Accident Prediction Model: A Comparison of Conventional And Advanced Modeling Methods

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***Abstract*—Primary objective of any transportation infrastructure is to facilitate mobility and accidents pose an unwarranted by products of the system, which need to be controlled in order to achieve the objective. Especially in India, there is a need to do a lot more to minimize the number of accidents. According to National Crime Records Bureau (NCRB) report, 51 cases of road accidents took place every one hour during 2014.In the above back drop of the accidents scenario it is imperative to reduce the level of road accidents through some sort of advanced methodology since the conventional methods lack to prevent the accident occurrences and reduce the severity. Hence, system dynamic (SD) model and conventional model were compared to establish the inadequacy in conventional modeling ensure Road Safety through accurate accident prediction.**

Keywords*— *Accident Prediction, System Dynamic (SD) Model, Conventional Model, Road Safety.

I. INTRODUCTION

Transport Sector in India is a very extensive system, comprising different modes of transport like roads, railways, aviation, inland waterways, and shipping that facilitates easy and efficient conveyance of goods and people across the country. The backbone of economic development of India depends on its transportation. Road Transport is the primary mode of transport, which plays an important role in conveyance of goods and passengers and linking the centers of production, consumption, and distribution. An efficient transport system is a pre- requisite for sustained economic development. It plays a significant role in promoting national integration, which is particularly important in a large country like India.

According to National Crime Records Bureau (NCRB) reports, during 2014 a total of 4,50,898 cases of Road Accidents were reported which rendered 4,77,731 persons injured and 1,41, 526 deaths. Deaths due to Road Accidents in the country have increased by 2.9% during 2014 (1,41,526) over 2013 (1,37,423). In Tamil Nadu, 67250 cases has been reported out of those 15190 were fatalities. The maximum fatalities in traffic accidents was reported in Delhi City (2,199 deaths) followed by Chennai (1,046 deaths) and Jaipur (844 deaths). [5]

II. OBJECTIVES

- To review various accidents prediction models established earlier locally and globally.
- To develop mathematical and simulation model for accident prediction and establish the inadequacy in conventional modeling.
- To suggest appropriate preventive measures to reduce the number of accidents through accident prediction to ensure road safety.

III. METHODOLOGY

The flow chart of this study has shown in Fig.1. The literature regarding various accident prediction models has been studied. Then, data related for model has been collected from various sources and the study stretch has been selected. Model was formulated in both conventional and system dynamic model. For conventional model, Smeed's formula and for SD model, STELLA software has been used. Various scenarios analysis like Do minimum scenario, Partial scenario and Desirable scenario has been developed.

IV. DATA COLLECTION

The accident data has been collected and analyzed for observing the current trend of accidents in India. The secondary data are collected from various sources like Population census, NCRB, MORTH (Ministry of Road Transport and Highways), etc. The secondary data collected includes details like total number of accidents and registered motor vehicles in India. [6, 7, 8, 9]

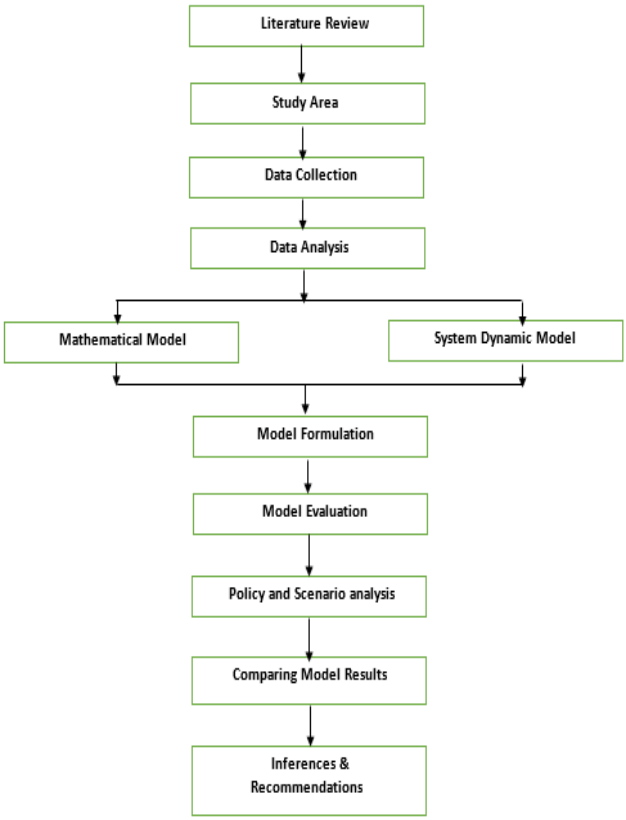

Fig .1. Methodology of the study

MODEL DEVELOPMENT

A. *Smeed's Model*

Smeed's examined the relationship on a number of Road fatalities with those of motor vehicles and the populations of 20 countries in 1938 in the following form

$$D / N = 0.0003 (N / P)^{-0.67}$$

Where D, N, P are deaths, motor vehicles, and population respectively.

P. Pramada Valli (2004), [1] the regression analysis was carried out using Smeed's model for the years (1970-2001) for india following equations are derived:

$$C / N = 0.0008 (N / P)^{-0.75} \quad (1)$$

$$F / N = 0.0003 (N / P)^{-0.58} \quad (2)$$

$$I / N = 0.0014 (N / P)^{-0.57} \quad (3)$$

In this study, development of relationships among the parameters namely road accidents, the number of registered motor vehicles and population. [4]

where C/N = Number of total accidents

Where **C/N** = Number of total accidents per vehicular population, **F/N** = Number of fatalities per vehicular population, **I/N** = Number of injuries per vehicular population and **N/P** = Number of registered motor vehicles per population.

B. . *System Dynamic Model*

It is a methodology whereby complex, dynamic, and nonlinear interactions in social systems can be understood and analyzed and new structures and policies can be designed to improve the system behavior.

The Road Accident model has been developed in this study, using the System Dynamics Simulation Software "STELLA". The STELLA is object oriented simulation software, which allows the development of any complex, dynamic and nonlinear systems with significantly less effort than using traditional programming languages. It has a user-friendly graphical interface and supports modular program development. [2]

The system dynamics modeling tool has four basic building blocks.

- Stocks or levels are used to represent anything that accumulates.
- Flows or rates represent activities that increase and decrease stocks. An example of flow includes birth rate or death rate.
- Connectors are used to establish the relationship among variables in the model, which is represented as arrows graphically in the model. They carry information, which can be a quantity, constants, an algebraic relationship, or a graphical relationship.
- Converters transform input into output. Converters can accept input in the form of algebraic relationships, graphs, and Tables.

Fig .2. Represents flow diagramming symbols, which are used in System Dynamics.

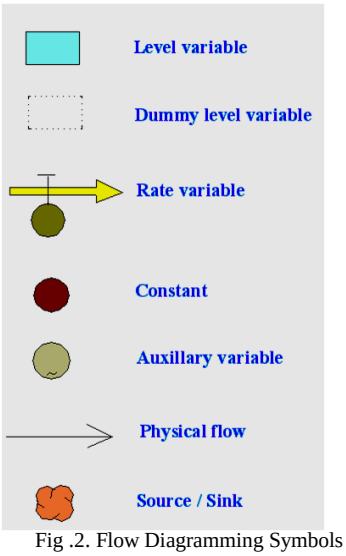

Fig .2. Flow Diagramming Symbols

V. DATA ANALYSIS

In this work SD model for human population and vehicle population were developed as shown in Fig 3 and 4 respectively. First, growth rate of human and vehicle population of previous years were obtained. Based on this trend, populations has been predicted. For both population, 2011 was taken as base year value. Then it has predicted up to horizon year 2020.

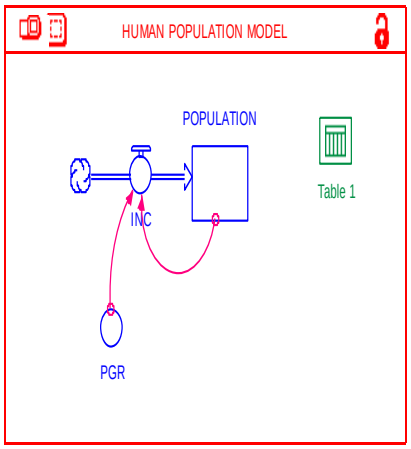

Fig .3. Model for Human Population

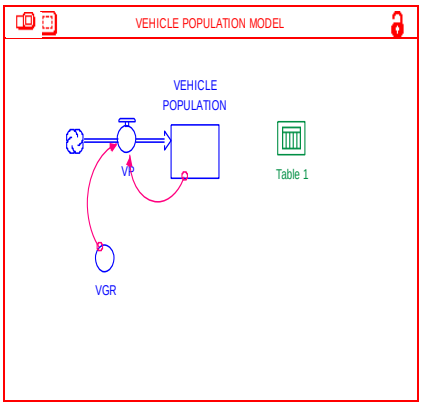

Fig .4. Model for Vehicle Population

The accident model is similar to above Population model and accident has been predicted with existing trends. This is also called as "Do minimum Scenario". Developed accident model as illustrated in Fig 5

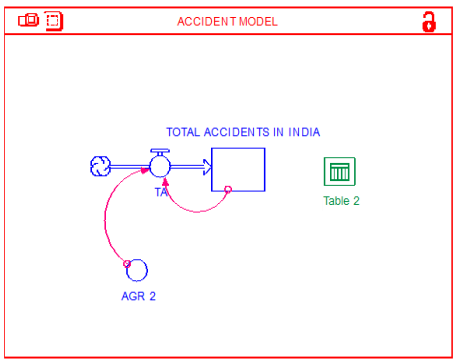

Fig .5.Accident Model for India

Years	Population	Vehicle Population
2011	1,210,193,422	141,866,000
2012	1,230,040,594	155,967,480
2013	1,250,213,260	171,470,648
2014	1,270,716,757	188,514,830
2015	1,291,556,512	207,253,205
2016	1,312,738,039	227,854,173
2017	1,334,266,943	250,502,878
2018	1,356,148,921	275,402,864
2019	1,378,389,763	302,777,909
2020	1,400,995,355	332,874,033

TABLE 1. PREDICTED HUMAN POPULATION AND VEHICLE POPULATION FOR INDIA

Years	Population	Vehicle Population	Total Accidents in Smeed's Model	Total Accidents in SD Model
2011	1,210,193,422	141,866,000	566,501	497,686
2012	1,230,040,594	155,967,480	587,203	508,137
2013	1,250,213,260	171,470,648	608,661	518,808
2014	1,270,716,757	188,514,830	630,903	529,703
2015	1,291,556,512	207,253,205	653,959	540,827
2016	1,312,738,039	227,854,173	677,857	552,184
2017	1,334,266,943	250,502,878	702,628	563,780
2018	1,356,148,921	275,402,864	728,304	575,620
2019	1,378,389,763	302,777,909	754,918	587,708
2020	1,400,995,355	332,874,033	782,506	600,050

TABLE 2. PREDICTED ACCIDENTS FOR INDIA IN SMEED'S MODEL AND SD MODEL

VI. PREDICTED ROAD ACCIDENTS

Total accidents increased from 566,501 to 782,506 in Smeed's model and 497,686 to 600,050 in system dynamic model during 2011 to 2020 as shown in Table II

VII. COMPARISON OF CONVENTIONAL AND SYSTEM DYNAMICS (SD) MODEL

After the total accidents has been predicted in both models, predicted values are compared with existing values, which is given in government records. Comparison of Smeed's and Stella model with total accidents for India as given in Table III. Percentage difference in Smeed's model is 19.74 % whereas Stella model 3.62% in the year 2012. So comparing both models, SD has accurate results when compared to Conventional model.

Years	Total Accidents in Smeed's Model	Total Accidents inSD Model	Total Accidents	% Differences in Smeed's Model	% Differences in SD Model
2012	587,203	508,137	490,383	19.74	3.62
2013	608,661	518,808	486,476	25.11	6.64

TABLE 3. COMPARISON OF CONVENTIONAL AND SYSTEM DYNAMICS (SD) MODEL

VIII. SCENARIO ANALYSIS

Scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes. There are three types of scenarios. They are Do minimum scenario, Partial scenario and Desirable scenario.

A. Partial Scenario

Partial Scenario Here the values of total accidents getting reduced when compared to do minimum scenario. This is done by providing training to drivers, create awareness among peoples and enforcement of rules. In Fig 5 depicts that enforcement and training are outflow. Table shows that the Partial scenario total number of accidents in 2020 was 277,084 which is less when compared to do minimum scenario.

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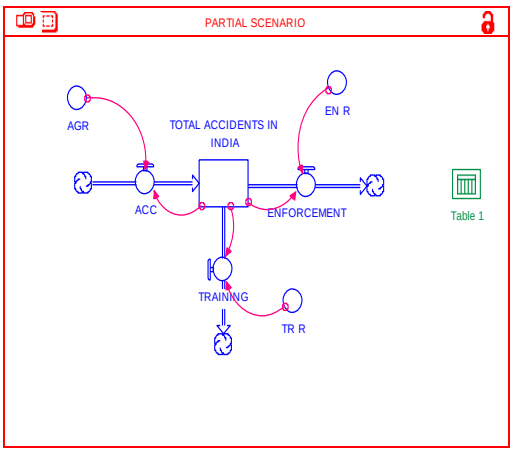

Fig .6. Partial Scenario Model

C. Desirable Scenario

In the "Desirable Scenario" has done to calibrate the model to achieve nil/ very minimum accidents in the future years. The Desirable scenario achieves an accident reduction in the horizon year 2020, which is in 148,101 numbers when compared to do minimum scenario. Here also accidents was reduced by providing training to drivers and enforcement of rules but efforts taken to achieve this will be more when compare to Dominium and Partial Scenarios. The results of all scenarios are consolidated and tabulated in Table IV

IX. RESULTS AND INFERENCE

- The total number of predicted accidents had been developed from Smeed's Model as well as System Dynamic Model for the years 2011 to 2020.
- It shows that System Dynamic Model gives accurate results.
- System Dynamic model can be used to perform any scenario whereas Conventional model is cumbersome to perform scenario like partial and desirable scenario.
- Comparing both System Dynamic and Conventional models, SD is the best and accurate Model.

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