Integrated Planning Model for Safe and Sustainable Transportation Development in Beijing, China

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Abstract. Following the urbanization trend all over the world, similar to other Asian countries China is also experiencing rapid urbanization and motorization. Specially, Beijing being capitol city has burgeoned in last decade unexpectedly. The problem related to traffic congestion including longer travel times, long queues at intersections and road crashes etc. have increased to alarming levels. The high rate of vehicle ownership and increase in road capacities by providing new roads and flyovers made the more worst. For developing Beijing as a livable city, a new integrated planning strategy is proposed here in the paper. The paper discusses model policy to be incorporated by urban planners and developers considering Transit oriented development, mixed use development, Non-motorized transportation and transport demand management tools for safe and sustainable development. The paper concludes with various suggestions and measures have been highlighted to address the urban development problems.

Introduction

According to the “UN Road Safety Report” 1.25 million people have died due to road traffic crashes, more than 50 million people get seriously injured around the world [1]. Humans play a critical role in accidents, so higher percentage of accidents happens due to Human Error [2]. Air pollution in China stood at Number-1 in the world ranking, the emission’s main source in China is industries and traffic [3]. In China the percentage of car user is increasing day by day, which increases the traffic congestion and jams. It’s common for motorists to weave in or out of the lanes, move in any direction and obstruct the path of others [4]. In China, due to higher commuter time, most of the drivers take any risk to move in any direction without considering others [5]. The shift towards car modes is increasing at a rapid phase, as well as the traffic accidents ratio also increase which make road more hazardous [6]. In China fifty-five thousand vehicles are registered per day, the vibrant increase in vehicle ownership is alarming for the developer [7]. Most of the deaths happen due to road traffic in China, the growing number of motor vehicles is the major cause considered for traffic accidents in stumpy-medium income countries [8], [9]. The mortality rate due to road traffic in China is three times higher than in developed countries [10], the accident rate is very high in China, the most percentage of accident caused due to commercial vehicles [11], 75% of fatalities occur due to cars in the world [12], [13], the lethality rate of 5.3% in China was recorded by [14]; the same research also predicted the rate for Britain 1%, USA 1.5%, and Japan 0.5 %. China have almost three times higher lethality rate in the world. Due to high number of motor...
vehicles, violations attributable to vehicles increases, which in turn increases accident rates in China [15].

According to WHO the USA has twice the number of registered vehicles compared to China, and three times as many as India. But the death rate is quite stunning and booming in under developing countries such as China and India [16]. In China annual fatalities and serious injuries rate is around 3,305,813 which cost 300 billion $, and is equal to 5% of GDP rate of china [17]. China safety manual for highways project recommends regulation and guidelines for safety but does not make these mandatory. He further explains the traffic accidents in China as due to inappropriate channelizing of intersections, road signs and lack of anti-skid surfaces [18]. Due to congestion vehicle driver not give any priority to pedestrian or bicycle in major cities like Beijing and Shanghai [19], congestion and pollution index of 20% is generated from vehicle driven to school every day in Beijing [20]. The crossing of pedestrian and cyclist is susceptible due to crossing infrastructure [21]. China traffic network is almost double that of the United States, but still one-third of cars on road, every day in all over China reports are published in different newspaper with huge death ratio due to road accidents [22]. In 2000 due to emission (PM10) generated by vehicle was equal to $974 million of health impacts of air pollution [23]. Megacities in China are experiencing the annual increase of 25% in vehicle ownership [24], after peak hour in Beijing, 60db of noise is analyzed which does not allow many residents to sleep [25]. The floating population, illegal and unethical driver training, and unsafe pedestrian intersection crossings due to unplanned traffic control measure are the major causes of car accidents in Beijing [26]. According to article-47 which is based on “Road Traffic Safety of the People Republic of China” clearly mentioned that at the pedestrians are passing the intersection, the driver shall reduce speed. The law further explains that vehicle should stop, and yield to pedestrians to cross [27]. Beijing roads are sprinting across eight lane, anxious and aggressive taxis, rickshaws and moped drivers. Chinese laws provide safe movement to pedestrian but what really take place on road is different [28].

**Integrated Planning Model**

An integrated planning model combining four policy measures including TOD, MUD, NMT & TDM has been proposed in this paper. The model uses the benefits of all four sustainable planning tools described in detail in previous sections.

![Integrated Planning Model Diagram](image)

All policy measures are implicitly connected and can be expressed as shown above. The model uses the inputs from the all tools and converges into safe & Sustainable transportation Network.
Transit Oriented Development (TOD). In Beijing, China subway and bus transportation are the key pillars to facilitate twenty million people, among those six million people have their own car/vehicle. TOD means to promote smart growth, inserting vitality in abating central metropolis scenarios, fulfill the travel demand, offer economical rides and expand the lifestyle choices. To implement the TOD in Beijing we don’t have a choice to develop the area and then provide the service. But the existing transportation system needs to be remodeled to increase connection and connectivity. The Beijing subway serves as feeder line for the city, whereas, being a secondary transportation service, buses have huge role to play on the streets. But due to planning errors most of them run on inadequate lines and provide poorly utilized services.

Launching TOD concept will mainly entice the private vehicle user to use public transportation instead of their car. The concept needs to address this need with special indicators, by providing dedicated bus lanes, with pre- and on-trip up-to-date information to achieve reliability. The percentage of modal shift will then increase towards public transportation user.

TOD concept should be introduced to Beijing Subway, whose stops are more than 2km apart. Local and fast train concepts need introduction by using zonal transportation networks. Similarly, in New York, the main attraction points are connected with fast trains, which customarily skip three stops. Beijing needs to increase the public transportation capacity rather than more planning and constructions for cars. The bus stops are mainly located on the poor network, and the reliability of bus network is very low. Pre-trip and post-trip information doesn’t exist. These two strategies will promote the TOD in Beijing, which strongly increases the motivation to select public transportation instead of driving a private car.
Mix-Use Development

Figure 2. Land-use and transport interaction scheme.

The land use, transportation supply and demand correlation are introduced by [29], [30] which further explain that the relation is dynamics and nonlinear. The figure derives a correlation between short term and long term decision variable. Increase in land use will increase the activations; more activations will increase travel demand. The transport supply is designed for a specific percentage of people, so if the demand increases the supply will be affected. There is a reciprocal and proportional impact between transport supply and demand. The balance between these two variable is important, if any limit exceed then the reciprocal impact will start.

Short term mobility decision greatly influence everyday activates like commuting and marketing, type of activity, modal choice, route choice, trip choice and route choice. Some aspects are also influenced by transport offer, if the ride quality offers more comfort then the travel demand will for that travel option will increase. As a result there will be congestion and the ride quality will be influencing strongly on attraction of a huge crowd in form of passenger. The improvement of transport supply is only possible through further investment to increase the capacity or operational management.

Similarly, increase in transport supply will increase the accessibility and for more accessibility more land will be needed. Future development is based on land availability and land usage pattern. Mixed land use with providing of all facilities is the only solution in Beijing, to facilitate and make Beijing a better place for living as well as increasing the safety of inhabitants. Mixed land use will increase the community integration, activates and also decrease need to travel.

Due Patronage to NMT

This best practice is done in many countries to increase safety and decrease the mortality rate due to road traffic. Modal shift of the city, selection of mode, route choice and attraction towards Non-Motorized Transportation (NMT) is dependent on availability of infrastructure. Inasmuch as the existing infrastructure has some flows, somewhere the pedestrian track is available but in most cases the pedestrian track doesn’t exist. This research will strongly recommend the connected sidewalks and pedestrian track which also ensure the safety of two wheelers (bicycles). Most of the traffic signals are based on fixed time after interval of three minutes for thirty seconds, but due to weak enforcement law again the pedestrian and cyclist feel unsafe because of the aggressive
behavior of motorists and weak, sporadic force mentor rules and regulation. Article-47 by “Road Traffic Safety of the People Republic of China” nominally provides the safe crossing to pedestrian and cyclist at intersection, but the reality looks different than the law on road of Beijing.

**Current View of Intersection**

Where vehicle not care about the pedestrian and cyclist and pedestrian think that they can cross.

![Existing Intersection in Situation Beijing, China.](image)

**Figure 3. Existing Intersection in Situation Beijing, China.**

**Least Conflicts Intersection Design**

New Least Conflicts Intersection Design is based on concept to reduce the conflicts points of different vehicle type and road user to reduce road crashes. The strategy is based on “Road for public, not for cars” Future planning will not be based on increasing the motor traffic option, but to further aim toward a safe environment which will reduce emission levels, lower noise, and prioritize transit-oriented development. The planner should redesign for people, and the private vehicle should be viewed as an often unwelcome guest.

In Beijing, China the cycle tracks exist in some places but due to weak connectivity it is very inconvenient and ineffective to choose this mode of transportation. The new design should focus on increasing cycle infrastructure, community integration places and pedestrian track.

Furthermore, the cycle tracks need to be demarcated with red asphalt, and be at least two meters from both sides of the vehicle lanes. Moreover, around all the subway station parking facility for bicycles should be encouraged throughout Beijing. Similarly, the pedestrian tracks need at least three meters width so the people can pass one another easily. Cycle and pedestrian tracks need to be separate from the road, because the bicycle track in most cases is ill-used by private vehicles for parking in Beijing.
Suggested Intersection Design (Less Conflict Model)

Figure 4. Public Transportation Dedicated Model.

Figure 5. Less Conflict Intersection Model.

Figure 6. Bus, Cycle, Pedestrian Dedicated Model.
Intersection designs need revision to limit the crossing traffic if possible, to reduce the accidents. As mentioned by different researchers, in China different accidents are head-on collisions of vehicles, that’s only due to weak regulation and model of intersection. The new model of intersection comes up with a solution to install dedicated bus lanes near the pedestrian tracks for safe boarding and alighting of passengers, along with remodeling the bus plan and running the bus on tracks which can only go straight or take turn to a designated bus lane.

**Transport Demand Management (TDM)**

TDM aims to increase the effectivity of the transportation network, by such strategies which are cost effective, reduce demand for travel, reduce congestion, assign better network operation, reduce pollution, and create more sustainable options for travel. To achieve TDM different approaches are suggested for Beijing, such as to discourage the parking on bicycle tracks, discourage free parking, increase fare of parking in peak hour, and reduce the capacity of parking -all strategies intended to dissuade the private vehicle owner. These strategies will reduce overall traffic, and will shift the people from private to public transportation. This strategy will further reduce emissions, improve health and fitness, and improve equity and community integration which will lead to greater safety.

**Conclusion**

A holistic planning approach for addressing urban traffic related problems in Beijing city is need of the hour. Integrated planning model incorporating sustainable tools are most suitable for Beijing. Integrated planning model efficiently maintains balance between land use and transportation planning. In this research model due patronage has been given to NMT to shift the car users to public transit system. The model proposed here helps to enhance road safety & public transit mode share, simultaneously it reduces the environmental pollution and road crashes.

**Contribution of Authors**

All authors contributed equally in the preparation of this manuscript.

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**References**


