Bangalore: Silicon City or Black City?

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I. INTRODUCTION

The most common myth of accident being unavoidable is the bane of any society with Bangalore being the prime example. Accidents can be unintentional and sometimes can be random but are generally found to occur along some hazardous locations called black spots. The area covering these black spots are called as black areas in traffic jargon. The study at this level can be limited to blocks, taluks or districts. Based on this theory and present traffic fatality rate, Bangalore can be rechristened as **"BLACK CITY"** in traffic terminology to emphasise poor safety infrastructure. In the subsequent sections, the author has tried to collect, analyse and derive some important conclusions concerning the issue of road accidents in Bangalore.

II. MOTORIZATION OF BANGALORE

The conversion of Bangalore from being once a "Garden City" to present "Black City" has been rapid. Bangalore has grown exponentially in the past two decades. The Booming Software, Biotech and manufacturing industries have magnified the requirements of basic and service employments, which generated and magnified urban sprawl into problematic proportions. Improvement in the quality of life along with substandard public transportation has resulted in spiraling growth of private automobiles. The resultant offshoot of such a high automobile growth along with supply intensive actions of the government is accidents.

The Motorization index calculated by the author (vehicles for 1000 persons) best describes the high intensity of vehicular growth, which projects that nearly every 3rd person owns a private vehicle. Motorization index has nearly doubled within a decade. This calculation is highly conservative since it does not consider high intensity of migration of persons with their vehicles from other parts of state to Bangalore.

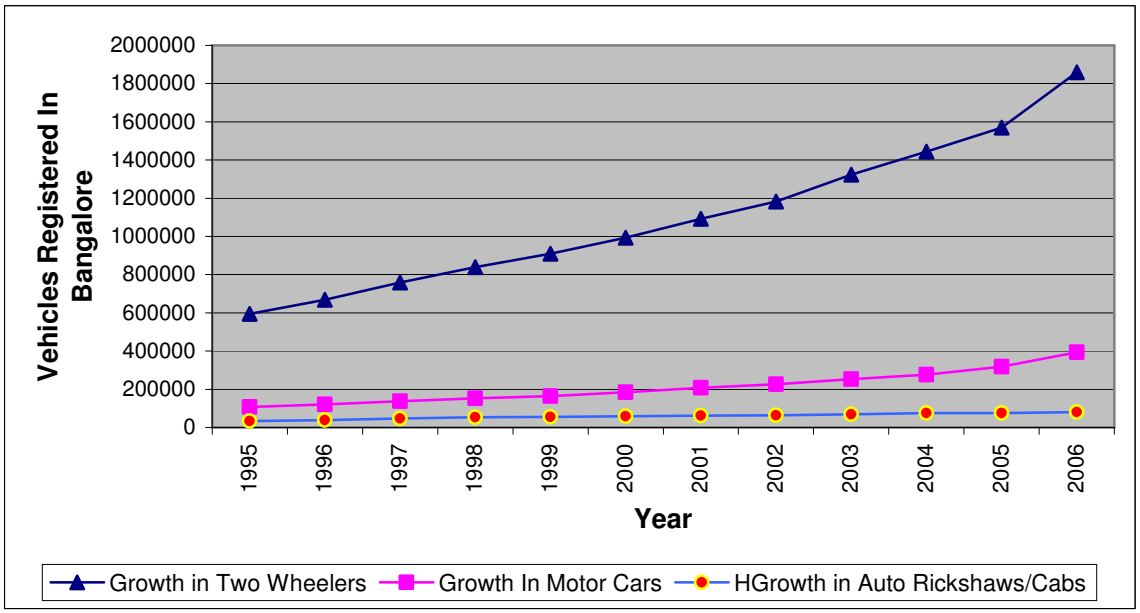
The high intensity of vehicular growth can be known from the simple area analysis. Karnataka State has 1,91,791 sq.kms of area whereas capital Bangalore as per revised estimates has 561 sq.kms of developed area, which works out to 0.29% of state area. Nearly 39-40% of vehicles registered in Karnataka state belong to Bangalore. Such a massive number of vehicles occupy 4.8% of total road length available in Karnataka. Availability of such a massive number of vehicles results in violation of individual spaces thus contributing to accidents.

Table 1: Motorization Index for Bangalore

Year	2-Wheelers	M/Cars	A/R. Cabs	Others	Total	Population*	Motorization Index
1995	594000	107000	34000	62000	797000	4850125	164.33
1996	669000	121000	39000	71000	900000	5048980	178.25
1997	758000	138000	47000	80000	1023000	5255988	194.64
1998	839000	152000	54000	84000	1129000	5471484	206.34
1999	910000	164000	55000	94000	1223000	5695815	214.72
2000	994000	184000	58000	101000	1337000	5929343	225.49
2001	1092000	207000	62000	112000	1473000	6170000	238.74
2002	1183000	226000	64000	123000	1596000	6333505	251.99
2003	1323000	253000	69000	137000	1783000	6501342	274.25
2004	1444000	277000	76000	153000	1950000	6673628	292.19
2005	1570000	318000	75000	167000	2130000	6850479	310.93
2006	1859994	394419	80593	209567	2544573	7032017	361.86

* Source: CDP-2006(Draft)-Reduced growth Considered

Chart1: Vehicular Growth in Bangalore



III. CURRENT ACCIDENT SCENARIO

Bangalore is one of the most accident-prone cities in India [12]. Bangalore contributes nearly 18% of total accidents in Karnataka. It is to be noted that Bangalore contributes fewer shares in person's killed category than person's injured category when compared with Karnataka state due to availability of hospital facilities near to the accident location but still it is very significant from nation's perspective. The other important fact to be kept in mind is the underreporting [13, 5] of accidents. A study [7] done in Bangalore proves that the number of accident deaths is reliable but the number of injuries is highly under reported.

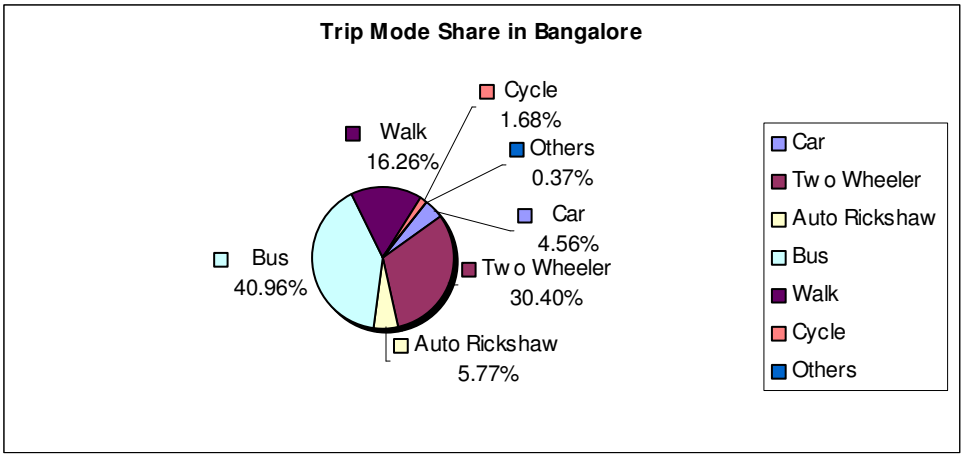
Table 2: Accident Scenario for Bangalore

Years	Karnataka State			Bangalore City		
	Total Accidents	Persons Killed	Persons Injured	Total Accidents	Persons Killed	Persons Injured
2002	35,854	6,366	45,769	9856	820	7577
2003	37,658	6,195	45,781	10505	883	7980
2004	38,896	6,496	50,395	9101	903	6921
2005	40,317	6,904	54,061	7575	833	5899

The above table shows that Bangalore has a prominent share in the total number of accidents occurring in Karnataka. The number of Accidents & Deaths may be showing a decline in trend but still the number is very high when compared with other cities.

In order to investigate the mode split of accidents, it is necessary to estimate the trip making characteristics of Bangalore People. The travel mode split for Bangalore city has been derived from CDP-2006.

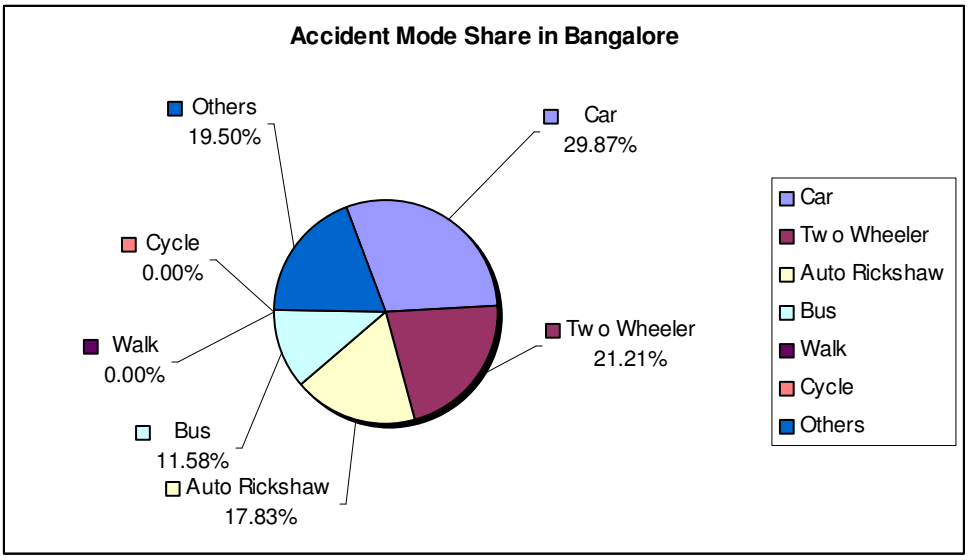
Chart2: Trip making Characteristics in Bangalore (CDP-2006)



The two Pie Charts (chart-2&3) developed illustrate the traffic capriciousness of private automobiles. The observations that can be derived are

1. Car is the main accident-prone mode in Bangalore.
2. Public Transportation/Bus is the safest mode for transportation but ingress and egress movements are risky.
3. The Share exposes the issue of vulnerable groups (Pedestrian/Cycle). The police do not consider them in the accident mode share, as they are the most affected ones. If an accident occurs between a car and a pedestrian, whoever the culprit may be, the accident gets registered in the share of car and the death/injury is mainly taken by the vulnerable group. In an accident between two modes, the more affected party is not included in the share while the larger mode is considered in share.
4. Other Mode share is 19.5%. Such a high share is due to presence of Truck share and unknown hit and run cases.

Chart3: Accident Mode Share in Bangalore (2005)



* Bangalore City police [3]

Photo Depicts accident caused due to traffic violation by the goods vehicle

IV. VULNERABLE GROUP CONCERNS

Society should address the concerns of the vulnerable group at priority. In Transportation studies, the vulnerable group constitutes pedestrians, school children, aged people, people using NMT, public transportation and bicyclists.

The high share of Pedestrian accident cases can be known from the high percentage 39-40% of pedestrians in the total fatal cases. Pedestrians constitute nearly 31-37% in the total injured category. The point of curiosity here is that Pedestrians constitute only 16.26% in total trip category but have very high fatality and injured rates. The high pedestrian fatality rates are emphasised in order to project poor pedestrian facilities existing in Bangalore.

Table 3: Pedestrian Accidents

Year	Total Killed	Total injured	Pedestrians Killed	Pedestrians Injured
1999	639	6026	257	1921
2000	659	6347	273	1968
2001	703	6929	282	2199
2002	820	7577	328	2362
2003	883	7980	348	2967

*Basic Data: http://www.hindu.com/2004/10/24/stories/2004102413300300.htm

The society's vulnerable group (Public Transportation users) mainly constitutes the pedestrian mode share. They are virtually exposed and have to compete with the traffic to gain space.

The other section of the vulnerable group i.e. school children form the other major share of total accidents. The below table indicates the high accident probability of school children. In fact School children constitute approximately 8-10% of Total road accident Fatalities thus highlighting the importance of traffic safety.

Table 4: School Children Fatalities due to Accidents

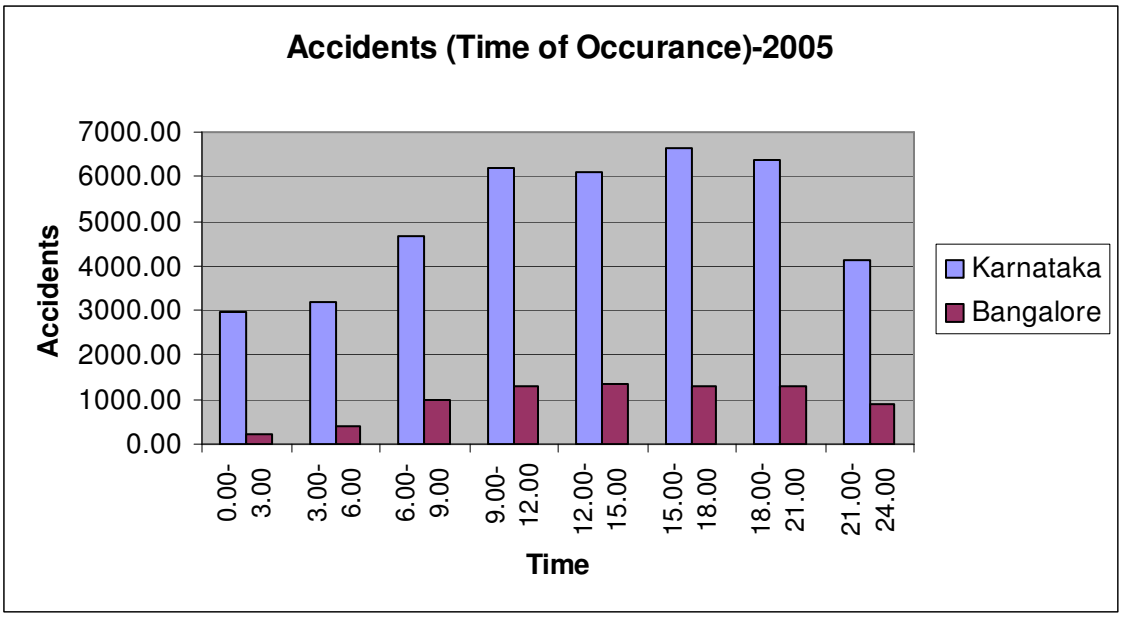
Age	2001	2002	2003	2004	2005	2006 (upto 30/11/2006)
0-6 Yrs	24	18	23	25	31	21
7-18 Yrs	61	51	67	67	56	45

*Basic Data: http://bprd.nic.in/writereaddata/presentation/File20.ppt

V. ACCIDENT ANALYSIS

The author has tried to analyse the accident pattern of Bangalore to derive some conclusions. The data gathered showed that nearly 36% of accidents occur in Night (18.00 pm-6.00 am). Such a high percentage in night times should be viewed in perspective of alcohol usage, less percentage of illuminated roads, lack of enforcements and availability of ample road space with no congestion. For proper accident analysis, speed and geometric design issues need to be highlighted.

Chart4: Time of Occurrence of Accidents-2005



Urban roads in Bangalore face a peculiar design lacuna, which can be named as **sinusoidal speed phenomenon** highlighting gross extremities in operating speeds for the same stretch of road during different periods, which needs proper investigation. The high volume of traffic during peak hours allows very poor LOS with hardly any room to maneuver. During these periods there may be more accidents due to violation of individual spaces and generation of traffic shock waves but the accidental severity would be less because of relatively lower speeds (accidents due to heavy vehicles are exception). The accidents are more of injury/vehicle damage types, which induce further incident congestions. The off-peak hour's accidents are more severe type, which makes an entry in official records. Further the design speeds of urban roads are dictated by restricted road space, high number of junctions with poor road furniture. The design and operating speeds of such roads are in order of 20-60 kmph. Ever availability of high congestion during peak hours leads to mental stress and frustration which the driver releases during night times by driving at free speeds thus generating sinusoidal speed profiles. Poor enforcement at such hour with safety risks allows driver to over-speed.

Bangalore is often called PUB-City of India because of high alcohol consumption and manufacture; the resultant of such a behavior is that it has the highest number of drunken driving cases in India. A study [16] has reported that 44% of crash two wheeler drivers seeking medical attention were under the influence of alcohol.

Other important fact to be emphasized here is the weekend/Holiday accident trend. Saturday-Sunday is the main accident death contributors (12-20% increase in accident death probability). The reason can be less traffic – more speed with less enforcement and high alcohol consumption.

Table 5: Drunken Driving Traffic Violations in Bangalore

Year	Number Of Drunken Driving Cases	Total traffic Violations
2001	30080	1257959
2002	9955	1320713
2003	10163	1268272
2004	19142	1097826
2005	27673	1646687
2006	27264	1498396

*Basic Data: Bangalore Traffic Police & Times of India-28-05-2007

The poor traffic sense prevailing in Bangalore is one of the chief contributors to high accidents. The author has tried to investigate further in this regard and concluded that approximately 77% of vehicles have officially violated traffic regulations and fined at least once in the year 2005 (assuming single traffic fine per vehicles). This result should be viewed in the perspective of poor enforcement strength available in Bangalore (Enforcement Density of 0.29per kilometer length of road).

Some of the potential accident black spots-35 [21] identified by the experts are mentioned in the Table-6 (Annexure1). These spots are geographically scattered with varied geometric configuration.

VI. DEVELOPMENT OF INDICES

Worldwide researchers [8] have developed variety of Accident Indices to attract the government agencies attraction and for selective comparison. In this section, the author has made an attempt to derive number of accident indices which can be used for future research purpose and which substantiates the claim of Bangalore being the accident black city.

While computing the indices, it should be noted that a single index generation should not be the basis for decision-making as it may give wrong representation. Many researchers have concluded and recommended use of multiple indices with weighted average for better appreciation, as motorization levels and population density are not same.

Traditionally, the variables adopted for linkage are Population (Resident) and Vehicle registration with each having its own complexity. The author has tried to include new parameter Fatality Violation Index that links the total accidental deaths, traffic violations and registered vehicles. The logic behind this derivation was that inclusion of violations with accidental deaths would provide traffic reckless behavior of people for comparison.

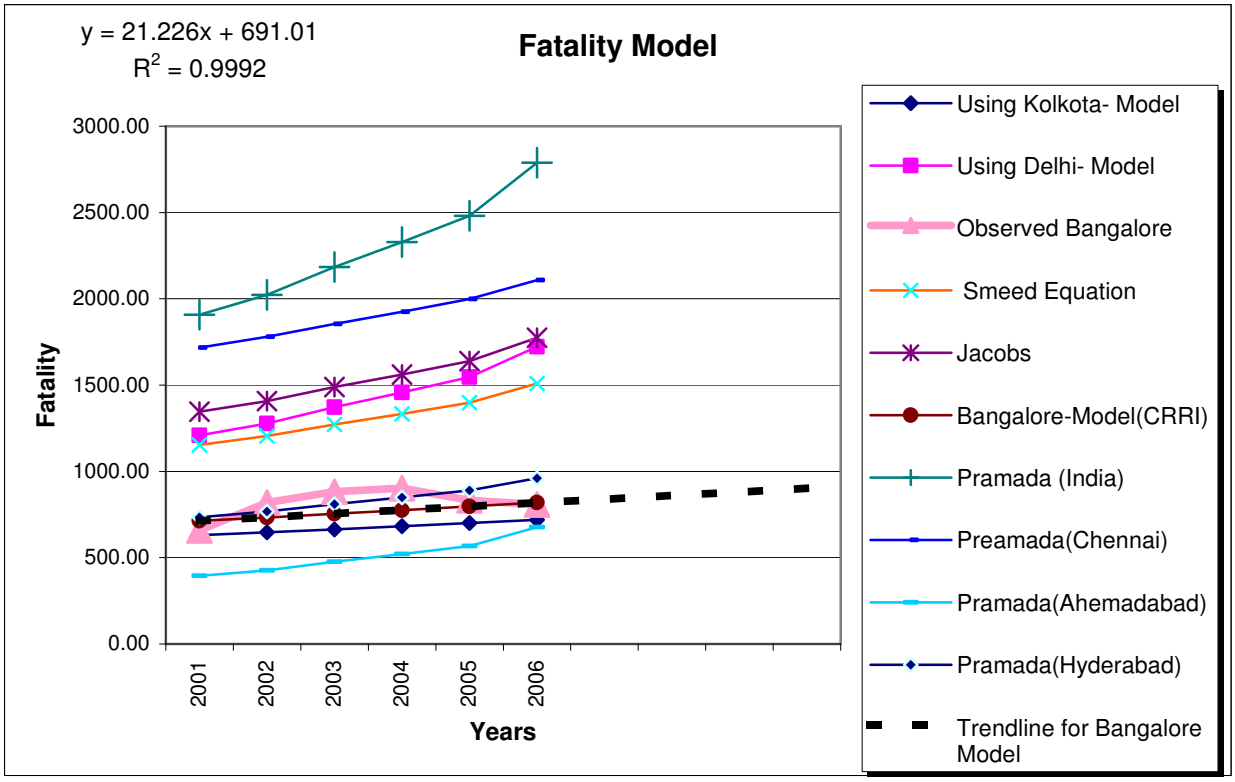
The following indices have been derived for better appreciation and future research comparisons (Table7- Annexure-1)

1. Fatality rate (Ratio of Number of Persons Killed by vehicles (in1000))
2. Fatality Risk (Ratio of Number of Persons Killed by population (in100000))
3. Accident Rate (Ratio of Total Accidents by vehicles (in1000))
4. Accident Severity Index (Ratio of Fatalities by Accidents (in100))
5. Accident Risk (Ratio of Total Accidents by Population (in100000))

6. Fatality Violation Index (Ratio of product of Fatalities with Traffic Violations by registered vehicles)

From the table it can be inferred that Accident scenario in Bangalore is simulating the international Cities decreasing trend phenomenon. Fatality rate is decreasing at an average rate of 11% in past 4 years. This should not be considered as an achievement since continuity of present trend with a vehicle increasing at a conservative rate of 3% would bring zero fatality rate only in 2083 (very less probability of that). This statement is highlighted in order to project the complexity and bleak present scenario. Similar trend can be seen with reference to fatality risk, accident rate and accident risk. The other serious concern is upward trend of accident severity index. This is very important as it means that accidents are becoming more fatal with time. The authorities should seriously consider this aspect. The hypothesis for this kind of trend can be supply intensive actions of government and more nighttime driving. The nighttime high fatality rate is virtually increasing the accident severity index. Due to lack of adequate data, the author could not prove this hypothesis.

Chart5: Bangalore Accident Death Scenario



In order to project future accident scenario, it is a must to base our assumptions on sound fundamental logic. Traditionally as seen from above population, numbers of vehicles are the popular variables, which have been used in time series calculations with accidents, deaths and injuries to fabricate accidental models.

In developing countries like India, the models generated for accidents and injuries would not be accurate as the data is not reliable. Under this assumption, an attempt was made to use the accident fatality models developed for other cities/countries along with developed for Bangalore by various researchers for fatality projection.

The following models have been utilized with Bangalore data for 2001-2006 data

1. Kolkota[18] Model
2. Delhi [19] Model
3. Smeed [8] Equation
4. Jacobs [8] Equation
5. Pramada Banglaore Model(CRRI) [14]
6. Pramada India Model [14]
7. Pramada Chennai Model [14]
8. Pramada Ahemadabad Model [14]
9. Pramada Hyderabad Model [14]
10. Observed Scenario

From the available data, it can be seen that the observed Bangalore scenario closely simulates the Bangalore and Hyderabad models. Since the existing scenario of the city dictates the model behavior, no match was observed with other international models. The simple trend projection shows that by 2010, Bangalore would have nearly **900** road accidental deaths. With such high projections, in order to substantiate the need for immediate serious action the author has made an endeavor in next section to estimate the economic loss due to such fatality.

VII. ACCIDENT COSTING

One of the most contentious topics in Traffic Engineering is the case of Accident Costing. The Tools utilized by the researchers for accident costing are Human Capital Approach (Gross Output Method), Net Output Method, Life Insurance Method, Court Award, and Willingness To Pay Approach.

The Human Capital method is mainly adopted in developing countries as the basis for calculation of Accident Costs. Road User Cost Study [15] and report by Tata Consultancy services [6] are the most recent government backed report available in this topic. The reports value the cost of road death to Rs 210554 (1990 prices)[15] and Rs 535489 (1999) [9].

Such a low cost of life should not be considered in the analysis. The Gross Output method and other methods are a sort of discriminatory tools. These methods judge the cost of life in view of its economic status and future output. The tool can become discriminatory if randomly used and applied to calculate accident costs. The Cost of life should never be judged by the government in view of its economic status while considering the funding of infrastructure development. Also there is a serious lacuna in government compensation methodology, the accident victims in a railway crash are paid very less compensation whereas the victims in an air crash are paid higher compensation on the basis of gross output/willingness to pay/Court award. The Court award in India for road accident deaths varies up to 40 million rupees (9). In road sector also there is variable accident compensation across the modes. There is

variable compensation paid for other type of ***accidental deaths*****,** though from a nation's perspective, all life should be measured from a common datum as they carry equal rights.

In fact there is a Supreme Court Hearing (India) (Case involving Zoremsangi)(22) where it has considered the age of claimant and not the age of victim as the basis of accident compensation along with other variables such as income of the deceased and other relevant factors like loss of love and affection, mental shock and others. Also for example in one more case involving Babu Rao [(11)], the Court disallowed compensation to a injury victim who died later after five months due to some other reason stating that "the claim of compensation for injuries was a personal tragedy and such claim dies with the death of the injured, unless the legal heirs are able to establish that the death was due to injuries sustained by the deceased claimant". The High court later took sympathetic view because of the lacunae in compensation methodology and directed the government to pay 50,000 Rs as compensation.

The varied rulings of the court virtually shake the fundamental understanding of accident costing phenomenon. The author recommends use of a fixed value of road fatality at least while estimating economic loss due to road fatalities as the possibility of accident death was present and that it was only a chance that a particular person died instead of some other person. As the government generally distributes the development fund based on economics along various sectors located at geographically varied locations, such an exercise would eradicate the bias associated with accident costing and compensation to other types of deaths.

Based on this alternate hypothesis, the author has tried to research the available findings, which list the cost of human life in India. With availability of such a highly variable spectrum of human's economic status in India, it is very difficult to firm up a cost of a human being for compensation for any kind of accidental death. There is a few data available for such an exercise. Findings by K.R. Shanmugan (1998) [(10)] was one of the first in its kind in India. This research uses the employment death risks to calculate the statistical life and injury cost of a human being through WTP approach. The Cost of a human life and injury was found to be in the range of Rs13.78-18.55 million and Rs 2014 to Rs7632 at 1998 price levels. This value is comparable to estimates by Brandon & Homman (1995) for VSL (value of Statistical Life) as $ 273000[(20)]. Soma Bhattacharya (2006) [(20)] has computed the value of VSL for Delhi as $150,000 using WTP approach.

Table 8: Road Accident Death Burden for Bangalore City

Year	Persons Killed	Accident Death Burden in Million Rs for Bangalore City			
		TCS (1999)	Shanmugan (1998)	Brandon & Homman (1995)	Soma Bhattacharya (2006)
2001	659	352.887251	9081.02	7196.28	3954
2002	820	439.10098	11299.6	8954.4	4920
2003	883	472.836787	12167.74	9642.36	5298
2004	903	483.546567	12443.34	9860.76	5418
2005	833	446.062337	11478.74	9096.36	4998
2006	809	433.210601	11148.02	8834.28	4854
Cummulative	4907	2627.64452	67618.46	53584.44	29442

*The datum is for respective years as mentioned for different methods (no escalation)
**Cost of 1$ is assumed to be 40 Rs

The author for accumulating the burden of accident deaths in Bangalore in present context has adopted the available studies for generating the Costs at their respective datum years to show the gross variation in government calculations that underestimates the road accident fatality economic loss. Further research and government intervention is required for balancing out the road accident-costing phenomenon.

VIII. GOVERNMENT ACTION/REACTION

The most common myth of accident being a random, unintentional, or predestined; i.e., unavoidable should be dispensed with [(1)]. The accidents are no doubt an offshoot of motorization phenomenon, but they are never unavoidable. There is urgent need to introduce VISION ZERO concept [(17)] In Bangalore city by the government agencies in order to reduce the escalating economic loss due to fatality. Forgiving roadside concept is still alien considering the present context in Bangalore.

The government has used the traditional traffic engineering "3E" concept for solving Bangalore accident problems. The tool of Engineering, Enforcement and Education has not yielded dramatic reductions, which is the need of the hour in view of bleak future.

The government has now embarked on prestigious BTRAC [(4)] project whose motive is to reduce accidents by 30%. The project involves traffic management with ITS involvement with a budget of 350crores is one of its kind in India. It has a host of smart technology innovations such as smart signals, smart enforcement, smart information, smart safety plan etc.

Operation Sanjeevani launched by the Manipal Institute of Neurological Disorders, is one of the post measures taken for reducing the accidental death by speedy and proper transportation of injured people to the hospital. A Comprehensive Trauma Consortium (CTC) was launched when it was found that the pre-hospital care can save many lives. It provides Para-medical help with GPS connected ambulances for all medial emergencies and accidents and liaises with 22 hospitals (all of which have been accredited by a qualified team) to ensure that the best help is available to the victim within the "golden hour" of the accident/emergency.

With 83.5% of accidents occurring in India (84% in Karnataka) being due to Driver Error, proper driver education strategies would help reduce accidents. Bangalore has the highest per capita income in India indicating good education across the stream. But the traffic education is still at the nascent stage considering high number of violations and road rage cases.

IX. CONCLUSIONS

Rechristening Bangalore as the Black City is bound to invite lot of interest in this topic. Author has tried to collate the existing traffic accident scenario for better appreciation. Calculated high Motorization Index indicates more accident risks. Car and Auto (IPT) are the most accident-prone modes available in Bangalore. Accident Occurrence being spread throughout the day rather peaking at some accident hours suggest poor enforcement and high operating speed variation. The Indices calculated

i.e. Fatality Rate, Fatality Risk, Accident rate and Accident Severity Index prove the urgent need of Intervention with regards to accidents.

Customary practice of accident costing was dispensed with in this paper to acknowledge poor government compensation strategy. The paper highlighted the complexities in the accident costing methodology. Using the modified Costs of a Human life and by not making discrimination about type of death an alternate hypothesis has been suggested which might generate more research.

Usual adaptation of "3E" in Bangalore is not getting the required results. The slow implementation is generating smaller accident reductions. Things look gloomy in future considering the supply intensive actions taken by the government. Accidents may decrease due to relentless work done by the police but the accident severity is bound to increase with increase in traffic Speed while roadside safety Environment is still neglected.

Finally it can be highlighted that Bangalore has the distinction of having the traffic with largest per capita income in India with full knowledge of having high accident risks but still has a very high number of traffic offenders indicating the willingness to take accident risks during the course of normal life thus debunking the classical traffic engineering theory and WTP approach.

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ANNEXURE-I

Table 6: Black Spots in Bangalore

Sl. No	Description	Location
1	Command Hospital	East Bangalore
2	Mutthu Mariyamma Temple	East Bangalore
3	Love Ri School	East Bangalore
4	Ulsoor bus stand	East Bangalore
5	Suranjan Das Road	East Bangalore
6	Benaganahalli	East Bangalore
7	Nagawara	North East Bangalore
8	Anepalya	South Bangalore
9	Kudlu Gate	South Bangalore
10	East End circle	South Bangalore
11	Jala Bhavan	CBD
12	Kalyananagar	East Bangalore
13	Kuvempu Circle	North Bangalore
14	Gangamma Circle	North Bangalore
15	Goraguntepalya	North Bangalore
16	Jalahalli Cross	North Bangalore
17	8th Mile in Peenya	North Bangalore
18	Raheja Apartments (Vijayanagar)	North Bangalore
19	Magadi-Chord Road	North Bangalore
20	Kengunte Cross	West Bangalore
21	Kengeri bus stand	East Bangalore
22	Arvind Mills	East Bangalore
23	Jnanabharathi	East Bangalore
24	Sumanahalli	West Bangalore
25	Lumbini Gardens	North Bangalore
26	Kodigehalli Cross	South Bangalore
27	Amruthalli	North Bangalore
28	Hosakerehalli	South Bangalore
29	Pallavi Dhaba in BSK	South Bangalore
30	Gubbalala Gate	South Bangalore
31	Fun World	North Bangalore
32	Amar Hotel underpass Upparpet	CBD
33	Khoday's Circle	CBD
34	Binny Mills Circle	CBD
35	City Market	CBD

Table 7: Accident Indices for Bangalore[2]

Year	Registered Vehicles	Population	Traffic violations	Total Accidents	Persons Killed	Persons Injured	F-RATE	F-Risk	AR	ASI	A-Risk	FVI
1990	628000.00	4036000.00	NA	6729	562	5677	0.89	13.92	10.71	8.35	166.72	-
1998	1129000.00	5471484.31	NA	8360	726	6358	0.64	13.27	7.40	8.68	152.79	-
2001	1473000.00	6170000.00	NA	NA	659	NA	0.45	10.68	-	-	-	-
2002	1596000.00	6333505.00	1320713	9856	820	7577	0.51	12.95	6.18	8.32	155.62	678.56
2003	1783000.00	6501342.88	1268272	10505	883	7980	0.50	13.58	5.89	8.41	161.58	628.09
2004	1950000.00	6673628.47	1097826	9101	903	6921	0.46	13.53	4.67	9.92	136.37	508.38
2005	2130000.00	6850479.62	1646687	7575	833	5899	0.39	12.16	3.56	11.00	110.58	643.99
2006	2544573.00	7032017.33	1498396	6827	809	5457	0.32	11.50	2.68	11.85	97.08	476.39

* FR- Fatality Rate
F-Risk - Fatality Risk
AR - Accident Rate
ASI - Accident Severity Index
A-Risk - Accident Risk
FVI-Fatality Violation Index