

A stochastic analysis of transportation system in J&K

Ubaid Illahi¹, Burhan-ul-wafa²,Ruhhee Tabbussum³

¹Research Scholar, Department of Civil Engineering, National Institute of Technology Srinagar, Jammu & Kashmir (India), 190006 ubaidillahi@nitsri.ac.in

² PG Student, Department of Civil Engineering, Amity University, Noida, Uttar Pradesh, (India) burhanulwafa1907@gmail.com

³ Research Scholar, Department of Civil Engineering, National Institute of Technology Srinagar, Jammu & Kashmir (India) ruhihamidmeh@gmail.com

Abstract

The rapid growth of population in urban areas of developing cities has resulted in massive traffic congestion and the various difficulties associated with it. The solution to this challenging issue is to achieve a sustainable system of transportation. The essentiality of sustainable transportation can be understood by the concept of vicious circle of congestion in which the road infrastructure to be provided is directly proportional to the demand which delays the problem instead of solving it as it is unfeasible to increase the road infrastructure in the later stages due to ribbon development. The sustainable mobility is a very complex engineering science and cannot be generalised everywhere in the world due to social, cultural, geographical and environment diversifications. In this analysis, an attempt has been made to study the sustainability of the transportation system in Jammu and Kashmir, the northern most state of India. The current approach followed in Jammu and Kashmir is Vehicle Oriented Approach (VOA), whereas, the rise in the traffic congestion problems show that this is not a fundamental approach and People Oriented Approach (POA) is strongly recommended at the planning stage to solve the problem sustainably. Instead of increasing the road capacity by road widening, underpasses, flyover, etc., there is a need to adopt the optimization techniques in traffic management and focus should be on decreasing the traffic volume. Emphasis should be laid on various sustainable modes of transportation like walkability, bicycling, Non-Motorized Transportation (NMT), water transportation, Bus Rapid Transportation System (BRTS), etc. It would be wise to leapfrog by considering the condition of developed cities that have already faced and overcome this problem. One of the best examples of such developed nations is Netherlands, where remarkable changes have been observed in the liveability and mobility after adopting the sustainable transportation systems.

Keywords: vicious circle of congestion, heterogeneity, road safety, vehicle occupancy, sustainable mobility

I. INTRODUCTION

Sustainability entails various fields like environment, transportation, urban development, etc. and is one of the most imperative sciences in today's world. The word sustainability can be defined as "the development that meets the needs of present without compromising the ability of future generations to meet their own needs" ^[1]. Sustainability and sustainable development balances a fine line between meeting our needs – our need to move forward technologically and economically, and the need to protect the environment in which we and others live. In the context of transportation, sustainable transportation, also known as green transportation, refers to the system of transportation that is sustainable in the senses of social, environmental and climate impacts. The developments are very rapid in today's world but care must be taken that they should not take place at the stake of our future. Sustainable transportation can be achieved pertaining to transportation system management, energy management, capacity management, and environmental management. Transportation has been found one of the sources of emission of greenhouse gases. Thus, sustainable transportation is important in reducing the greenhouse gases in the environment especially in developing countries. Process-based approaches involve community representatives and other stakeholders in planning and present opportunities to educate the public and influence collective behaviours which can be used to help agencies refine their visions as well as develop policies, planning procedures, and measurement and monitoring systems for achieving sustainable transportation systems. ^[2] Achieving sustainable system of transportation is not only necessary from mobility and safety perspective, but also from local and global environment point of view.

II. UNDERSTANDING THE CONCEPT OF VICIOUS CIRCLE OF CONGESTION

Due to lack of sustainable system of transportation in developing cities, numerous problems have risen. One of the major problems that almost all the developing country is facing is the increase in volume of traffic on roads which results in traffic congestion and delay in travel time. The traditional approach to such problem that is being followed religiously is to increase the road capacity through road widening, flyovers, underpasses, etc. It seems to solve the problem for an early period but research has shown that this approach does not solve the problem but delays it. It can be understood more precisely by the concept of vicious circle of congestion (Figure 1). When there is growth in economy of a nation, it attracts the need of car ownership as a symbol of wealth asset which results in the increase in number of cars on the road. This causes congestion on roads and need for more capacity of roads arises for more cars to accommodate. Traditional solution to such problem being improvement of the physical infrastructure of roads and increasing the road capacity by flyovers, road widening, underpasses, etc., is followed which attracts more users to apply for car ownership and thus again increase the traffic volume which leaves us on square one, i.e., need for more roads, which forms a vicious circle of congestion. Thus, it only shifts the problem from one time period to another and does not solve it efficiently. Also, the human and capital that is invested in such approach is unthinkable huge as compared to the benefits it give and that too for a very short span of time thus making it uneconomical, unethical and environmentally devastating. As the space on earth is limited and we cannot continue with such an approach, the solution to this cardinal issue of the most developing cities today is to adopt a sustainable system of transportation

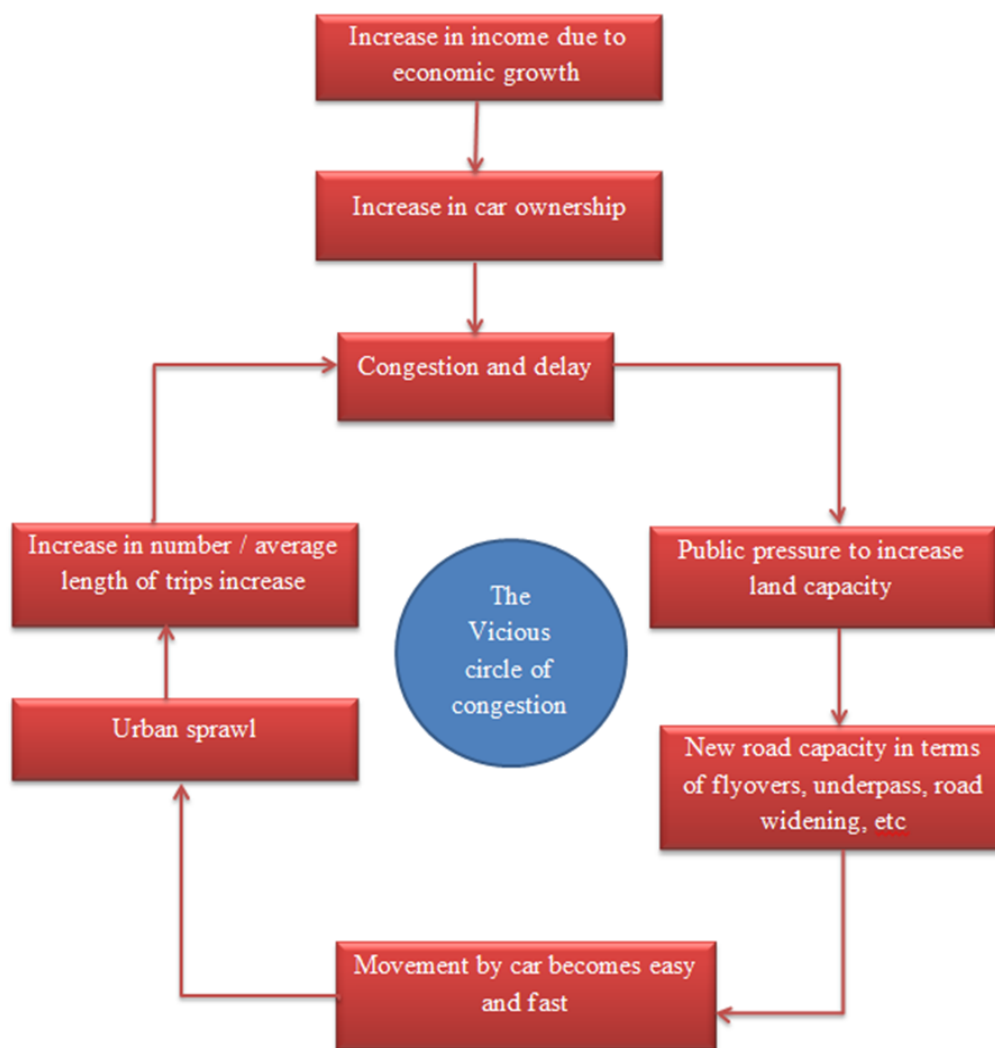


Figure 1. Vicious Circle of Congestion

III. TRADITIONAL APPROACH VS DESIRED APPROACH

Our city is currently at an early stage of the major problem of traffic congestion and it is unfortunate that we are adopting the traditional car/vehicle oriented approach (Figure 2). In Srinagar (the summer capital of J&K), travelling by car is being given more preference day by day over public transportation system (PTS) and very few percentage of people prefer to travel by active modes of transportation i.e., bicycling and walking which have been proved sustainable. Though a considerable population in Srinagar is willing to travel by PTS but the infrastructure and the overall system of PTS is such that people hesitate to travel in it. Also there are no separate cycle tracks and poorly integrated footpaths in Srinagar which refrain people from using these modes of travelling. Whereas the preference pyramid should be inverse to what it is as shown in Figure 3 i.e. people oriented approach. We should prioritise sustainable means of transportation more as compared to motorised transportation. More heed should be given in improving the transportation system such that people opt for such means of transportation which is not environmentally degrading as we need to have a consideration of our future generations. We have taken a lot from them and now it's time we constrain ourselves in order for them to live a fresh and a healthy life. It can be clearly seen (Figure 4) that how different is the space occupancy by the same number of people using different modes of transport. It gives a clear view of why we should follow the people oriented approach and how it can change the present scenario. The traffic congestion will be reduced to a huge extent and it will help us grow a healthy and clean environment. Shift in single goal of increasing economic benefits to goals of economy, environment, and integrated social equilibrium needs to be adopted by scientific and reasoning planning, improvement in transport means and high technicalization of transport management. [3] Also the active modes of transportation will improve the health state of the people. So, decision needs to be taken by the road users as to improve health and save the environment.

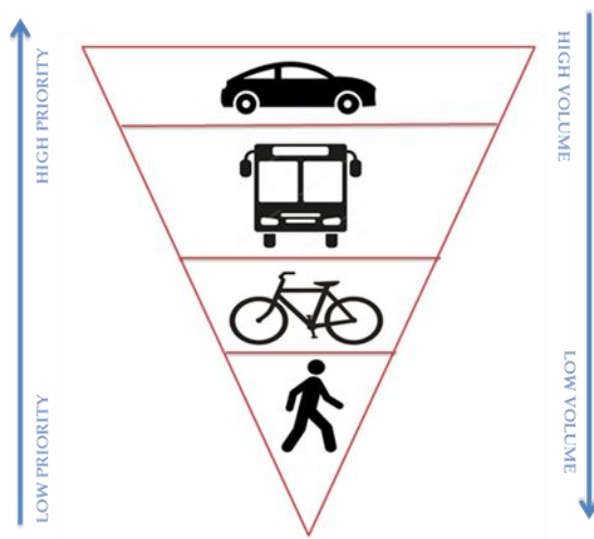


Figure 2. Car/Vehicle Oriented Approach

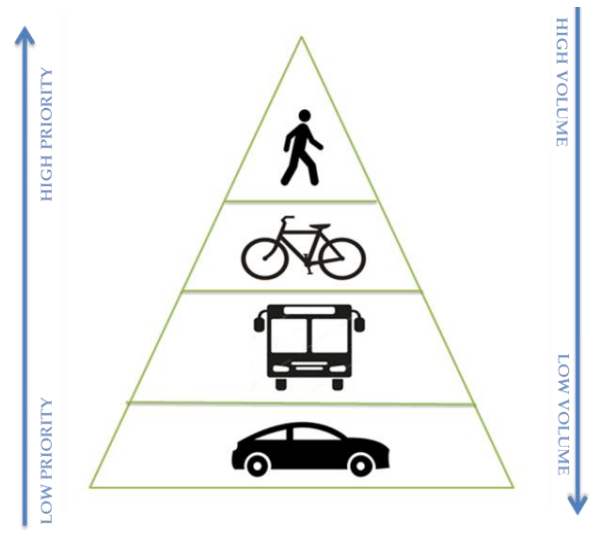


Figure 3. People Oriented Approach



Figure 4. Space occupied by the same number of road users using different modes of transport

IV. CONDITIONS IN EMERGING ECONOMIES

- **Population Growth**

The growth in population (Figure 5) makes it evident that the density of people per square km is increasing day by day and as a result more land occupancy is required. According to census 2001, census 2011 and the extrapolation method, it is found that the population has increased from 1.01 crores in 2001 to 1.44 crores in 2018.^[4] This has a definite impact on the travel demand and thus on the modes of transportation being used.

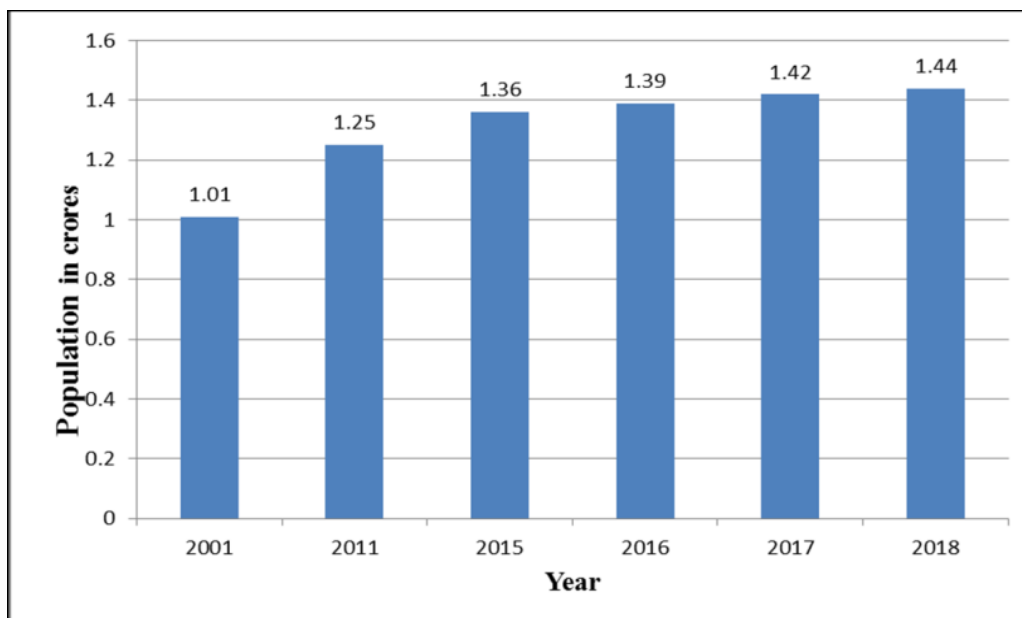


Figure 5. Population Growth in J&K

- **Exponential Growth of Vehicles and urbanisation**

The growth of urbanization, being one of the major causes of traffic congestion in cities, has increased in Jammu and Kashmir from last few years. This is a result of increase in economy of the state and as a result there has been an enormous increase in the number of vehicles in the city. The graph (Figure 6) shows an almost vertical trend in the growth of vehicles from 2010 to 2017 in J&K which indicates that there is a rapid growth in the number of vehicles and it will continue to happen if right measures are not taken at the right time.^[5] The magnificent increases in vehicular ownership and transport demand create general urban transportation problems such as severe traffic congestion, air and noise pollution, and serious parking difficulties.^[6]

- **Heterogeneous Traffic**

Due to presence of different types of vehicles, the movement becomes more difficult. The same route is used by buses (PTS), cars, two wheelers, Intermediate Public Transportation System (IPTTS), trucks and trailers. This mixed traffic makes the roads more congested. In the year 2017, vehicle registration records show that highest number of two wheelers has been registered in Srinagar while as the second highest registration has been that of the cars (Figure 7).^[5] This shows that people are opting for private vehicles rather than PTS.

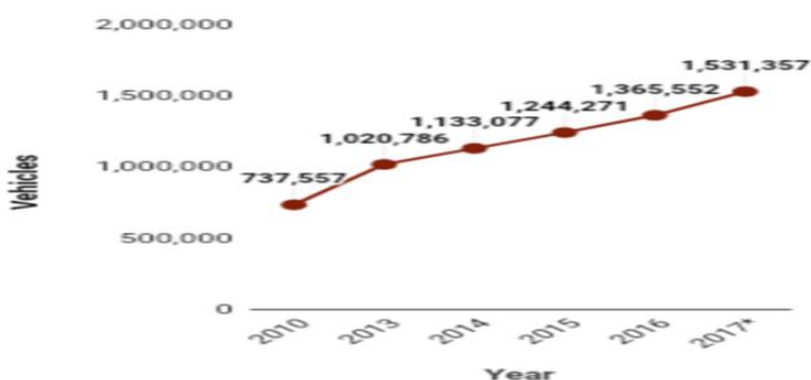


Figure 6. Vehicle population growth in J&K

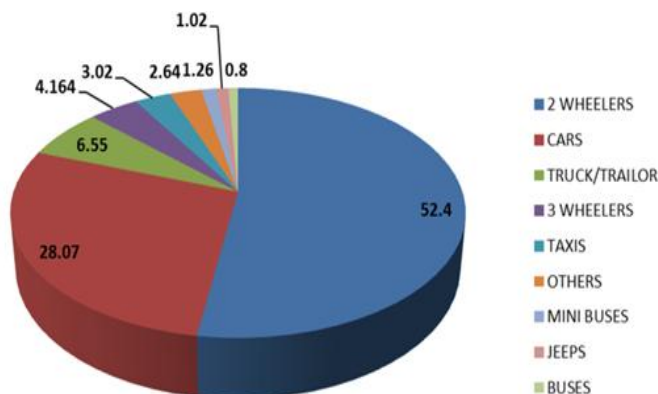


Figure 7. Vehicle Registration in J&K upto March 2017

• **Increased Parking Demand**

With the increase in the number of vehicles rises the demand of safe parking for the vehicles in order to avoid the nuisance due to unreasonable parking on roads. Traffic wardens and parking problems are the greatest cause of delay at the road intersections in the city.^[7] The data given by Srinagar Smart City Concept, Report by Srinagar Municipal Corporation, depicts that the demand for parking of vehicles is 7188 ECS while the supply is 1937 ECS which means that there is no parking space for 73.05 % vehicles which is a matter of concern.^[8]

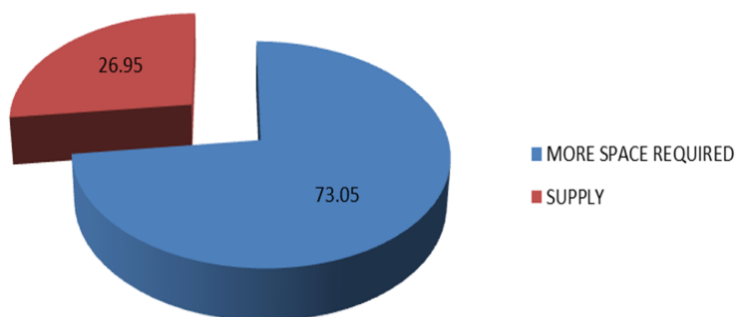


Figure 8. Parking Demand vs Supply

• **Higher Number of Road Fatalities**

With the increase in number of vehicles on roads and better quality of roads, it often feels feasible to speed up the vehicle. The high speed vehicles make them more prone to accidents. Increasing number of accidents has been recorded in the past years. The indices (Table 1) show that on an average 3 people die each day while around 15 people get injured and most of the accidents are not even registered.^[9]

Table 1. Traffic accident data of J&K

Description	From 2010 to 2016	Computed Index (per day)
Total no. of accidents	43,140	17.11
Total no. of fatal accidents	5,713	2.82
Total no. non-fatal accidents	37,427	23.85
People killed	7,216	2.23
People injured	60,947	14.64

- **Degradation of Environment**

Transport is the one of the major emitters of greenhouse gases. Cars and trucks produce air pollution throughout

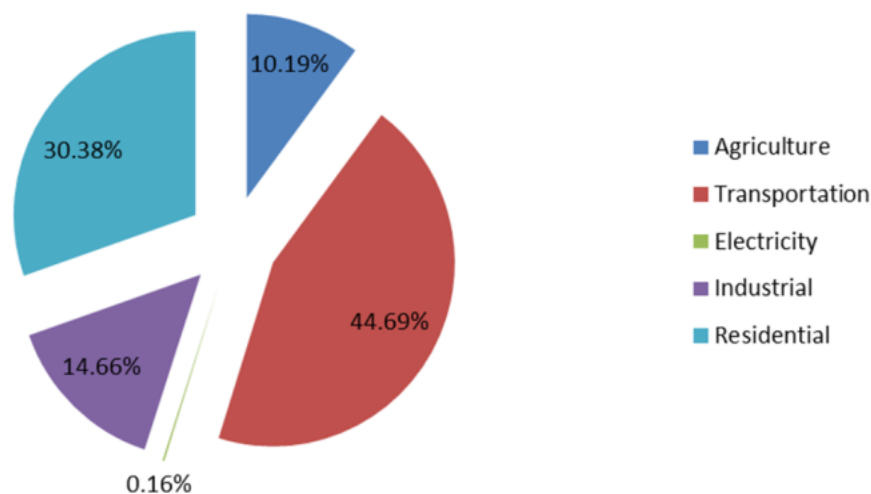


Figure 9. CO₂ emission from energy consumption in

their life, including pollution emitted during vehicle operation, refuelling, manufacturing, and disposal. The major pollutants emitted from vehicles are nitrogen oxides, carbon dioxide, carbon-monoxide and sulphur dioxide. The average annual carbon dioxide emission per person in India is 1.6 tons and that of J&K is 0.6 tons. The transport sector in J&K emitted 44.69% of the total Green House Gases, in 2013-2014.^[10] The motorized vehicles used for personal movement plays an important role in traffic congestion problem and it also causes major environmental degradation by reducing the quality of air.^[6]

- **Non lane based**

The roads in most of the developing countries like India are non-lane based. The movement of traffic on non-lane based also contributes to traffic congestion. People often lack discipline and don't follow the lane provided for a particular speed limit. According to the traffic rules, high speed vehicles should move in the right lanes and slow speed vehicles in the left lanes. When this rule is not followed, the overtaking action also takes place in an indiscipline way making the travel more vulnerable to accidents.

- **Uncertainty in Driver behaviour**

The driver behaviour in India is very uncertain. According to PIEV theory, the reaction time of a driver is split into four components, i.e. perception, intellection, emotion and volition. These characteristics vary from a person to person. So, it cannot be predicted and the correct evaluation is cumbersome.

- **Poor integration**

The roads in most of the developing cities are poorly integrated. The route followed by PTS often does not directly connect from starting point to destination. There are various intervals in between and these intervals need to be properly connected by IPTS which is rare to find. Sustainable transportation behoves on greater reliance on non-motorized transportation, and increased use of integrated mass transportation.^[6] With an integrated mass-transit, there will be no scope of vandalism and collision, which will also prove to be environmental friendly.^[6]

- **Enforcement problems**

The capacity of roads is often decreased by the enforcement. It is seen that the walkways and footpaths are occupied by the road vendors and also by the shopkeepers in the vicinity. As a result, movement of people becomes unsafe and shrinkage of road occurs.

V. VOLUME TO CAPACITY RATIO

As we have a definite space on earth and we cannot go beyond limits to fulfil our greed, we need to take steps that will prove to be an economical, eco-friendly, untroublesome solution to the problem of traffic congestion. The current approach followed is Supply Centric whereas it should be Demand Centric. If we consider the ratio of volume of traffic and capacity required, the optimization is acquired if the ratio is less than 1, i.e., $\text{volume/capacity} < 1$. The current approach towards this expression is increasing the capacity so that the optimization is obtained avoiding the fact that if we keep following this approach, the day is not far when we will reach a yield point and there will be no further possibility of expansion of the capacity. This approach entails road widening, flyovers, underpasses, etc. and it comes at the cost of huge capital investment, human resource, and short and long term environmental degradation. Hence, the desired approach should be to decrease the volume of the traffic instead. With such an approach we will save the environment as well as lot of resources and can improve the health standard of people. This can be achieved by adopting sustainable system of transportation. Bus, car, and two-wheeler need particular attentions to mitigate their environmental impacts while Mass Rapid Transit System (MRTS) would be an effective solution to restrict the booming energy demand and associated air pollutant emissions. ^[11]

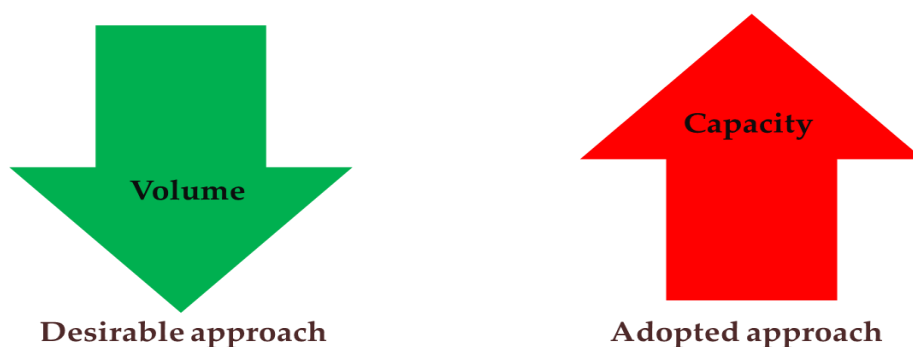


Figure 10. Desirable approach and adopted approach

LESSONS TO LEARN FROM SUSTAINABLE TRANSPORTATION IN NETHERLANDS

As mentioned earlier that we are at the early stage of the problem, it should be an eye opener to what this major issue has

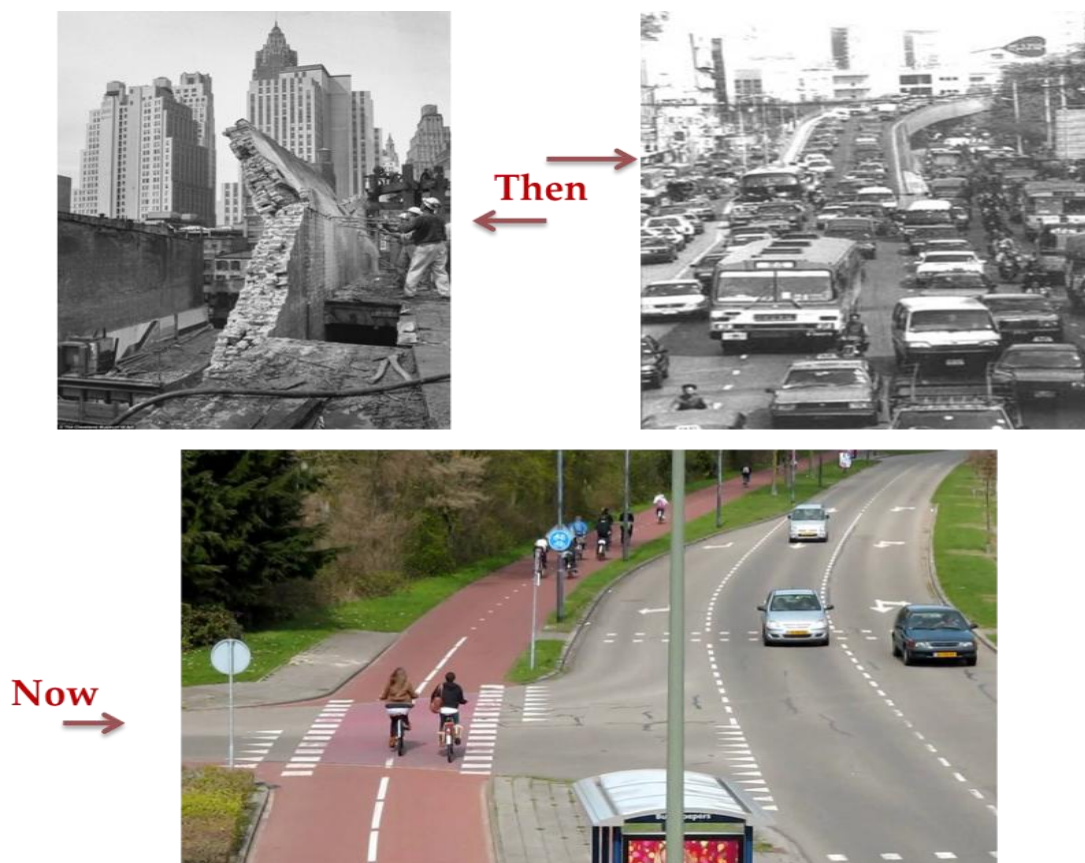


Figure 11. Netherlands before and after adopting sustainable system of transportation

done to the already developed countries and how they have combatted the problem successfully, one of the best examples being Netherlands, where 27% of all trips are by bicycling. In 1960's, Netherland faced the massive traffic congestion problem which resulted in demolishing of huge structures to increase the capacity of roads and losing a lot of lives in accidents. There were protests against such government policies as people had to give up on their houses for the construction of roads. This led to shift of the policies in 1970s. The way Dutch streets and roads are built today is largely the result of deliberate political decisions in the 1970's to turn away from the car centric policies. Changed idea about mobility, safer and more liveable cities and the environment led to a new type of streets in the Netherlands as shown in Figure 11. Amsterdam, a city of Netherlands, also known as bicycle-friendly capital of the world, is a home to 8,81,000 bicycles and 38% trips of the total trips are by bicycling. The health benefits of sustainable system of transportation are noteworthy in the Netherlands. About 16,000 (underestimated) deaths have been prevented each year and life expectancy has increased by half a year. Figure 12 shows the remarkable change that seems practically impossible. It should boost our motivation to plan our traffic system and road network which is not degrading our natural resources and imbalance our ecological system. We should improvise our policies such that optimization of the resources to maximise the productivity can be achieved and such examples prove that it is not impossible.



Figure 12. Revolutionary change in Netherlands after adopting sustainable system of transportation

VI. CONCLUSIONS AND RECOMMENDATIONS

It is challenging to overcome the problem of traffic congestion in the developing cities and proper measures are to be taken in order to achieve the goal. Sustainable system of transportation needs to be given prime importance to combat this problem as it is a solution to the problem of traffic congestion and the other hazards associated with it. Ten-point solution is highly recommended to have a long term goal of achieving a sustainable transportation system:

1. **Setting up of State Traffic Data Collection Centre (STDCC):** Data becomes the foundation of analysis. Quality data bases make the analysis robust and efficient. The data collection centres in our state are neither exhaustive nor sufficient.
2. **Incorporating urban transport as an important parameter at the planning stage:** The present demand-oriented approach should be replaced by goal-oriented approach for developing urban transport strategies.
3. **Minimize travel demand by better integration of land-use and transport planning:** Land use policies have a direct impact on transportation sector. So integrating the two at the planning level itself is very important. This integration between the two should not be stopped at the planning level, but it should move along the various developmental stages.

4. **Equitable allocation of road space:** Road space should be designed in such a way that it accommodates all the road users efficiently and safely. Our current system is bias. We hardly have dedicated spaces for pedestrians and non-motorists.
5. **Improvement in public transport system:** The space occupied by a “n” number of road users when using cars is much more than the space occupied by the same number of users when using a public transport facility. It has been seen that a properly designed and well-coordinated Public Transport System shift the road user psychology from cars to buses and road users prefer to use the latter.
6. **Introducing intelligent transportation system (ITS):** With the increase in parameters like population it is becoming difficult to organize and ensure the efficiency of the system as a whole with every passing day. ITS has proved to solve this problem in lot of megacities across the globe. For example, ITS-based traffic law enforcement proves to be highly beneficial and its time we start adopting such modern technologies in our transportation system.
7. **Facilities for use of non-motorized vehicles:** One of the best examples across the globe which proved that it is quite possible to achieve a shift from using cars to adopting active transport modes such as bicycling and walking is that of Netherlands. Why can't we think about it? Research shows that active transport modes have huge number of benefits ranging from improving the quality of environment around us to improved overall health and social well-being of a society.
8. **Exploration of alternative transport modes:** If we go back to history of transportation system in Srinagar city, water transport was used for movement of people and essential commodities (like rice) in most of the areas. In contrast, we hardly see the use of water transport other than for tourist recreation nowadays. Researchers see a huge potential of water transport here. An attempt was made previously by the authorities but it failed miserably and the reasons were poor integration of the system with expected users of the facility. The questions like “*Why would people use and adopt a new system?*” should be answered at the planning stages itself.
9. **Use of cleaner technology:** It is unfortunate that despite of many years of introduction of LPG and CNG vehicles, we still lack the infrastructure for the same. World is not only exploring the cleaner technologies for example hybrid vehicles but they have already started exploiting them. Not only the infrastructure but awareness is equally important to be introduced.
10. **Incorporating research work with the practical world:** There is hardly any link between the research teams and implementing authorities. As a result of this, traditional approaches are still applied which are not only expensive but unsustainable.

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