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Creation and Data Analysis of Women Safety Index of Delhi and It's Neighbouring Cities

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Abstract: ***The objective of this study is to create a women safety index for measuring the safety of women in pilot cities and use this for the comparative assessment of five cities i.e. Delhi, Gurgaon, Faridabad, Jaipur, Ghaziabad in terms of the safety for women to travel in public places. This study has focused on searching relevant papers and urban mobility plan in order to understand urban infrastructure topic. Various statistical techniques are used to analyse different parameters like transport, security and infrastructure to provide a standardised, quantitative and transparent measure for ranking all cities. The result based on analysis indicates that Delhi performed best on all parameters while Ghaziabad is the least ranking city. But, cities like Jaipur, Faridabad and Gurgaon do poorly on some dimensions but very well on others. Moreover, results from simple linear regression shows that police strength has significant impact on reducing crime rate in Delhi. The results from the research gives us some hints to assist policy makers, Urban local bodies, Municipalities and local authorities to improve women safety in urban cities***.

Index Terms: Data association, multi-model filter, bearing-only tracking, passive sensor, targets

I. INTRODUCTION

Urbanising is a world-wide phenomenon. India is also witnessing the faster rate of urbanization. In 2017, 33.54% [1] of total population in India resides in cities and projected to add 300 million [2] new urban residents by 2050. However, the Indian government is facilitating this rate of urbanization by improving infrastructure, connectivity, security, safety and governance issues etc. Although India has embarked upon certain ambitious projects like 'Smart City' initiative to reorganise its cities but still no provisions have been made to prioritise specific measures for women safety. In 2017 Indian Government has announced 20% [3] hike in the budget allocation for women and child welfare. But as per NCBR the crime data reflects that Government is not able to provide sense of security to its female citizens.

According to 2016 [1] crime statistics the rate of crime recorded against women (crimes per 100,000 female population) was 55.2 increase from 41.7 in 2012.In last decade in India 2.5 million crimes against female population have been reported. The year 2016 has seen 83% rise in reported crime cases against women from 0.185 million in 2007 to 0.338 million in 2016. Under the Indian Penal Code, Delhi alone records 1.73 lakh incidence of cognizable crimes among other 53 Indian mega cities. This corresponds to 25.72% of total 676086 cases in these 53 cities. Even though Delhi is the national capital but it still holds the label of being highly unsafe for women population. In 2016 there were total 13803 recorded crime cases against women.

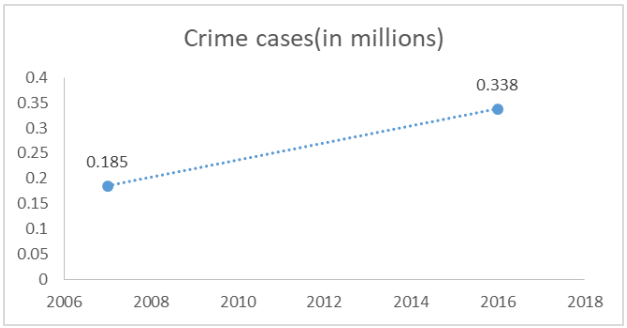

Figure 1: Increase in the number of Crime cases (in millions)

Global indices are a way to assess national progress and these are increasingly popular as they can distil complex information into a single number. These numbers are highly comparable and can call out low performers and help to reinforce good performers. Yet, women safety index is restricted to parameters like infrastructure, transport and security. These are important aspects related to women safety nowadays. The overall objective is to create safety index for women. Subsequently, simple regression model is used to predict the women safety for Delhi city.

II. METHODOLOGY

This deals with the creation of a robust women safety index for measuring the safety of women in a pilot region/city and use this for the comparative assessment for pilot cities in terms of the safety for women to travel in public spaces. The index captures the most important aspects of women safety thus, it is measure capturing three basic dimensions: transport (availability, waiting time, bus stop spacing), Infrastructure (availability of lighting, footpath width) and security (police personnel density, CCTV in public places). The index and its 8 indicators (Table 1), grouped into three dimensions, provide a standardized, quantitative, and transparent measure for ranking all cities.

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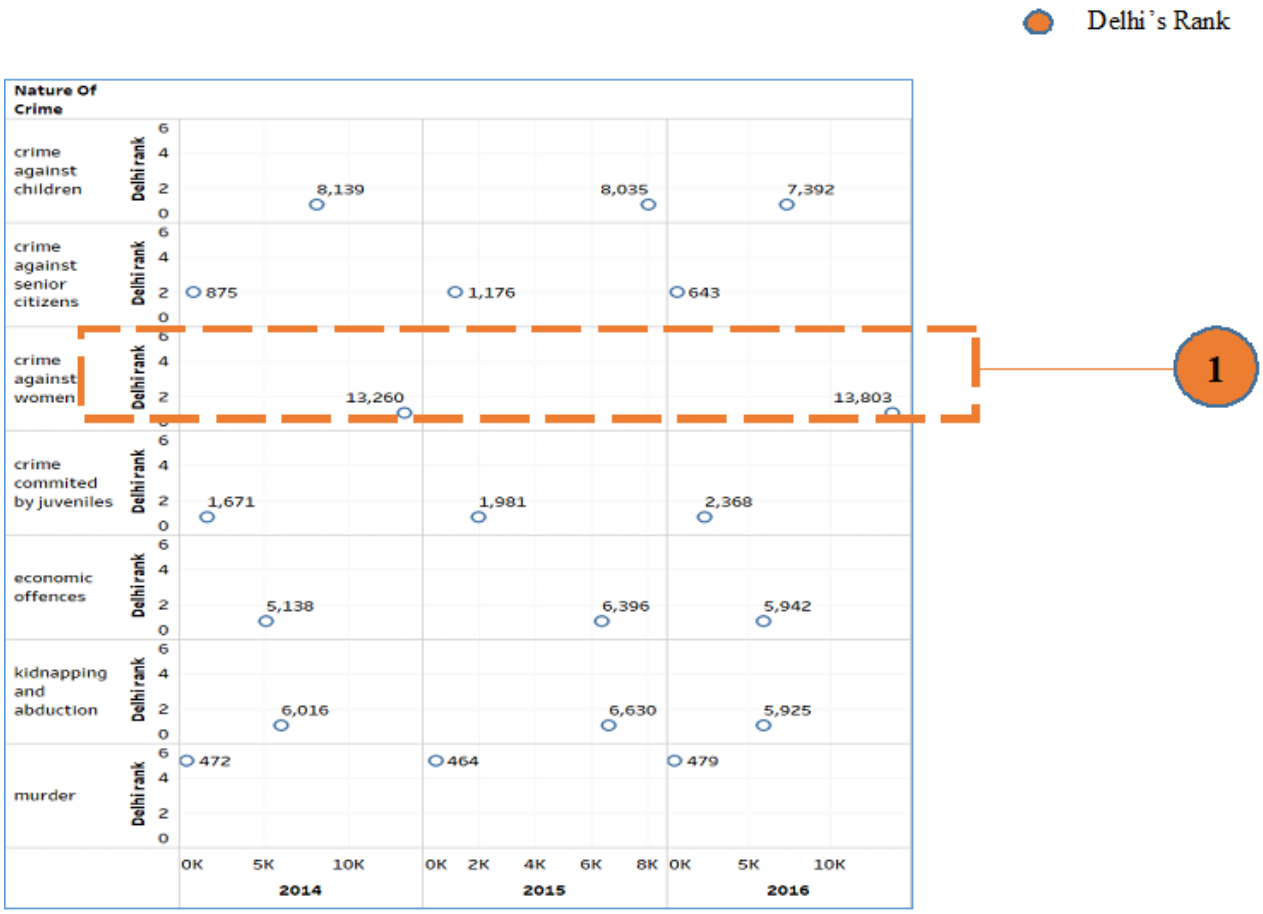


Figure 2: Delhi's Rank in Nature of Crime Over the Years

TABLE1: INDICATORS FOR WOMEN SAFETY INDEX

SNO.	Dimension and Indicator	Definition
1.	**Transport**	
1.1	Bus Availability	Presence of public transport in urban areas per 1000 population
1.2	Bus waiting Time	Average waiting time for public transport users(minutes)
1.3	Bus stop spacing	Spacing between two bus stops
2	**Infrastructure**	
2.1	Availability of lighting	Measures the amount of brightness / illumination at a place
2.2	Footpath width	Refers to the width of the footpath (width=10m) alongside road
3	**Security**	
3.1	Police personnel density	No. of security personnel available per 1000 population
3.2	CCTV availability	No. of buses with CCTV cameras installed
3.3	Women police personnel	No. of women police personnel per 1000 population

A. *Creation of Index*

The information on current operating status of all parameters such as infrastructure, transport and security were collated and index was created using two basic steps - Normalization and Aggregation.

Normalization - This makes the data comparable across different indicators to combine the information in the meaningful way. Indicators are normalized using below formula:

$$Indicator\ score = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

Aggregation: It is done to give equal weights to each of the three dimensions in the index. This proceeded in two steps:

1. Normalized variables were aggregated for each dimension and then aggregated across the three dimensions of the index. Then, the arithmetic mean was used to aggregate indicator scores within each dimension.
2. To ensure that all the three dimensions are equally important and that the cities are expected to perform well on each dimension, geometric mean was used to aggregate the dimension sub-indices into overall safety index

$$Safety\ Index = \sqrt[3]{T} \times \sqrt[3]{I} \times \sqrt[3]{S}$$

Where,

T = Transport sub-index;

I = Infrastructure sub-index; and

S = Security sub-index

$$T = \frac{BA + WT + BS}{3}$$

Where,

BA = Bus availability;

WT= Waiting time;

BS = Waiting time

$$I = \frac{FW + LA}{2}$$

Where,

FW=Footpath width;

LA = lighting availability

$$S = \frac{PD + WP + NB}{3}$$

Where,

PD = police personnel density;

WP = women police personnel;

NB = no. of buses with installed CCTV

III. Findings and Analysis

Referring to analysis cities were ranked on the women safety index and its indicators. The ranking reveals that some cities are good performer while others are not. We have highlighted the top and bottom performers on various indicators

A. *Women Safety Index Score and Ranking*

The index in Table 2 displays the overall standing of various cities standing from the top (Delhi with index score – 0.96) through bottom (Ghaziabad with index score -0.04). The above figure also shows the relative performance of 5 cities across different subset-good, average, poor. However, some cities performed best on one parameter but not on other parameter.

Table 2: Women Safety Index and Ranking

Rank	City	Overall Index	Transport sub index	Infrastructure sub-index	Security sub-index
1	Delhi	0.96	1	1	0.9
2	Gurgaon	0.53	0.38	0	0.73
3	Jaipur	0.28	0.34	0.16	0.4
4	Faridabad	0.22	0.29	0.08	0.52
5	Ghaziabad	0.04	0.15	0	0.32

Top performing city on overall index parameters

Worst performing city on overall index parameters

The index displays the overall standing of various cities standing from the top (Delhi with index score – 0.96) through bottom (Ghaziabad with index score -0.04). The above figure also shows the relative performance of 5 cities across different subset-good, average, poor. However, some cities performed best on one parameter but not on other parameter.

B. *Best and worst performing cities*

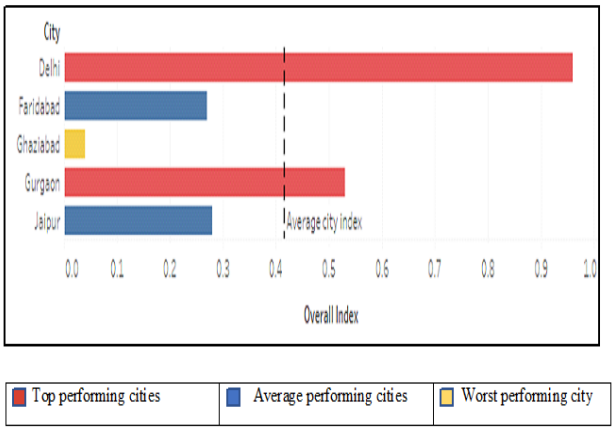


Figure 3: Best and Worst performing cities

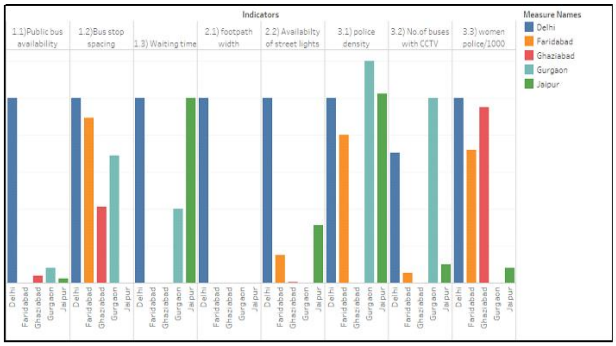


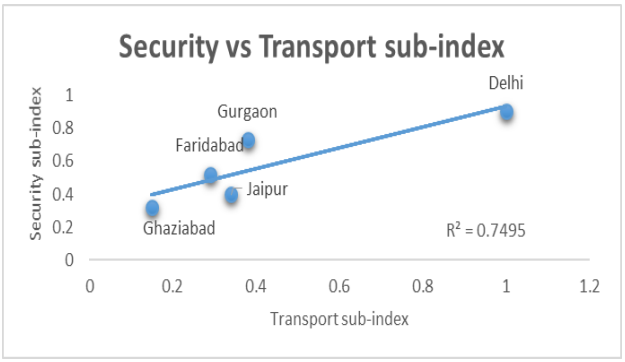
Figure 4: City performance across different parameters of index

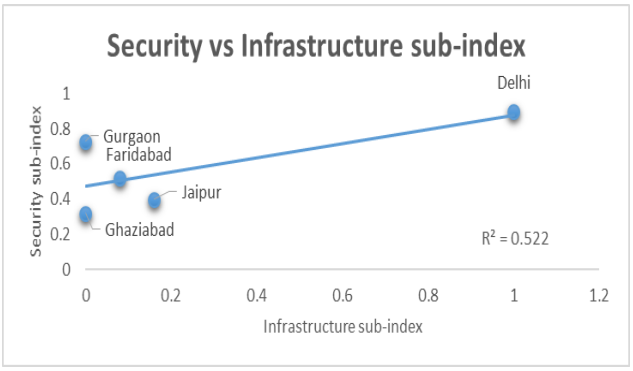
Figure 3 and 4 reflects the performance of 5 cities on various dimensions. Delhi tops the list with the best transport parameter (public bus availability, bus stop spacing and bus waiting time), infrastructure (footpath width, availability of streetlights) and security (police density, no. of buses with cctv and women police strength) among other cities.

Gurgaon is also classified as top performer after Delhi. Gurgaon performs best on transport and security sub index while do badly on infrastructure sub-index. The city lacks availability of public transport but on other hand performs best on the bus waiting time for the available transport comparable to Delhi. Gurgaon possess excellent scores on police density while least score on the availability of women police per 1000 population of the city. This suggest enrolment of more women police to make women of the city feel safer. The city also performs badly on infrastructure front with non-availability of street lights and footpath width much below the city benchmark. The city must focus on the infrastructure development in order to reduce crime rate against women in the city. Jaipur and Faridabad are both comparable to each other on the overall safety index. Both the cities perform best on security sub-index which ensures security is well managed to provide safety to women. But, both lack on infrastructure parameter with inadequate foot path with far below the city benchmark and scanty lit roads. Footpath in these cities are highly encroached which reduces its usable width that is unsafe for women to walk freely on roads. Jaipur performs 5% higher on transport sub-index than Faridabad. Faridabad lacks availability of public buses and there are only 150 buses per 1000 population. This drives our focus to augment city bus system to increase safety within the city. Ghaziabad performed poorly on multiple fronts especially on infrastructure and transport sub-index. The city needs to strengthen its public bus transport system and availability of street lights in order to make city safe for women.

C. *Statistical Analysis – Correlation between dimensions*

The safety index allows us to investigate correlations at the city level between pairs of dimensions (figure 5). Cities in the upper right quadrant in the three panels in figure 6 have higher levels of achievement on both dimensions, whereas cities in bottom left quadrant have lower levels of achievements. While, the general tendency is that all three dimensions are positively associated with each other as indicated by upward sloping fitted line in each panel. Delhi is in top right quadrant in all the three panels representing positive associations between all dimensions. This reflects that in Delhi all the dimensions considered above are important parameters to ensure safety in Delhi. But, in city for example Ghaziabad is the least ranking cities on security, transport and infrastructure. While cities like Jaipur, Faridabad and Gurgaon shows striking variations around the best fitted line indicating these cities do poorly on some dimensions but very well on others.





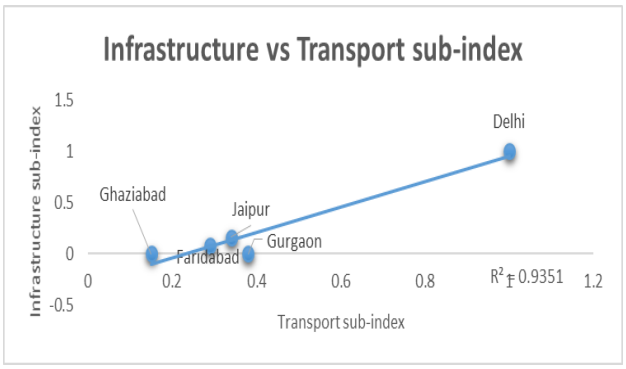


Figure 5: Positive correlations between dimensions

IV. DISCUSSIONS IN TERMS OF SIMPLE REGRESSION ANALYSIS

In order to make the discussion on the relation between the chosen parameters and crime against women in detail we perform regression analysis. From the above discussion we found that Delhi performed well on all parameters especially Transport and Infrastructure but slightly less on security parameter. Thus, we conclude that there is no further requirement to improve chosen sub-parameters of transport and infrastructure to make the city safe. So, our focus is shifted to improve security parameter in order to improve safety. Here, we will consider factor police strength per 1000 inhabitants to predict its impact on crime cases per 1000 population in the city.

The primary hypothesis relates to the correlation of police strength in the city and crime cases in the city. Ho: There is a negative relationship between police strength and crime cases which means as police strength increases in the city the crime case in the city decreases. H1: Police strength has a positive relationship with the crime cases in the city The results of Simple linear regression analysis between police strength per 1000 inhabitants and crime cases per 1000 inhabitants of the city are in fourteen years are summarised in table 4. The result showed adjusted R2 value to be - 0.075 and p value to be 0.7693. So, the prediction equation as is follows

$$Y = -1.8710 - 0.2294X$$

Where, Y: No. of crime cases per 1000 inhabitants of the city
X: police strength per 1000 inhabitants of the city

TABLE 3: SIMPLE REGRESSION ANALYSIS

Coefficients	Estimate Std.	Error t value	Pr (>|t|)
Intercept	-1.8710	1.0757	0.108
Police strength	-0.2294	0.7646	0.769

Since the p value > 0.05 so our null hypothesis is accepted and hence concluded that as police strength is increased by 1 unit the crime cases reduces by 0.2294 units but the model R2 value is too less for a model to be accurate. This calls for additional crimogenic factors which impact crime to be included in our model to make it robust. This paper limits the availability of data and time span for the consideration of additional parameters.

V. CONCLUSION

The Women Safety Index is a pilot project which could assist change agents, policy makers, NGOs, Urban Local Bodies, Municipalities, Public Works Department (PWD), State Transport Authorities, Police and Emergency Response officials in the improvement of women safety in the cities. The index uses data sources from trustworthy sources like urban mobility plan of the city. For creation of index the data are then normalized and aggregated. The 8 indicators are equally weighed and combined into 3 dimensions using athematic mean. The three dimensions are combined using geometric mean which rewards the simultaneous improvement of all drivers over the improvement of one at the expense of another. The index is a relative measure of women safety that includes transport, infrastructure and security. Five cities are scored using the index with the range of scores between 0-100. Delhi is ranked first on the safety index and performed well on all the dimensions followed by the Gurgaon city whereas Ghaziabad performed least on the women safety index. This study also focuses on Delhi to improve women safety by applying simple regression analysis to predict safety in Delhi. A remarkable conclusion can be drawn that the "police strength" has significantly positive impact on reducing crime in the city. The future scope of this project can be extended to highlight the areas for improvements, weaknesses in women safety interventions that can be shared with the various stakeholders helping them to make future decisions about transport, infrastructure and security to ensure proper safety in the cities.

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