate demand.

(iii) Enforcement has improved through use of ITS; hence high occupancy vehicle lanes can be better enforced which will then create a greater incentive to pool cars, thereby reducing demand.

(iv) Collecting information on traffic status on a large number of road sections and disseminating it as well as the predictions of travel times on these sections to the population are now feasible; it is envisaged that such information will allow travellers to choose paths and departure times more judiciously. This in turn will lead to modulation of demand through spatial and temporal distribution of the demand. It is also not too far-fetched to imagine that such information will lead to people making better choice of modes, which will again lead to a modulation of demand.

(v) A more direct way in which ITS can help in temporal modulation of demand is through ramp-metering. The process of monitoring the traffic flow on freeways (expressways) and accordingly modulating the inflow at different intake points is a strategy which has been around for some time now and has proven to help the system by achieving a smoother flow on its primary roadways. As can be imagined, ITS does play an important role in improving the effectiveness of ramp-metering strategies.

(vi) ITS can also help in improving capacity through better implementation and enforcement of reversible lanes as well as use of shoulders from time to time. Reversible lanes and use of shoulders help augment capacity in the peak direction of travel.

(vii) Incidences (accidents) often reduce capacity of roads significantly. Better identification of incidences and quicker response to them can reduce the impact of such events on the capacity of a road. ITS can help in improving both the aspects related to incidence management enunciated earlier. It may be noted here that efficiency of incidence management depends largely on how quickly relevant information is obtained from the incidence site and how quickly appropriate instructions reach the right agencies (like towing companies, ambulance service, hospitals, fire services, etc.). Not surprisingly then, ITS can play (and does play) an important role in improving incidence management and through it improving capacity.

(viii) Signal efficiency can be improved through, among other things, adaptive phases, reduced start-up loss times (through information to waiting drivers on the time left for the next green, etc.), and better pedestrian control. As these features rely on collecting and disseminating accurate information on the state of the system, ITS features can play an important part.

(ix) Often, especially in India, the full capacity of the road is not realized due to non-compliance with driving rules and lack of driving decorum. The flow at intersections (especially unsignalized intersections), and rail–highway grade crossings are some examples of how improper driving behaviour limits efficient use of roads. It is felt that ITS can improve this through better driver education and improved enforcement of rules.

Application of modern information and communication technologies can improve safety of the road network through *better design* (primarily of vehicles), *better enforcement* and *better information* dissemination to the drivers. In the following, as before, some of the ways in which ITS can achieve these are mentioned.

(i) High-end vehicles come equipped with collision avoidance systems, lane-change assistance systems and intelligent anti-skid devices which assist in improving safety. Most of these systems are a part of ITS and with further improvements in ITS technologies, many of these features will become routine in all cars and will make a considerable impact on the improved safety of roads.

(ii) Over-speeding and non-compliance with signal indications are major causes for accidents the world over; India is no different. ITS technologies, like cameras which record defaulters, can and do play an important and impartial role in enforcing speed limits and signals. Such enforcements improve the safety of roads.

(iii) Information on surface conditions and incidences help improve safety. ITS plays an important role in providing this type of information to the drivers. Real-time information on driving errors like (i) problems in longitudinal control where a vehicle

closes in on another in a dangerous manner, (ii) problems in lateral control where a vehicle fails to stay within a lane, or (iii) problems in speed control where a driver over speeds, often helps the driver correct these problems. These corrections in turn help avoid possible accidents and improve road safety.

ITS can be used to improve the *efficiency of terminal (parking) facilities* in an urban area. Information on nearby parking lots, their current occupancy status, and information within the parking lot about the general location where space is available improve the efficiency of parking facilities. This helps in reducing the time that drivers spend on the road searching for an appropriate parking facility. This further helps in reducing the demand (especially of the unproductive kind, where the only purpose is to find a place to park) as well as the safety hazards as drivers' exasperation levels are low.

Efficient public transportation through ITS

The long-term efficiency of public transport systems depends on improvements in right-of-way categories, technology issues and certain operational issues. Public transport systems, like the bus system, which utilize the road network can improve their efficiency manifold and become even more attractive if such systems get an improved right-of-way category. One way, where ITS technologies can help is by allowing buses to get preferential treatment at signals.

However, the biggest impact that ITS can have on improving the efficiency of the public transportation system is through improvements in operational issues. Some of ways in which operations can be improved are:

(i) Improvements in routes and schedules to increase coverage and reduce in-vehicle travel times and waiting times.

(ii) ITS can help improve fleet management thereby making operations more economical; this helps in keeping the fares down without relying much on government subsidy.

(iii) ITS can also help make transit systems more user-friendly by: (a) providing personalized route plans though hand-held devices like cell (mobile) phones; (b) providing current information about the operation (routes and schedules) both inside the vehicle and outside (for example, at terminals); (c) improving transfers through schedule coordination; (d) making fare payment easier and faster and (e) making ticketing for multi-modal systems seamless, and the like.

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