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ROAD ACCIDENT COST PREDICTION MODEL USING SYSTEMS DYNAMICS APPROACH

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Abstract. Accident costs are an important component of external costs of traffic, a substantial part is related to fatal accidents. The evaluation of fatal accident costs crucially depends on the availability of an estimate for the economic value of a statistical life. This paper aims to develop a model for road accident through systems dynamics approach. To build an accident model, various factors causing the road accident and cost were identified. This model is capable of calculating the accident rate and its costs for the future. In this study the accident caused by bus alone is considered. The cost model is dealt more in this study as it requires more complex assessment. The accident model is built on the year 2000 data and predicted the accidents up to 2020 for every 5-year interval. The accident model is valuated by comparing the predicted and actual accident data for the year 2005. Three scenarios were studied by changing the income growth rate and discount rate. Finally, best scenario is suggested for implementation. The outcome of the study is highly useful for the planners, administrators and police to make their decisions effectively for road safety investment projects.

Keywords: accident, modelling, systems dynamics, safety, accident cost.

1. Introduction

Road accidents are one of the most important problems being faced by modern societies. Apart from the humanitarian aspect of reducing road deaths and injuries in developing countries, a strong case can be made for reducing road crash deaths on economic grounds alone, as they consume massive financial resources that the countries can ill afford to lose. The deaths of persons and serious economic loss caused by road accidents demand a continuous attention in accordance with the spectacular growth in road transportation. It is now realised that better and more efficient techniques of accident information management system are required. The rapid population growth and increasing economic activities have resulted in the tremendous growth of motor vehicles. This is one of the primary factors responsible for road accidents in many metropolitan cities, including Chennai, in India. The increasing number of road accidents is imposing considerable social and economic burdens on the victims and various direct and indirect costs to individuals and government.

The automobile boom is becoming a curse in disguise by killing and injuring millions of people all over the world. Traffic on the Indian City roads has increased tremendously due to the increasing rate of urbanisation. Globalisation of the Indian economy and the improvement in economic status of the people have also induced greater impact on the transportation system. Increasing inadequacy of public transport, rising rate of vehicle ownership and migration of people to urban fringes have led to extensive use of private modes, all along the road network. The traffic movements on city roads have been compounded by frequent interruptions, resulting in drastic reduction in speed, leading to congestion and accidents.

Road accidents cause injury, death, loss of property and damages to vehicles. All these involve a monetary loss to the economy. When roads are improved, road accident rate will come down. This results in quantifiable benefits to the economy. Though the overall death rate has declined and expectation of life has gone up, the death risk on roads has considerably increased. It must of course be borne in mind that in developing and emerging nations, road safety is one of the many problems demanding its share of funding and other resources. Even within the boundaries of the transport and highway sector, hard decisions have to be taken on the resources that a country can devote to road safety. In order to assist in this decision-making process it is essential that a method be devised to determine the cost of road crashes and the value of preventing them.

Many researchers have devoted their work to the area of road accidents and traffic safety aspects. Works have been undertaken on accident characteristics, accident forecasting and better roadway and vehicular design for the improvement of road safety in different traffic and roadway conditions.

A number of studies on road safety have also been carried out in India, in different cities such as Delhi, Mumbai, Chennai and Ernakulam as well as on some highways. The notable studies include Srinivasan and Prasad (1979), Tuladhar and Justo (1981), Kadiyali *et al.* (1983), Valli and Sarkar (1997), Victor and Vasudevan (1998), Sikdar *et al.* (1999), Chand (1999), Baviskar (1999), Saija *et al.* (2000), Sing and Misra (2001), and Chakraborty *et al.* (2001). However, no significant studies have appeared on the accident trend and its cost analysis in systems dynamics approach. In this article, an accident and costing model is built which is used to forecast the future number of different types of accidents in the city and the accident cost. In the absence of accident cost data, many a time cost effectiveness technique is used instead of cost-benefit analysis. Nevertheless such analysis is not complete and can only be used in optimum allocation of safety budget and not in overall transport investment planning.

2. Road accident cost estimation

A number of alternative methodologies are available for accident cost estimation and accident reduction. Jones-Lee (1976) has summarized the different approaches and has listed the following six. The *Gross output* approach, quantifies the cost of a traffic accident as the sum of real resources cost such as vehicle damage, medical expenditure and police cost and the discounted present value of the victims future output. The *Net Output* approach subtracts the amount of the victims future consumption from the gross output value. The *Life insurance* approach treats the cost of an accident or the value of accident prevention as the sum of real resource cost and the amount for which typical individuals are willing to insure their own lives or limbs. The *Court award* approach considers the amounts awarded by the court to the surviving dependents of those killed as indicative of the cost that society associates with the fatality or the value it would have placed on its prevention. The *Implicit Public sector valuation* approach is based on the costs and values that are implicitly placed on accident prevention in safety legislation or in public sector decisions taken either in favor of or against investment programmers involving traffic safety. The *Values of risk-change* approach assumes that a typical public sector investment in traffic safety provides each individual affected with a very small reduction in the risk of involvement in a fatal accident.

The above methods substantially differ in approach and the resultant cost estimates vary to a great extent. In developed countries while the output approach generally provides moderate cost of accident, the life insurance and court award approaches provided slightly higher estimates. Implicit public sector valuation-based cost is quite low, whereas value of risk change approach gives quite high estimate of accident cost.

The estimation of accident cost is many times avoided on the grounds that it would be too difficult and controversial to determine the actual cost of an accident. Though it is agreed that precise estimation of an accident cost is quite tedious and involves elaborate procedures, it is necessary to arrive at a rough and reasonable estimate.

The important uses of accident cost are:

- to gauge the problem of accident in economic terms.
- to work out safety standards keeping in view the cost of the facility- construction vis-à-vis the value of the accidents avoided.
- to calculate the optimum level of investment / expenditure on road safety management.
- to evaluate the impact of road safety improvements in economic terms.
- to include the accident cost as a part of road user cost in road project appraisal i.e., in cost / benefit analysis of road projects.
- to work out the national loss due to accidents.

It is important to keep in view the source of cost i.e., to whom does the accident cost accrue. The cost of an accident to the victim, to the family of the victims, to the nation, to the national economy and to the society is all different. Death of a leader in an air crash may cost a future to the grieved family while the loss to the nation cannot be estimated at all. It may bring faster development, more democratic political set up or total disturbance, loss to public property and life (Mohan, 2002). Similarly the cost of social worker or a planner dying in an accident is a matter of great dispute. Dancers getting leg amputated in a road accident may lose their full career while the society may lose all the entertainment expected from the dancer.

The cost to the society is generally greater than the cost to the economy. In transportation, planning cost to the society is generally considered as a project appraisal and is carried out by using social cost-benefit analysis. The cost of accident would also differ from region to region, victim to victim and the types of the vehicles involved in the accident. Some of these factors are enumerated below.

The main objective of this paper is to build an accident and its cost model using systems dynamics approach. This model is capable of calculating the accident rate and its costs for the future. The study area, Chennai is the fourth largest city in India and 30th largest city in the world. In this study the accident caused by Metropolitan Transport Corporation bus alone is considered. The accident model is valuated by comparing the predicted and actual accident data for the year 2005. Three scenarios were studied by changing the income growth rate and discount rate. Finally, best scenario is suggested for implementation.

3. Systems dynamics and dynamo

Control theory (Gordon 1980) is concerned with understanding how the response of a system can be changed by modifying the signals occurring in the system. There are many examples outside the field of engineering in which some of instability or oscillation can occur. Business cycles cause fluctuation in the general level of economic activity. In individual industries there are similar cycles where prices and supplies fluctuate or temporarily appear to go out of control. There are also many examples in the field of biology of oscillations or explosions in populations. It seems natural to speculate on whether these phenomena can be controlled. Clearly, the precision obtained in engineering cannot be duplicated in economic or social systems. Nevertheless, insight gained from control theory can be used to analyze the systems and perhaps, suggest changes that will improve performance.

Systems dynamics is a method for studying the world around us. Unlike other scientists, who study the world by breaking it up into smaller and smaller pieces, systems dynamicists look at things as a whole. The central concept to systems dynamics is understanding how all the objects in a system interact with one another. A system can be anything from a steam engine, to a bank account, to a basketball team. The objects and people in a system interact through "feedback" loops, where a change in one variable affects other variables over time, which in turn affects the original variable, and so on. Systems dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. In fact it has been used to address practically every sort of feedback system. While the word system has been applied to all sorts of situations, feedback is the differentiating descriptor here. Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X and Y and, independently, the link between Y and X and predict how the system will behave.

The principle concern of a Systems dynamics study is to understand the forces operating in a system in order to determine their influence on the stability or growth of the system. The output of the study will, it is hoped for, suggest some reorganization or change in policy, that can solve an existing problem or guide developments away from potentially dangerous directions. It is not usually expected that a system dynamics study will produce specific numbers for redesigning a system, as occurs with engineering systems. Correspondingly, many of the coefficients in the models of systems dynamics studies consist of estimates or best guesses, particularly since the models must some times reduce such quantitative factors as personal preferences, or social tensions, to qualitative form. Nevertheless, the lack of precision that may have to be tolerated does not destroy the value of the study. The model can establish the relative effectiveness of different policies under the same assumptions, or mark out ranges of values that can be expected to produce a given type of output.

A language that was developed especially for Systems dynamics (in their original implementation as Industrial Dynamics model) is called DYNAMO: an acronym for Dynamic models. It is in particular a simple language designed for users who have little or no training in programming. Variables in DYNAMO are represented by symbols of from one to five characters, with some reserved names. The name TIME is reserved for making reference to the time in the system model. The previous instant at which calculations were made is TIME.J, just passed is called the JK interval, coming up is the KL interval. Calculations are made for uniform intervals of time, so that the JK and KL intervals are designated by the symbol DT. The size of DT is chosen by the user. Professional DYNAMO Plus is a state-of-the-art interactive simulation program that combine the results of over 30 years of programming and the power of mainframe DYNAMO with the convenience of microcomputers. The result is a modular program that provides modeling conveniences and expanded features for advanced simulation development, and enhancements in running, analyzing, reporting and publishing computer models.

4. Traffic and accident characteristics of Chennai

Chennai is the fourth largest city in India and 30th largest city in the world. The total geographical area of Chennai is more than 174 square km. and total length of the road is more than 3.5 lakhs km. The current population of Chennai is 5.9 million (59 lakhs) when compared to the population of Chennai in 2002 it is more than 35 lakhs. There has been a rapid growth of population between 2002 and 2004. The total accident that occurred in Chennai during the year 2002 is more than 10,000, from that the Metropolitan Transport Corporation bus accident is more than 1700. In the total population of Chennai 35 % of people are injured by the accident.

The observed traffic composition on roads does not reflect the percentage of vehicles registered. Though buses and autorickshaws are less in numbers compared to the total vehicles registered, their average travel distance is found to be more than that of the two-wheelers which is reflected in the observed traffic composition on the roads. The volume of traffic has increased by about 35 % to 250 % on the roads of Chennai city for the ten-year period (Gunasekaran 2003).

It is generally recognised that the accidents on urban and sub-urban roads could be due to several reasons such as the heterogeneity of traffic, the congestion created by reduced road width caused by on-street parking, heavy concentration of activity systems on the sides of the roads, direct vehicular interactions with pedestrians, wide variations in speed due to defective traffic management measures, lack of public awareness about rules and regulations in utilising the road facilities and lack of stricter enforcement measurement. In Chennai traffic accidents occur for various reasons. Poor traffic management especially in respect of the reckless driving of buses, Share auto and autorickshaws, inefficient traffic control at intersections, poor road geometrics, lack of public awareness, road users' indiscipline and inefficient movement, undefined bus stops, etc. are the major causes of road accidents.

An accurate and comprehensive system of collecting and recording accident data is required for studying the traffic accident characteristics in a city. Such data serve to identify the basic causes of accidents and to suggest ways and means for overcoming the deficiencies that lead to such accidents. In this study, the accidents due to the Metropolitan Transportation Corporation (MTC, Chennai) buses alone were considered and the data was collected from the Institute of Road Transport (IRT) for the year 2000. The time and volume of data restricted to take other types of vehicles involved in accidents. The accident data collected includes location, time, type of accident, type of area, category of road, type of injury, and detail of person killed, etc. It is observed that 80 percent of accidents occurred during peak hours in the study area.

The Accident severity index measures the seriousness of an accident. It is defined as the number of persons killed per 100 accidents. In Chennai, the Accident severity index has gradually increased from 3.02 in 1996 to 4.03 in 1999, after that the trend is not uniform. It is observed that in 2003 there was a sudden rise of fatal accidents resulting in the increase of the accident severity index. Fig. 1 represents graphically the accident severity index for the period 1996 to 2005. Accident severity index for Chennai City shows comparatively lesser values than that of Kolkata City (Chakraborty and Roy 2005) and up to 2002 data was used in their study for Kolkata.

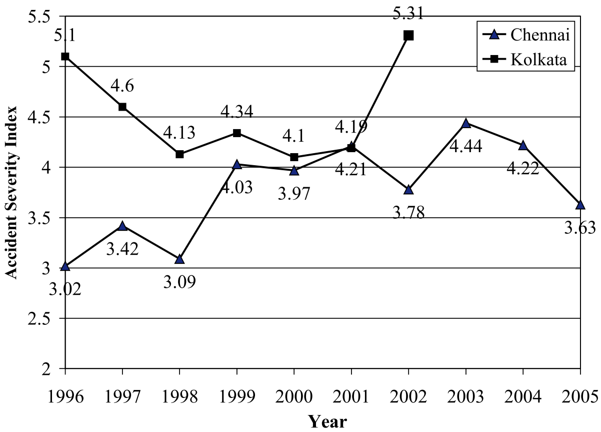

Fig. 1. Accident severity index (persons killed per 100 accidents)

The Economic loss due to traffic accidents is quite enormous apart from untold human suffering, pain and grief. Here an attempt is made to estimate objectively the economic loss caused due to traffic accidents. An estimate is made for average loss due to a fatality, a serious injury and minor injury. An objective assessment is also made for property damage to different types of vehicles. Table 1 gives the average values of factors of accident cost separately for fatalities, serious injuries and minor injuries for the year 2000.

5. Model formulations

A study on road safety includes the estimation of the number of probable accidents in the future. One of the pioneering works in this regard has been done by Smeed (1972). Jacobs and Hutchinson (1973) modified Smeed's model for the developing countries and Valli and Sarkar (1997) developed a model for India based on Smeed's approach. In this study a model developed for total accident, fatality and injury types of accidents in Chennai by applying the Systems Dynamics approach.

The average income growth rate, discount rate per annum, National value of pain, grief and suffering, average consumption per month are assumed for the model formulation. Fig. 2 shows the flow diagram of road accidents and their cost model for Tamil Nadu. The human accident cost subsystem appears at the top of the diagram, the vehicle damage cost subsystem at the bottom and the middle part shows the total cost subsystem.

A computer program has been prepared in DYNAMO language for forecasting the accidents and their costs. In this model the 2000 year data is used as base data for formulation of model. The forecasting of accidents is done by a simulation (dynamo language) and this model can be used to estimate the probable number of accidents in the future. Predicted accidents of different types are given in Fig. 3. The projected accidents are in a declining trend. There is a sudden fall in accidents from 2000 to 2005 and then it is gradually decreasing.

Table 1. Average values of factors of accident cost (1 US$ = 46 INR)

Sl. No.	Description	Average Value		
		Fatal Accident	Serious Accident	Minor Accident
1	Expectation of life (years)	60	60	60
2	Average age of accident victim (years)	30	30	30
3	Income per month (Rs.)	5 200	5 200	5 200
4	Period of loss	30 years	60 days	7 days
5	Period of hospitalization (days)	5	25	1
6	Daily hospital Expenses (Rs.)	400	350	100
7	First time payment in the hospital (Rs.)	1 000	8 000	800
8	Court related expenses (Rs.)	2 450	2 500	500
9	Administrative expenses of Police, Insurance etc., (Rs.)	3 110	3 000	400
10	Consumption per month (Rs.)	1 700	1 700	1 700

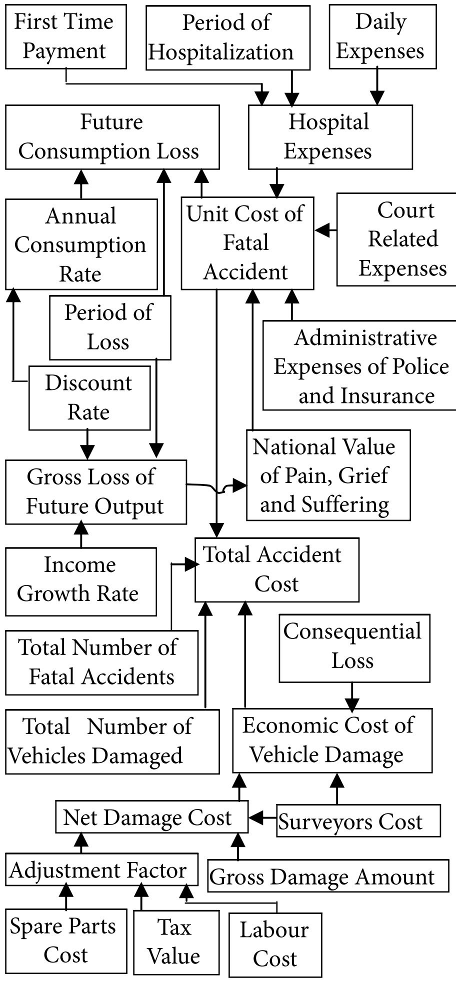

Fig. 2. Accident cost model

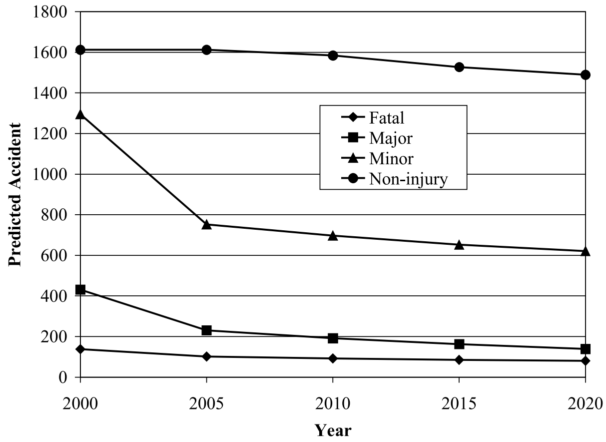

Fig. 3. Predicted accidents

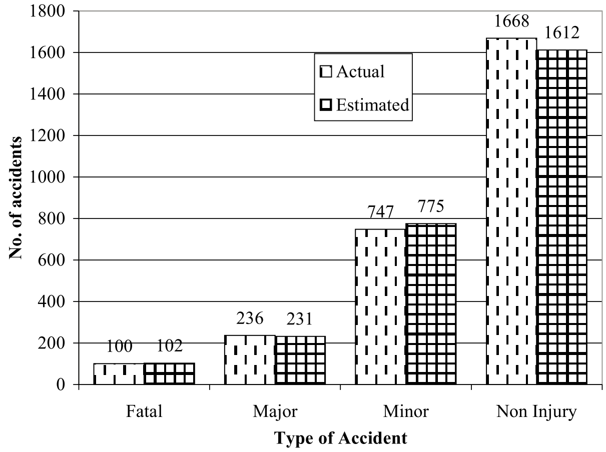

Fig. 4. Comparison of actual vs predicted accidents for the year 2005

The reason is due to the road safety measures which are followed very regressively. The fatal accident rates are decreasing gradually for the projected period. Fig. 4 represents graphical comparisons of actual and projected numbers of different types of accidents by the model for the year 2005. Predicted accidents are nearly same as those of actual accidents with variation of –3.36 % and +3.47 % and hence the predicted value using this model is very well accepted.

The following assumptions are made in the model for road accident cost estimation. These assumptions are used in India by the other studies (RUCS 1982, Chand 1995; Srinivasan 1975).

1. Average rate of growth of income is 2.45 % per annum, which is constant throughout the project period.
2. The discount rate can be taken as 12 % per annum, which is assumed constant for the next 20 years.
3. The National value of pain, grief and suffering are assumed to be 20 percentage of the gross loss of output.
4. The study is limited to Chennai City only.
5. The cost data utilized in the study are mostly from National study reports and Kerala State study report.
6. The average consumption per month is assumed to be Rs.1700.

5.1. Components of accident cost

Medical Costs include emergency transport, medical, hospital, rehabilitation, mental health, pharmaceutical, ancillary, and related treatment costs, as well as funeral/coroner expenses for fatalities and administrative costs of processing medical payments to providers. Other Resource Costs include police, fire, legal/court, and victim services (e.g., foster care, child protective services), plus the costs of property damage or loss in injury incidents. Work Loss Costs value productivity losses. They include victims lost wages and the replacement cost of lost household work, as well as fringe benefits and the administrative costs of processing compensation for lost earnings through litigation, insurance, or public welfare programs like food stamps and Supplemental Security Income (Mohan 2002). As well as victim work losses from death or permanent disability and from short-term disability, this category includes work losses by family and friends who

Table 2. Total cost of accident for scenario 1 (Rs. in Crores)

No.	Total cost of accident	Years				
		2000	2005	2010	2015	2020
1	Fatal accident	11.46	3 608.00	9 343.00	17 220.00	27 230.00
2	Serious injury accident	14.36	136.70	308.20	529.00	799.00
3	Minor injury accident	4.93	1 123.00	4 144.00	9 067.00	15 890.00
4	Buses	12.57	22.03	38.49	67.08	116.60
Total		43.32	4 889.73	13 833.69	26 883.08	44 035.60

care for sick children, travel delay for uninjured travelers that results from transportation crashes and the injuries they cause, and employer productivity losses caused by temporary or permanent worker absence. Quality of life includes the value of pain, suffering, and quality of life loss to victims and their families.

Accident cost is composed of the following components.

1. Public cost
   - Human capital cost,
   - Resource cost.
2. Private cost or human suffering cost

The above cost can be represented in the form of the following equations:

HCC – Human capital cost

– Life period lost × average output per victim

or

– (Life period lost × average output per victim) – Future consumption

or

– Value of willingness to insure the life

or

– Value of court award for accident

or

$$= E_x \times P - E_x \times C, \quad (1)$$

where E_x = Expectation of life at age x ; x being the average age of accident victim; P = Productivity at age x; C = Consumption at age x; RC = Resource cost = (Damage to roads + Damage to vehicle + Court overheads + Medical expenditure and overheads + Police overheads + other incidental expenses); HSC = Human Suffering cost, a national value based on value judgment.

$$Accident\ cost = HCC + RC + HSC. \quad (2)$$

GD = Average gross damage amount paid to the accident victim by the insurance company; ND = Average net damage amount for particular type of vehicle = $GD\text{-}SPC$; AF = Adjustment factor for ND.

Damage amount paid include the cost of spare parts and labor charges. Cost of spare parts has tax component, which has to be excluded to arrive at economic cost. Thus, if SPC is the Spare Parts Cost exclusive of taxes, T is the Tax components and LC is the Labor Cost, then

$$AF = \frac{SPC + LC}{SPC + T + LC}. \quad (3)$$

Values of AF for different vehicles have been computed from the data collected from automobile dealers.

CL = Consequential losses after accident: the vehicle remains idle and is not used for commercial purposes. Goods in the vehicle may get spoiled and vehicle may undergo further damages. Insurance companies do not cover these consequential losses. It was estimated that consequential loss may amount to 40 % of the gross damages amount paid by insurance companies.

EC – Economic cost of damage to the particular type of vehicle.

$$EC = ND \times AF + SC + CL. \quad (4)$$

Accident cost is a complex problem covering various domains of socio-economic, political, legal, medical and administrative features. The systems dynamics in its extensive forms can take all these aspects. However the model suggested in this study is a sample form to analysis of road accident costs. Many assumptions have also been made in this study. Most crucial issue in the accident cost estimation is non availability of data and the cost factors are not static. The cost factors like annual income of victims and the value of money are changing day by day. In this study both the factors have been considered. Three scenarios have been tested and results are obtained;

- SCENARIO 1 – do nothing,
- SCENARIO 2 – increased annual income growth rate,
- SCENARIO 3 – increased discount rate per annum.

5.2. Do nothing scenario (Scenario 1)

Do nothing scenario refers to the condition of annual income of accident victims and discount rate per annum for the model in the year 2000 that are continued in the same trend without any alteration. Table 2 gives the output obtained for the do nothing scenario. The total cost of accident for the base year is Rs. 43.32 crores. There is a sudden increase in the total cost of accident for the year 2005, it increased suddenly 112 times comparing to the year 2000. Even though that the accident rates are decreasing for the year 2005 but the cost is increasing. This rise is due to changes in the country's economic policy, developments in the information and technology and income growth rate of the people. The total cost for the years 2010, 2015 and 2020 are increasing 2.8, 1.9, 1.6 times respectively comparing to the years 2005, 2010 and 2015. This trend is due to assuming that the present condition will continue throughout the study period.

Table 3. Total cost of accident for scenario 2 (Rs. in Crores)

No.	Total cost of accident	Years				
		2000	2005	2010	2015	2020
1	Fatal accident	11.46	3 608.00	9 541.00	17 490.00	27 550.00
2	Serious injury accident	14.36	136.70	308.10	528.80	798.80
3	Minor injury accident	4.93	1 123.00	4 141.00	9 062.00	15 890.00
4	Buses	12.57	22.03	38.49	67.08	116.60
Total		43.32	4 889.73	14 028.59	27 147.88	44 355.4

Table 4. Total cost of accident for scenario 3 (Rs. in Crores)

No.	Total cost of accident	Years				
		2000	2005	2010	2015	2020
1	Fatal accident	11.46	3 608.00	8 788.00	16 460.00	26 330.00
2	Serious injury accident	14.36	136.70	308.00	528.70	798.60
3	Minor injury accident	4.93	1 123.00	4 138.00	9 057.00	15 880.00
4	Buses	12.57	22.03	33.69	57.85	100.60
Total		43.32	4 889.73	13 267.69	26 103.55	43 109.2

Table 5. Total cost comparison under different scenarios (Rs. in Crores)

Scenarios compared	2010	2015	2020
1 and 2	196.31	216.92	314.4
1 and 3	–566.00	–779.53	73.60
2 and 3	762.31	996.45	240.8

5.3. Increased annual income growth rate scenario (Scenario 2)

This scenario pertains to increased income growth rate for the years 2010 and 2015. From this factor, one would expect higher accident cost. Since, the gross loss of future output is increased by the income growth rate; this policy would be in line with the policy of the Government. The Government intends to improve the quality of life of the people by increasing the monthly salaries. This income growth results in higher accident cost. Under this scenario income growth rate per annum is increased by 2.75 % in the year 2010 and by 3 % in the year 2015. These results are presented in Table 3. Due to increase in income growth from 2010 and 2015 the total cost of accident also increases. It is observed that the total cost of accident increases for the years 2010, 2015 and 2020, respectively Rs. 196.31, 216.92 and 314.4 crores compared to the scenario 1 (Refer to Table 5). While comparing the changes of the year 2015 to 2020 the result is due to increase in the income growth for the year 2015.

5.4. Increased discount rate per annum scenario (Scenario 3)

This scenario pertains to increased discount rate per annum for the year 2010 and 2015. Increase in the discount rate will reduce the accident cost, since the higher discount rate has an effect on the value of money. This policy would be in line with the inflation rate of our economy. Under this scenario, discount rate per annum is increased by 13 % in the year 2010 and by 14 % in the year 2015. The result obtained under this scenario is given in Table 4. The total cost of accident is decreasing under this scenario as compared to scenario for the years 2010 and 2015, whereas the total cost is increasing for the year 2020. The total cost comparison of the above three scenarios with different combinations is presented in Table 5. Scenarios 2 and 3 were compared and it is found that the total cost differences are very high. The difference in the total cost of accident reached its peak for the year 2015 due to both increase in income growth rate and discount rate. In reality these two factors will change based on the particular country policy decisions on economy and other Governmental policies.

6. Conclusions

The fast changing nature of information technology compels us to break with conventional methods of data manipulation. Road accident information is usually available in the form of tables and charts which are accessed by laboriously searching different registers. Even then the data retrieved may not be comprehensive and at times the relevance of a certain set of data items may be lost by the time it is retrieved.

Cost of accident is an important parameter in the economic appraisal of transportation projects. Even though there are several methods of calculating the accident costs the choice of a particular method primarily depends on the objectives of the intended project and largely on national objectives. In India, very few studies have been carried out on the subject and the studies already undertaken lacked in area coverage and precise cost estimation. International analysis showed a high degree of variation in cost of accidents. It is felt necessary to carry out detailed accident cost studies for Chennai city. Accident cost needs to be estimated for urban and rural areas separately.

Three scenarios were analysed to predict the future accident cost estimation by considering income growth and discount rate per annum. It is found that the combined changes in income growth and discount rate per annum results in higher total accident cost.

In this study, a special factor has been considered while calculating the future loss of accident victims. This is also known as future consumption value, i.e. a person would have consumed if he had lived, that has been deducted from the accident costs. In the earlier studies this factor was not taken into consideration. No longer will planners have to struggle through stacks of registers to access information. The portability of data and the ability to incorporate changes and modification in the existing databases make the system a desirable tool for planners and administrators. The following are the recommendations based on the results of this study:

1. The Government should allocate more funds for laying well-conditioned roads and for repair works to the road.
2. The enforcement of rules and regulations should be improved and strictly enforced by forming safety councils.
3. License issuing system can be modified. Training should be made compulsory for those who want a license.
4. Vehicles should be maintained in good condition, fitness certificate must be periodical and should be strictly verified.
5. Accident awareness programs may be conducted by the insurance agencies.
6. Medical facilities should be made available to the accident victim by providing medical centers on highways at regular intervals.

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