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A Study of Correlating Factors for Various Crimes in Delhi through Remote Sensing and GIS

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Abstract: ***A crime is an illegal act that can be punished by a state or authority. The word "crime" comes from a Latin root meaning "I decide" or "give judgment". Crime can involve violence, sex or drugs but also discrimination, road rage, undeclared work and burglary. Crime is any behaviour and any act, activity or event that is punishable by law. The objective of this study is to provide the meaningful insights using Remote Sensing Technology and GIS. There are always some favourable factors which help successful execution of crimes. Nighttime imagery in remote sensing, particularly from satellites, can be used to analyse crime patterns in India by providing insights into areas with higher human activity at night, which can be correlated with potential crime hotspots, allowing law enforcement to focus patrols and preventative measures in those locations; essentially, areas with brighter nighttime lights on satellite imagery may indicate higher crime risk due to increased population movement after dark. The in - situ data for the period 2011 - 2021 from official website of Delhi Crime Records have been analysed. The data were mapped on Google Earth Engine and Google Earth Pro after preparing FeatureCollection. A graphical representation was also made on GEE to understand the pattern of crimes. The correlation of Average DNB radiance values, population density, percent tree cover, building volume, non - residential building volume, NDVI and population age has been established with each type of crime. Further, a joint correlation of crimes with said properties divulged a very clear picture about the crimes, area of crimes, hot spots etc.***

Keywords: Remote Sensing, GIS, Nighttime, percent tree cover, Correlation, Geospatial mapping etc.

1. Introduction

Crime has been an enduring element of human society, challenging social norms, structures, and legal boundaries throughout history. The question of why individuals commit crimes and the underlying motivations has led to the development of various criminological theories. Each theory attempts to explain the causes of criminal behaviour from distinct perspectives, encompassing psychological, social, biological, and economic factors. Low self - control is an important predictor of crime and of "analogous behaviours. " (TRAVIS C. PRATT, FRANCIS T. CULLEN, **https: //doi. org/10.1111/j.1745 - 9125.2000. tb00911. x**)

Meaning of Theories of Crime and Criminal Behaviour
Theories of crime and criminal behaviour aim to explain why individuals commit crimes, offering insights into the underlying factors that drive criminal actions. These theories fall into several categories, each examining different causes and motivations. A theory of crime must be flexible, able to explain criminal events against diverse variations in the backcloth. To be of much value, a theory must make it possible to recognize and understand both individual and aggregate patterns of behavior at many levels of resolution (*Patricia L. Brantingham, Paul J. Brantingham*)

Biological theories suggest that genetics or physical traits may predispose individuals to crime. Psychological theories focus on mental processes and personality traits that influence behaviour, while sociological theories consider the social environment, such as family, community, and economic conditions, in shaping behaviour.

Other theories, like conflict and critical theories, view crime as a response to social inequality or power struggles within society. Together, these theories provide a framework for understanding the complex, multifaceted nature of crime, aiding efforts to prevent and address criminal behaviour.

Important Theories of Crime: By analysing these theories, we can better understand the complexities of criminal behaviour and potentially develop more effective policies for crime prevention and rehabilitation.

Biological Theories of Crime
Biological theories posit that individuals may be predisposed to criminal behaviour due to their genetic makeup or physiological traits. This approach gained prominence in the 19th century with Cesare Lombroso, an Italian criminologist who believed that criminals possessed certain "atavistic" traits or primitive features, suggesting a biological inclination toward crime. Lombroso theorised that criminals were evolutionary throwbacks who displayed physical characteristics such as sloping foreheads, receding chins, or large jaws (Charles A. Ellwood)

Although Lombroso's theories have been largely discredited, modern biological theories still explore genetic and neurobiological factors. For example, research on the MAOA gene, often dubbed the "warrior gene, " has suggested that certain genetic variants may predispose individuals to aggressive or impulsive behaviour. Additionally, studies have examined the role of testosterone, serotonin levels, and brain structure in influencing behaviour.

Contemporary biological theories focus on the interplay between genetic predispositions and environmental factors, known as **biosocial criminology**. This field suggests that while biology may provide certain inclinations, social environments and life experiences ultimately influence whether an individual engages in crime. For example, an individual with a genetic predisposition for aggression may be less likely to commit crimes if they grow up in a nurturing and supportive environment.

Psychological Theories of Crime

Psychological theories focus on mental processes, personality traits, and emotional responses to explain criminal behaviour. These theories propose that criminal behaviour can result from abnormalities in cognitive function or personality, leading individuals to respond differently to social situations.

One foundational approach within this theory is **Freudian psychoanalysis**, which argues that criminal behaviour stems from unresolved psychological conflicts rooted in childhood. Freud's model divides the psyche into the **id** (impulsive desires), **ego** (rational thought), and **superego** (moral compass). Imbalance or dysfunction among these components, such as a dominant id, can result in criminal impulses taking precedence over rational decision - making.

Additionally, **personality theories** propose that certain personality traits, such as impulsivity or aggression, make individuals more prone to criminal behaviour. Psychologists have used models like the **Big Five Personality Traits** (openness, conscientiousness, extraversion, agreeableness, and neuroticism) to study how specific characteristics relate to criminal behaviour. Traits such as high neuroticism (emotional instability) or low conscientiousness (lack of impulse control) have been linked to higher risks of criminality.

Other psychological theories focus on **cognitive development**. For instance, **Kohlberg's stages of moral development** suggest that individuals progress through stages of moral reasoning. Those who do not fully develop morally may have difficulty distinguishing right from wrong, making them more susceptible to criminal behaviour. **Learning theories**, such as **classical conditioning** and **operant conditioning**, also highlight how behaviour is shaped by reinforcement and punishment, explaining how criminal actions may be learned and repeated if reinforced.

Sociological Theories of Crime

Sociological theories view crime as a result of social conditions, environmental factors, and group dynamics. Unlike biological or psychological theories that focus on the individual, sociological theories examine how interactions within society influence criminal behaviour.

Social Disorganisation Theory

Social Disorganisation Theory, developed in the early 20th century by sociologists at the University of Chicago, examines how community structures impact crime rates. This theory suggests that crime is more prevalent in areas with high poverty, unemployment, and lack of social cohesion. Researchers Clifford Shaw and Henry McKay found that areas with high crime rates often lacked stable institutions (like schools and community organisations) and social ties, leading to disorganisation.

According to this theory, social disorganisation hinders communities' ability to exert informal social control, making it difficult to prevent criminal activities. Therefore, this theory suggests that improving neighbourhood conditions and building social cohesion can reduce crime rates.

Strain Theory

Strain Theory was developed by sociologist Robert K. Merton, who argued that crime is a result of the disconnect between culturally accepted goals (such as wealth or status) and the legitimate means available to achieve them. When individuals are unable to attain these goals through socially acceptable avenues, they may experience "strain" and resort to deviant behaviours to achieve success.

Merton identified several responses to strain, including **innovation** (using unconventional methods, such as crime, to achieve goals), **ritualism** (adhering to socially accepted means but abandoning goals), and **rebellion** (rejecting both societal goals and means). Strain Theory has been influential in understanding why marginalised groups or those facing socio - economic disadvantages may turn to crime.

Labeling Theory

Labelling Theory focuses on how society's response to individuals can influence their behaviour. According to this theory, labelling an individual as a "criminal" or "deviant" can reinforce criminal behaviour by influencing their self - identity and limiting social opportunities.

Once labelled, individuals may internalise this identity, leading them to act in accordance with society's expectations. This self - fulfilling prophecy can perpetuate criminal behaviour, as labelled individuals face obstacles in education, employment, and social relationships that push them further toward deviant behaviour. **Labelling Theory** has implications for the criminal justice system, as it suggests that punitive measures, such as incarceration, may reinforce criminal behaviour rather than rehabilitate offenders.

Social Control Theory

Social Control Theory, developed by Travis Hirschi, posits that strong social bonds with family, friends, and the community reduce the likelihood of criminal behaviour. According to this theory, individuals with stronger attachments to others, greater involvement in productive activities, and a commitment to social norms are less likely to commit crimes.

Hirschi's **Social Bond Theory** identifies four elements that promote social bonds and discourage crime: **attachment** (emotional bonds to others), **commitment** (investment in conventional goals), **involvement** (participation in socially approved activities), and **belief** (acceptance of social norms). Weaknesses in these bonds can increase an individual's likelihood of committing a crime. Social Control Theory suggests that social institutions, such as family and schools, play a crucial role in fostering these bonds and preventing delinquency.

Rational Choice Theory

Rational Choice Theory posits that individuals are rational actors who weigh the potential costs and benefits of their actions. In this view, crime is a calculated decision based on the perceived likelihood of success and the anticipated rewards versus the risks, such as punishment.

According to this theory, individuals commit crimes when they believe the benefits outweigh the consequences. Rational

Choice Theory has influenced policies emphasising deterrence, such as increased penalties, stricter law enforcement, and surveillance. By increasing the perceived costs of crime, policymakers aim to discourage rational actors from engaging in criminal behaviour.

Conflict Theory

Rooted in Marxist thought, **Conflict Theory** suggests that crime arises from social and economic inequalities. According to this theory, laws are created and enforced by the ruling class to maintain control over the lower classes. Crime, therefore, is a response to oppressive conditions and an act of resistance against a system perceived as unjust.

Conflict Theory emphasises how economic disparity, discrimination, and lack of access to resources contribute to crime. This perspective argues that the criminal justice system is biased, with the laws often disproportionately targeting marginalised groups. By addressing social inequalities and reforming oppressive laws, Conflict Theory suggests that society can reduce crime rates.

Critical Theory

Critical Theory expands on Conflict Theory by arguing that crime definitions and laws are created by a select few to maintain control over society. This theory explores how crime and deviance are defined by those in power, often reflecting their interests rather than universal moral principles.

Critical Theory challenges traditional concepts of crime, arguing that what is considered "criminal" often reflects the interests of those in power. For instance, white - collar crimes or corporate abuses may be less severely punished than street crimes, reflecting the influence of economic and political elites. This theory advocates for a critical examination of laws and societal structures that perpetuate inequality and criminalise marginalised groups.

Social Learning Theory

Social Learning Theory proposes that individuals learn behaviours, including criminal ones, through observation and imitation of others, especially influential figures in their social environment, such as family, friends, or media. This theory is rooted in the idea that behaviour is shaped through interaction with others.

According to **Albert Bandura's social learning model**, people learn not only through direct experience but also by observing the consequences of others' actions. This theory explains how criminal behaviour can spread within social groups or communities, as individuals learn norms, techniques, and motivations for crime. Programs that provide positive role models and encourage pro - social behaviour are central to preventing crime within this framework.

Positivist Theory

Positivist Theory, or **Positivism**, is based on the belief that crime is caused by external factors beyond an individual's control, such as biological, social, or psychological influences. Unlike rational choice perspectives, Positivism rejects the idea of free will, viewing individuals as products of their environment.

Positivist Theory emphasises scientific methods to understand crime, focusing on measurable factors, such as genetics, environment, and mental health. This theory has influenced rehabilitative approaches that address underlying causes of criminal behaviour rather than simply punishing individuals.

Theories of crime provide a multidimensional view of criminal behaviour, each offering unique insights into its causes and consequences. Biological, psychological, and sociological theories highlight the interplay between individual factors and social influences, while Conflict and Critical theories reveal the role of power dynamics and social inequality in shaping crime.

No single theory can fully explain the complexity of criminal behaviour. Instead, understanding crime requires a synthesis of these perspectives, recognising the influence of individual traits, social structures, economic conditions, and legal frameworks. By studying these theories, policymakers, criminologists, and the justice system can develop more effective strategies for prevention, intervention, and rehabilitation, ultimately contributing to a safer and more just society.

2. Literature Review

Delhi is growing very fast. Rapid growth i. e. planned as well as unplanned colonies, has taken place in Delhi over the led to significance increase of population from neighbouring states and the entire country. This has resulted into a lot of anonymity which helps criminals to go undetected after committing crime. Further, many affluent colonies abut areas inhabited by underprivileged sections of society. This along with increasing economic disparities has had an impact on crime trends in the city. Social and family structure is undergoing change. More nuclear families are coming up with loosened family control over young adults. Delhi shares its borders with Uttar Pradesh, Haryana and Rajasthan which allows easy escape to criminals committing crime in Delhi. All these factors, contributed to increasing trend of crime in Delhi in the last decade or so.

A statics of crime in Delhi is as below: (Table 1.0)

CRIME IN DELHI

CRIME HEAD	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	* UPTO 15TH JULY	
												2021	2022
DACOITY	33	28	33	82	75	46	36	25	15	9	26	8	9
MURDER	543	521	517	586	570	528	487	513	521	472	459	235	277
ATT. TO MURDER	386	439	585	770	770	646	645	529	487	570	761	360	473
ROBBERY	562	608	1245	6464	7407	4761	3147	2444	1956	1963	2333	1110	1221
RIOT	50	79	113	160	130	79	50	23	23	689	68	36	55
KID. FOR RANSOM	25	21	30	38	36	23	16	19	15	11	17	8	5
RAPE	572	706	1636	2166	2199	2155	2146	2135	2168	1699	2076	1033	1100
TOTAL HEINOUS	**2171**	**2402**	**4159**	**10266**	**11187**	**8238**	**6527**	**5688**	**5185**	**5413**	**5740**	**2790**	**3140**
SNATCHING	1476	1440	3638	7350	9896	9571	8231	6932	6266	7965	9383	4468	5024
HURT	1946	1747	1768	2077	1898	1489	1352	1508	1312	1064	1360	608	885
BURGLARY	1419	1715	2835	10309	12848	14307	9819	4117	3026	2199	2637	1362	2893
M.V.THEFT	14668	14391	14916	23384	32729	38644	40972	46433	46215	35019	37910	18814	19548
HOUSE THEFT	1918	1746	3216	12735	15318	14721	10739	3727	2630	2036	2485	1158	7561
OTHER THEFT	6313	5895	11992	42634	56385	77563	114054	138596	190874	132419	150203	75053	70906
M. O. WOMEN	657	727	3515	4322	5367	4165	3422	3314	2921	2186	2551	1244	1480
OTHER KID./ABD	3767	3949	6294	7105	7694	6596	6079	6032	5886	4051	5510	2766	3193
FATAL ACCIDENT	2047	1822	1778	1629	1582	1548	1565	1657	1433	1163	1206	583	690
SIMPLE ACCIDEN	5233	5115	5788	6994	6503	5827	5108	4858	4177	3015	3514	1743	2240
OTHER IPC	11738	13338	20285	26849	29970	26850	25712	27857	31160	53794	70804	36533	41488
TOTAL NON HEINOUS	**51182**	**51885**	**76025**	**145388**	**180190**	**201281**	**227053**	**245031**	**295900**	**244911**	**287563**	**144332**	**155908**
TOTAL IPC	**53353**	**54287**	**80184**	**155654**	**191377**	**209519**	**233580**	**250719**	**301085**	**250324**	**293303**	**147122**	**159048**

The factors responsible for crime may be enumerated as under:

1) socio - economic inequalities,
2) Proximity of colonies of the affluent and the under - privileged,
3) Anonymity encouraging deviant behaviour,
4) Loosening social structures and family control,
5) Adverse sex ratio (866 females/ 1000 males),
6) Easy means of escape available to criminals, particularly across the borders,
7) Extended hinterland in the NCR region

Delhi, the capital city of India is called the 'Crime Capital' of the country. The city tops the slot for almost all violent crimes, particularly highlighting dismal state of women (Sharma, P., Rajput, S. (eds) Sustainable Smart Cities in India)

Space–Time Permutation Model (STPM) inbuilt in SatScan (an open source statistical tool), was used for crime hotspot detection in Pune city, Maharashtra, India, and compare the result with two GIS - based statistical methods namely, Kernel Density Estimation (KDE), and Getis - Ord Gi*, being utilized extensively for crime hotspot detection and mapping (Saswati Mondal et al).

The study says that social media provides an opportunity to observe human behavioral traits, spatial and temporal relationships. Based on study Crime analysis using social media data such as Facebook, Newsfeed articles, Twitter, etc. is becoming one of the emerging areas of research across the world. Using spatial and temporal relationships of social media data, it is possible to extract useful data to analyse criminal activities (Boppuru Rudra Prathap et al).

Crime is a human phenomenon which violates the law and is punishable by the state. Modern world has seen an upsurge in the recording of criminal activities since the global urban process began in the early 19th Century and formal police institutional arrangements began (L. John, 2004; Urbanization of America). In today's world, it is important to analyze the pattern of criminal activities in a certain area to tackle the crime. In developing and less developed countries, crime data is not highly organized and is maintained in many places on hardcopies by manual efforts. Data repository is not standardized (UNDA, 2011). Usually, crime maps are not available in context of crime locations, police station jurisdiction areas, administrative boundaries etc. This makes crime analysis a tedious task with no provision for hot spotting, zonation, navigation facilities, criminal profiling, landuse patterns, terrain conditions etc (Amarjeet Kaur et al).

The traditional and age - old system of intelligence and criminal record maintenance has failed to live up to the requirements of the existing crime scenario. Manual processes neither provide accurate, reliable and comprehensive data round the clock nor does it help in trend prediction and decision support. It also results in lower productivity and ineffective utilisation of manpower. The solution to this ever - increasing problem lies in the effective use of Information Technology. (C. P. JOHNSON Geomatics Group, C - DAC, Pune University Campus, Pune 411007).

The advancement in computer science technology and development of GIS application softwares and the accessibility of various geographic data through open source data sources make it feasible for police and law enforcement departments to use it effectively. Crime mapping and spatial analysis using GIS tools such as hot spot generation, zonation, navigation, and crime profiling, mobile location identification and web based various application are well recognized and can be scientifically applied for betterment of citizens whereas it can be effectively used for prediction and control of crime. (**Firoz Ahmad, Md Meraj Uddin, Laxmi Goparaju, 88 (2) (2017) 211 - 226)**

The cities areas with working class population are relatively higher crimes than where the people from HIG (high income group) and LIG (lower income groups) live together with high economic disparities. Mainly this thing is related to the

different types of people or nature of people in specific areas, class of people, type of city or area in the city, distance of basic services from the specific location, distribution of spaces etc. Mainly there is a strong relation in between the different types of crimes and locations (Specific locations), type of development (around the particular location) also plays a vital role in increasing the chances of major crime happenings at particular location. One major important thing is that there is a relation of crime hot spot areas with their surrounding physical built up and existing environment, which make easy for the offenders or criminals to do crimes and escape easily from the locations after committed the criminal activities. (Harcharan Singh & Vinay Maitri, **Part of the book series:** Advances in Geographical and Environmental Sciences).

It is well accepted that GIS has been emerged as robust technology in monitoring and controlling the crimes. However, at the same time it is very much essential that crime data must be thoroughly captured geographical locationwise, type of crime, occurance of crime, demography etc. and be displayed on authorized Govt. websites. As the data are available in consolidated manner now, therefore exact hot spotting, navigation is very difficult to conduct.

Keeping in view the said limitation, the extensive use of Remote sensing has been made in the instant study and an effort is made in identifying the factors that correlate with different type of crimes and useful insights have been drawn.

3. Materials & Methods/ Methodology

Site Description:

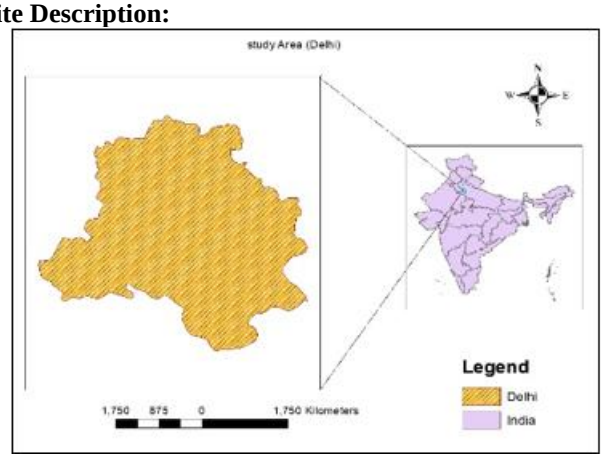


Figure 1.0

Delhi, officially the National Capital Territory (NCT) of Delhi, is a city and a union territory of India containing New Delhi, the capital of India. Straddling the Yamuna river, but spread chiefly to the west, or beyond its right bank, Delhi shares borders with the state of Uttar Pradesh in the east and with the state of Haryana in the remaining directions. Delhi became a union territory on 1 November 1956 and the NCT in 1995. The NCT covers an area of 1, 484 square kilometres (573 sq mi).

The crimes data of Delhi has been collected from Govt. website for the period (2011 - 2021) and satellite's imageries i. e. ee. Image Collection ('LANDSAT/COMPOSITES/C02/T1_L2_8DAY_NDVI'), ee. Image ('UMD/hansen/global_forest_change_2023_v1_11'), ee. ImageCollection ("JRC/GHSL/P2023A/GHS_BUILT_V"), ee. ImageCollection ('NOAA/VIIRS/DNB/MONTHLY_V1/VCMSLCFG'), ee. ImageCollection ('CIESIN/GPWv411/GPW_Population_Density'), ee. ImageCollection ('WorldPop/GP/100m/pop_age_sex_cons_unadj'); used for analysing the crimes including pattern, areas and favorable factors facilitating crimes.

Monthly average radiance composite images using nighttime data from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band (DNB).

As these data are composited monthly, there are many areas of the globe where it is impossible to get good quality data coverage for that month. This can be due to cloud cover, especially in the tropical regions, or due to solar illumination, as happens toward the poles in their respective summer months. Therefore it is recommended that users of these data utilize the 'cf_cvg' band and not assume a value of zero in the average radiance image means that no lights were observed.

Cloud cover is determined using the VIIRS Cloud Mask product (VCM). In addition, data near the edges of the swath are not included in the composites (aggregation zones 29 - 32). Version 1 has NOT been filtered to screen out lights from aurora, fires, boats, and other temporal lights. This separation is under development and will be included in a later version of this time series. Also in development is a method to separate lights from background (non - light) values.

The Global Human Settlement Layer (GHSL) project produces global spatial information, evidence - based analytics, and knowledge describing the human presence on the planet. The GHSL relies on the design and implementation of spatial data processing technologies that allow automatic data analytics and information extraction from large amounts of heterogeneous geospatial data including global, fine - scale satellite image data streams, census data, and crowd sourced or volunteered geographic information sources.

The Global Land Analysis and Discovery (GLAD) laboratory at the University of Maryland, in partnership with Global Forest Watch (GFW) , provides annually updated global - scale forest loss data, derived using Landsat time - series imagery. These data, available here, are a relative indicator of spatiotemporal trends in forest loss dynamics globally. However, inconsistencies exist due to the following factors:

1) Differences in Landsat sensor technology, whether Thematic Mapper, Enhanced Thematic Mapper Plus, or Operational Land Image data. For example, the Operational Land Imager (2013 - onward) onboard the Landsat 8 spacecraft employs a pushbroom sensor technology that increases per observation dwell time compared to past whiskbroom systems. The result is a signal to noise ratio that is a magnitude greater than that of Landsat 7's Enhanced Thematic Mapper Plus sensor. The increased signal enables better detection capabilities in mapping land change.

2) Data richness, or the number of viable land observations available as inputs to analysis. The global acquisition strategy has improved over time, with acquisitions increasing from under 150k per year in the early 2000s to over 250k per year in recent years. Additionally, Landsat 7 was the only input for the 2001 - 2012 initial product, and is affected by the scan - line corrector malfunction of the Enhanced Thematic Mapper from 2002 onward, where nearly a quarter of the footprint of each scene is not collected. Also, the gap between the decommissioning of Landsat 5 in 2011 and the launch of Landsat 8 in 2013 resulted in a total 2012 global collection of less than 100k Landsat 7 images.
3) Algorithm adjustments, including modifications of training data and input image feature space. For example, the original 2001 - 2012 forest loss map was made using a single algorithm run, compared to subsequent years that have been added individually. Additionally, models have been iterated to improve performance in the 2012 - forward period. Such changes in the mapping method can result in year to year inconsistencies.

While the resulting map data are a largely viable relative indicator of trends, care must be taken when comparing change across any interval. Applying a temporal filter, for example a 3 - year moving average, is often useful in discerning trends. However, definitive area estimation should not be made using pixels counts from the forest loss layers.

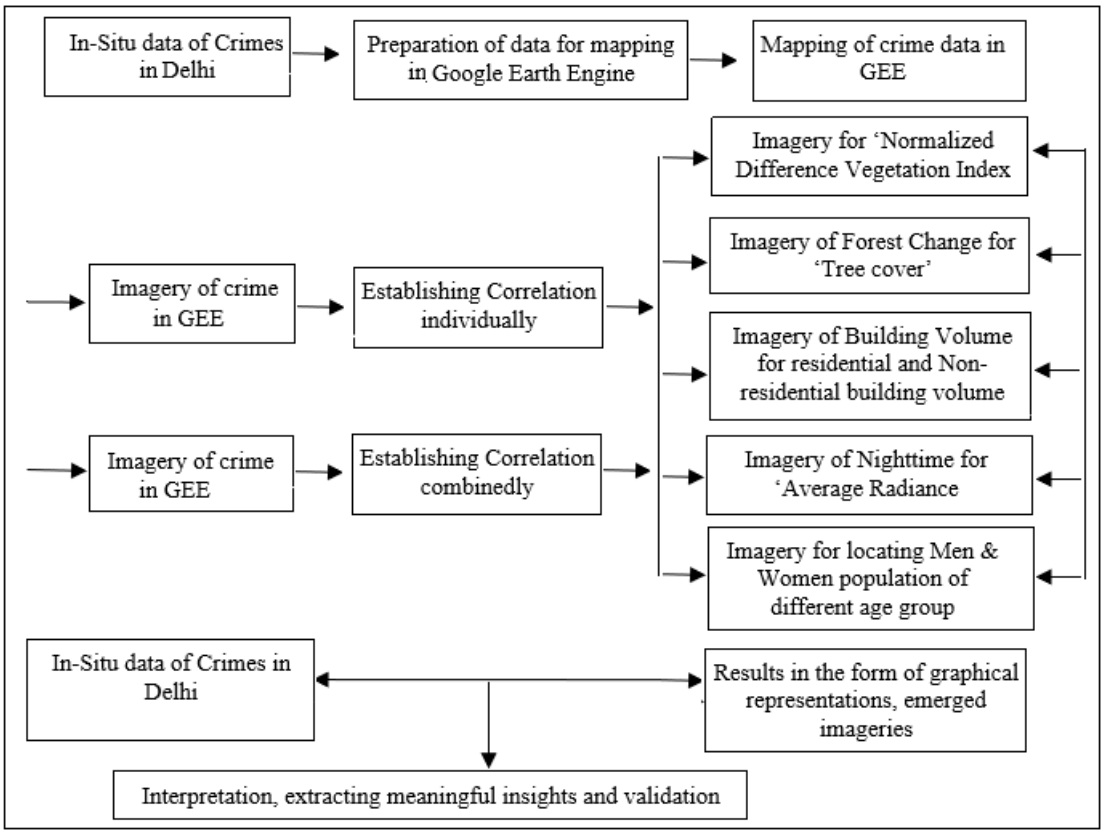
The Intergovernmental Panel on Climate Change (IPCC) provides guidance on reporting areal extent and change of land cover and land use, requiring the use of estimators that neither over or underestimate dynamics to the degree possible, and that have known uncertainties. The maps provided by GLAD do not have these properties. However, the maps can be leveraged to facilitate appropriate probability - based statistical methods in deriving statistically valid areas of forest extent and change. Specifically, the maps may be used as a stratifier in targeting forest extent and/or change by a probability sample. The team at GLAD has demonstrated such approaches using the GLAD forest loss data in sample - based area estimation (Tyukavina et al., ERL, 2018, Turubanova et al., ERL, 2019, and Potapov et al., RSE, 2019, among others).

Global high - resolution, contemporary data on human population distributions are a prerequisite for the accurate measurement of the impacts of population growth, for monitoring changes, and for planning interventions. The WorldPop project aims to meet these needs through the provision of detailed and open access population distribution datasets built using transparent and peer - reviewed approaches.

Full details on the methods and datasets used in constructing the data, along with open access publications, are provided on the WorldPop website. In brief, recent census - based population counts matched to their associated administrative units are disaggregated to ~100x100m grid cells through machine learning approaches that exploit the relationships between population densities and a range of geospatial covariate layers. The mapping approach is Random Forest - based dasymetric redistribution.
This dataset contains top - down constrained breakdown of estimated population by age and gender groups. Currently only 2020 data are present.

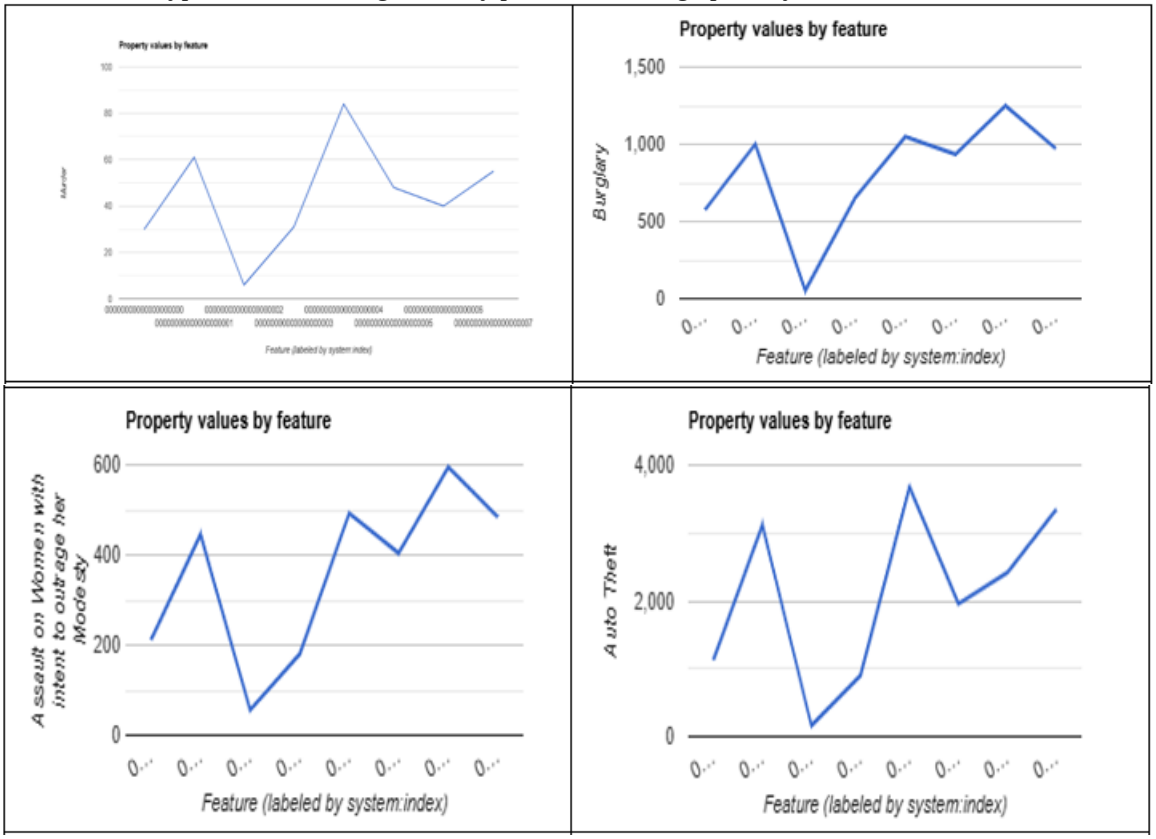
Top - down constrained age/sex structure estimate datasets for individual countries for 2020 at 100m spatial resolution with country totals adjusted to match the corresponding official United Nations population estimates that have been prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2019 Revision of World Population Prospects).

Methodology: Fig. (1.1)



4. Results and Discussions

The pattern of different type of crimes during the study period is shown graphically here as under:



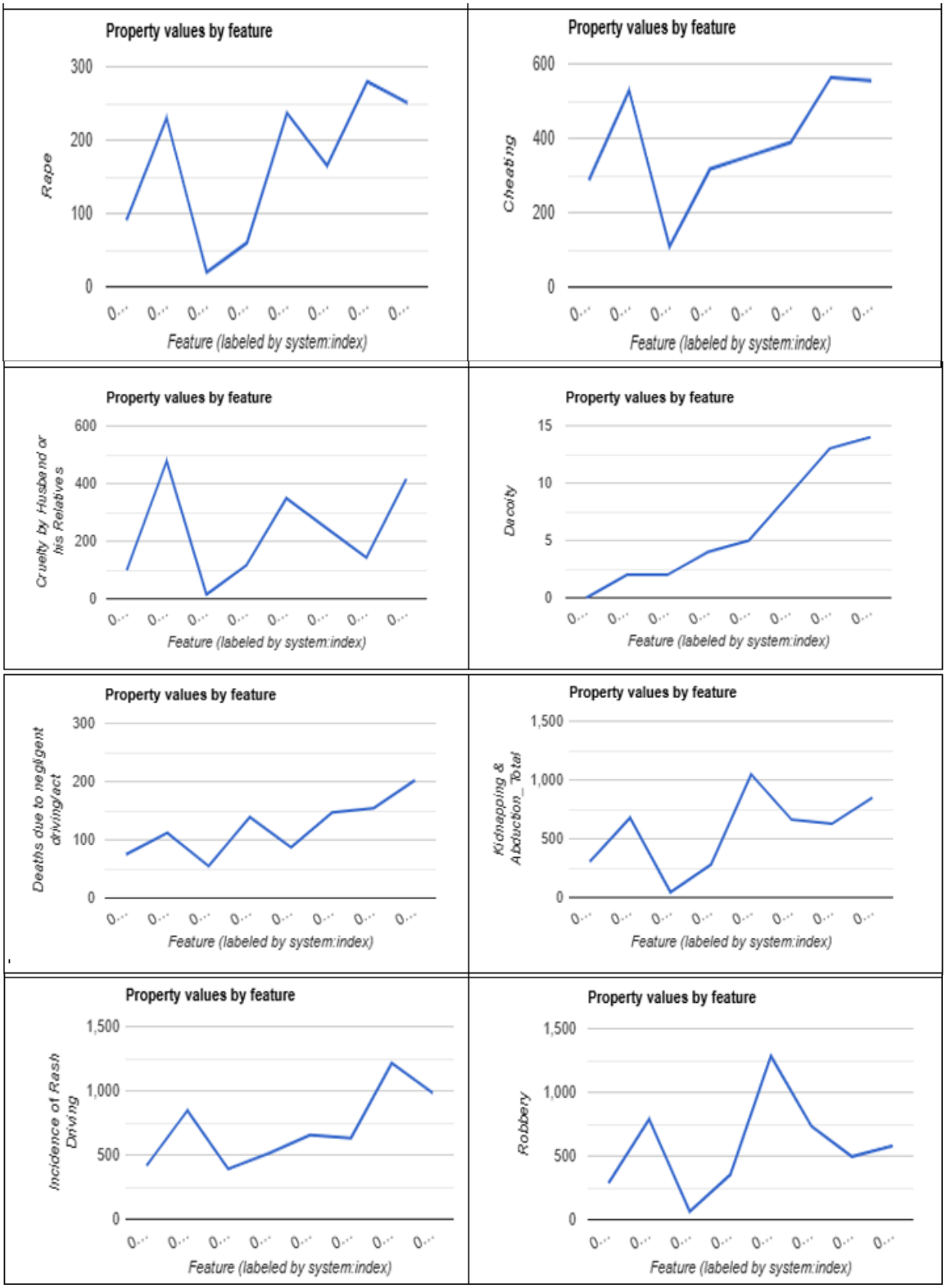
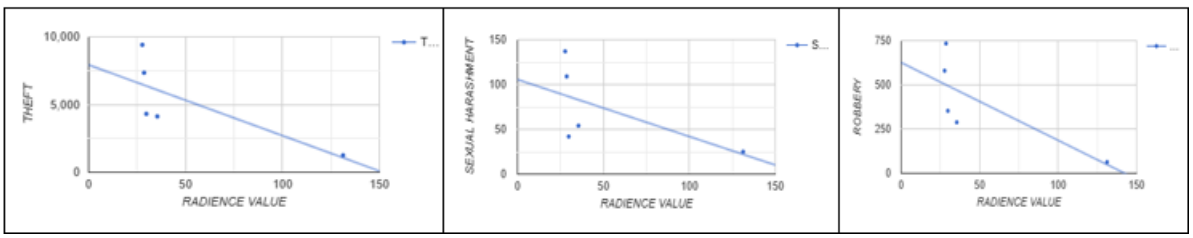


Figure 1

The study finds that mostly the crimes in Delhi have strong negative correlation with average radiance available, i. e. the volume of crimes is less in more illuminated region and vice - versa.



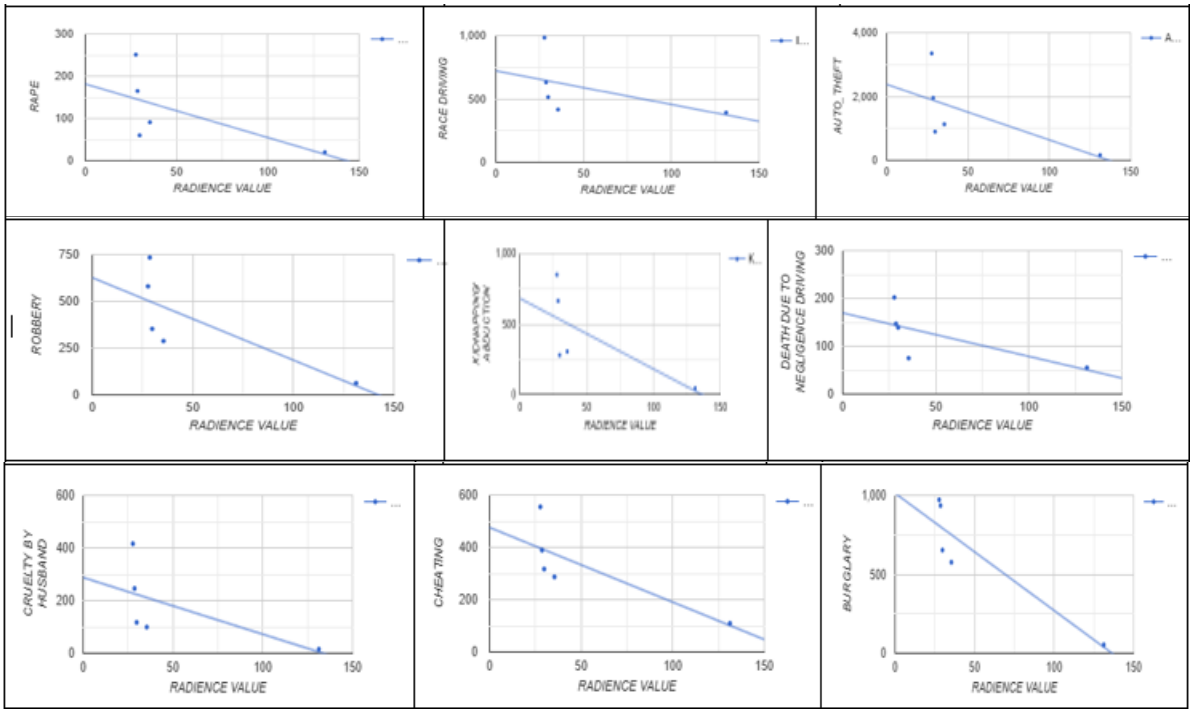


Figure 1.3

The processed satellite imagery also indicates the various classes of average radiations. Class 1 indicates very poor illumination and class 6 indicates highest illuminated regions.

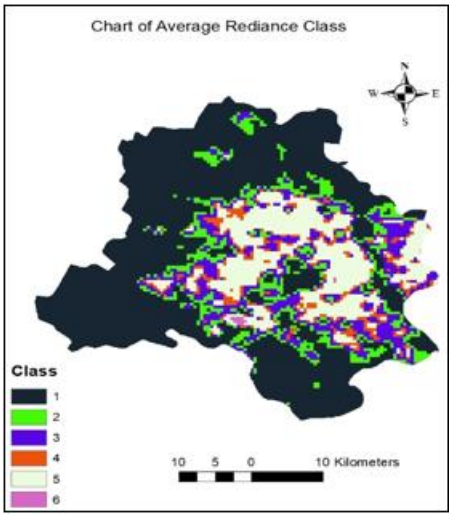


Figure 1.4

Figure 1.5

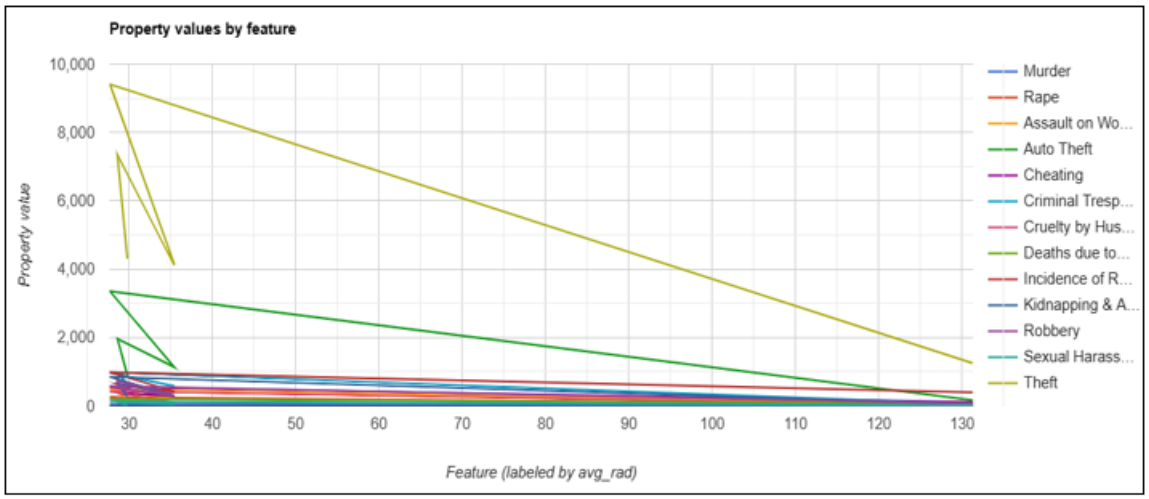


Figure 1.6

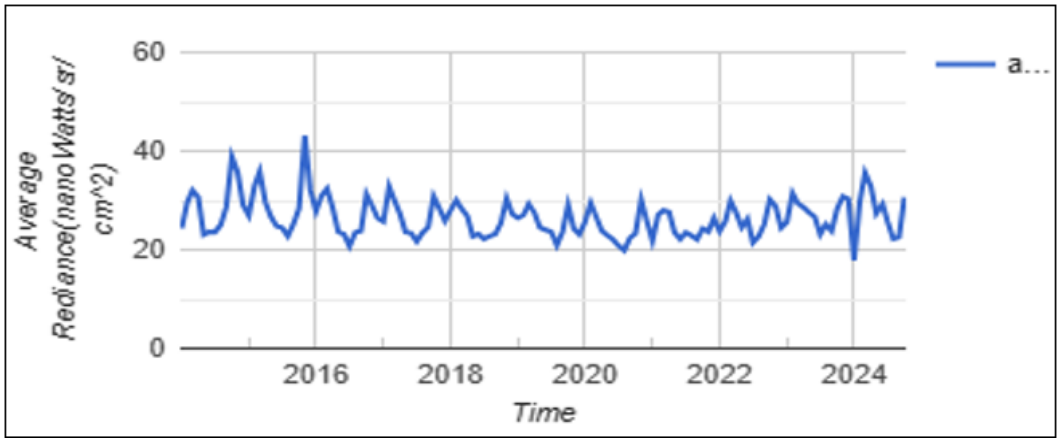


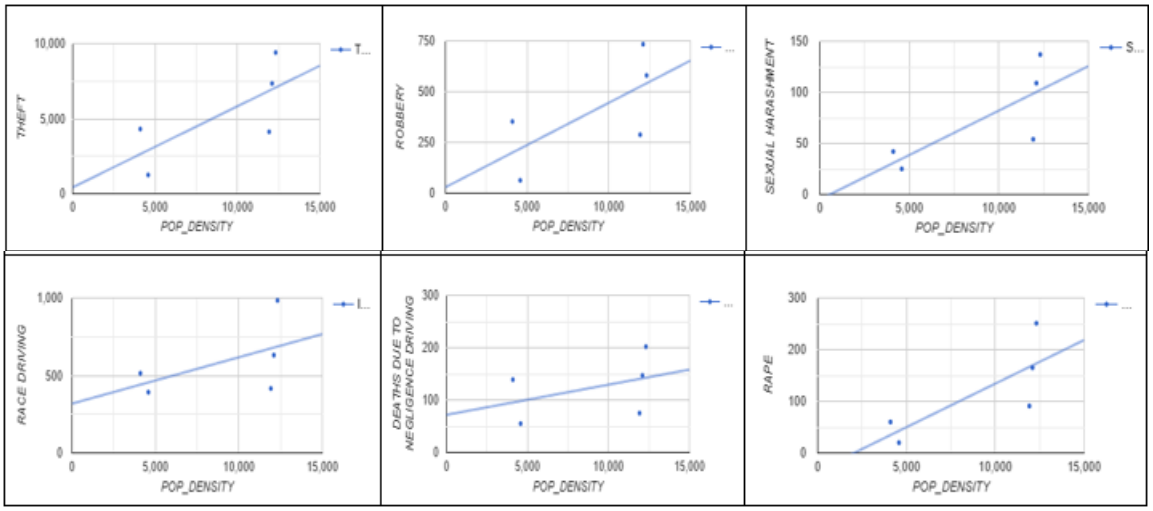
Figure 1.7

(Average Radiance of West Delhi during the study period)

From Fig.1.3, 1.4 and 1.5, it is concluded that max. number of incidence of thefts, rash driving, kidnapping and abduction, Assault on Women with intent to outrage her Modestyand, cheating, Sexual Harassment, Cruelty by Husband or his Relatives, autotheft, murder, rape occurred in west Delhi, particularly where average radiance was about 28 nanoWatts/sr/cm^2. Incidence of Criminal Trespass/Burglar in Central Delhi. Incidence of robbery, Deaths due to negligent driving/act in North - west Delhi.

Study finds that max. type of crimes have been executed in West Delhi in the presence of very low illumination. The label of average radiance as shown in Fig.1.6 is low and decreased over a period of time.

The study finds that mostly the crimes in Delhi have strong positive correlation with population density, i. e. the volume of crimes is more in more densed region and vice - versa.



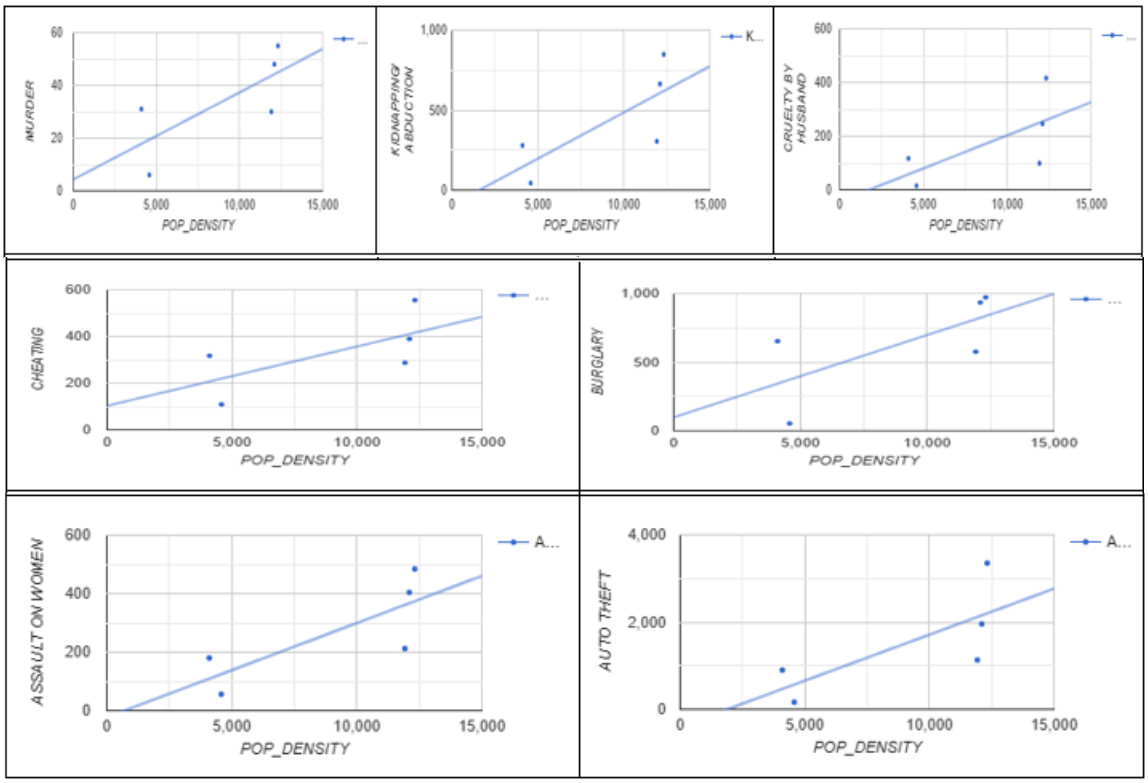


Figure 1.8

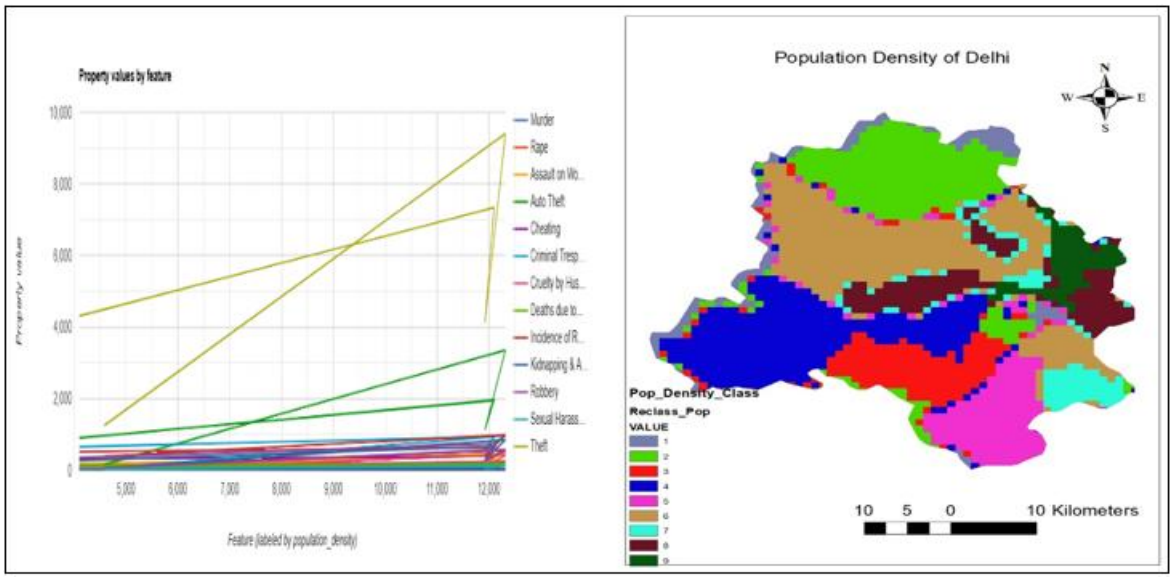


Figure 1.9

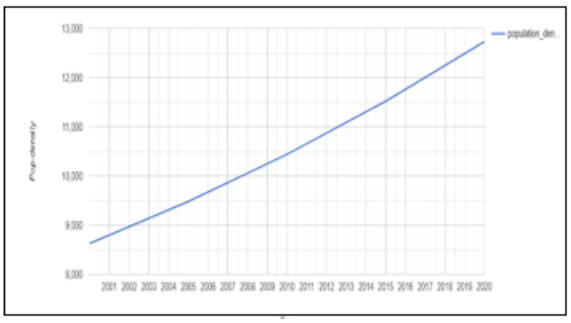


Figure 2.0

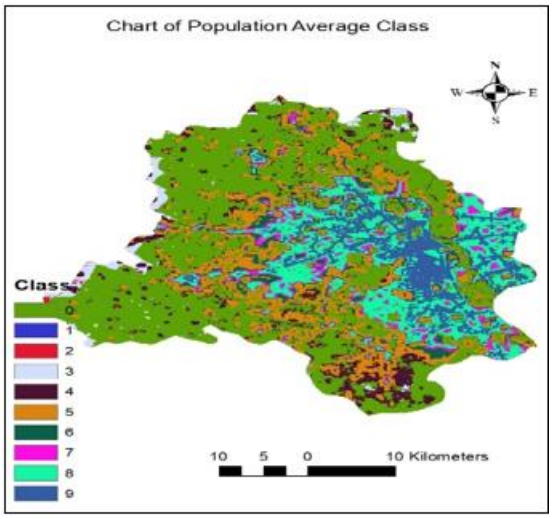


Figure 2.1

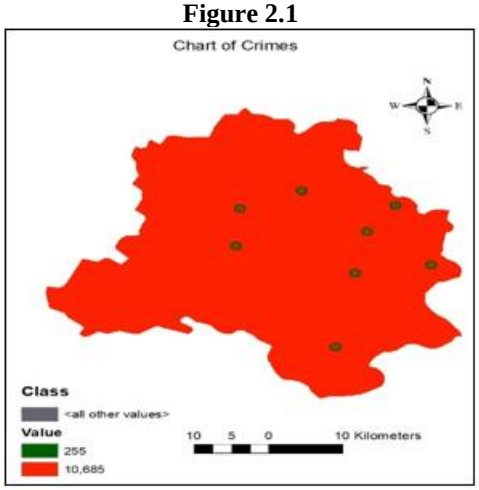


Figure 2.2

From Fig.1.4 and 1.9, it is concluded that max. number of incidence of thefts, rash driving, kidnapping and abduction, Assault on Women with intent to outrage her Modestyand, cheating, Sexual Harassment, Cruelty by Husband or his Relatives, autotheft, murder, rape occurred in West Delhi, particularly where average population density is tremendously increased as shown in Fig.2.0 above. However, it is also found referring fig.2.0 and 2.1 that mainly crimes occurred in densely populated regions.

Incidence of Criminal Trespass/Burglar, Robbery, Deaths due to negligent driving/act in have been observed in North - west Delhi.

Study finds that max. type of crimes have been executed in West Delhi in the presence of highly populated areas.

The distribution of Men/Women population distribution in Delhi as derived from high resolution satellite imagery is as below:

Table 1.1

Sr. No.	Men Population Age Group	Residing Area (Sq. Km)	Women Population Age Group	Residing Area (Sq. Km)
1	0 - 1	1205.07	0 - 1	1020.41
2	1 - 4	4617.42	1 - 4	3903.09
3	5 - 9	5795.22	5 - 9	4760.01
4	10 - 14	6311.26	10 - 14	5119.07
5	15 - 19	7100.95	15 - 19	5661.40
6	20 - 24	7972.83	20 - 24	6407.77
7	25 - 29	7816.53	25 - 29	6544.07
8	30 - 34	7347.81	30 - 34	6148.48
9	35 - 39	6471.03	35 - 39	5469.25
10	40 - 44	5445.99	40 - 44	4796.43
11	45 - 49	4731.86	45 - 49	4052.84
12	50 - 54	3887.33	50 - 54	3451.31
13	55 - 59	3187.54	55 - 59	2674.33
14	60 - 64	2276.29	60 - 64	2180.70
15	65 - 69	1460.10	65 - 69	1386.98
16	70 - 74	819.85	70 - 74	908.73
17	75 - 79	579.21	75 - 79	648.12
18	80 and above	457.34	80 and above	603.25

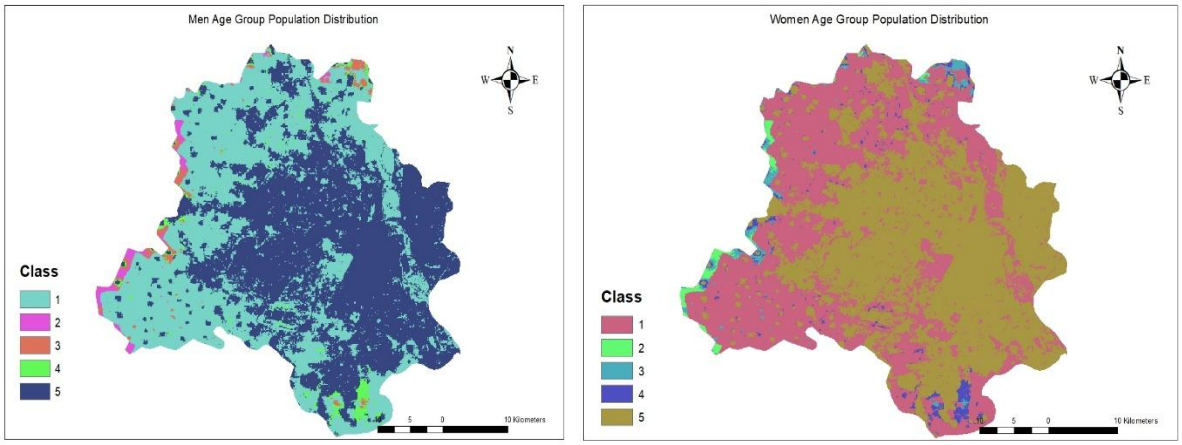


Figure 2.3

The study further finds that women population especially above 70 years are less densed as compared to men population above 70 years. Portion of this population also in heritage in scattered places therefore quite susceptible to crimes. However, the women population below 70 years of age are more densed as compared to men population below 70 years. This population is mainly mixed and clustered in West, North - west, Central, North - East, East and South parts of Delhi.

The impact of forest growth during the study period has also been studied. The net growth during the period is found to be 0.71% and the area of growth is depicted in shown below:

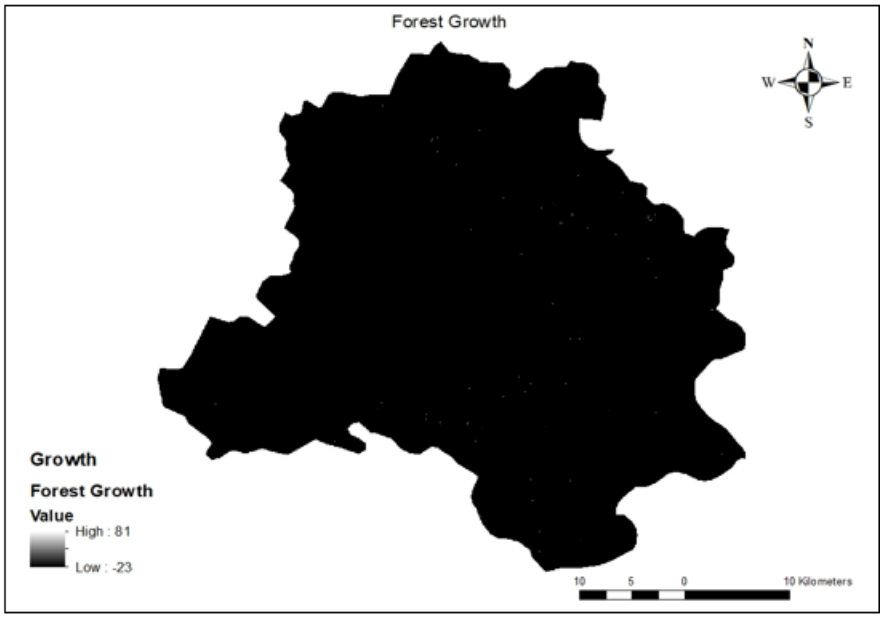


Figure 2.4

The cumulative effect of forest growth on different types of crimes is depicted graphically as below:

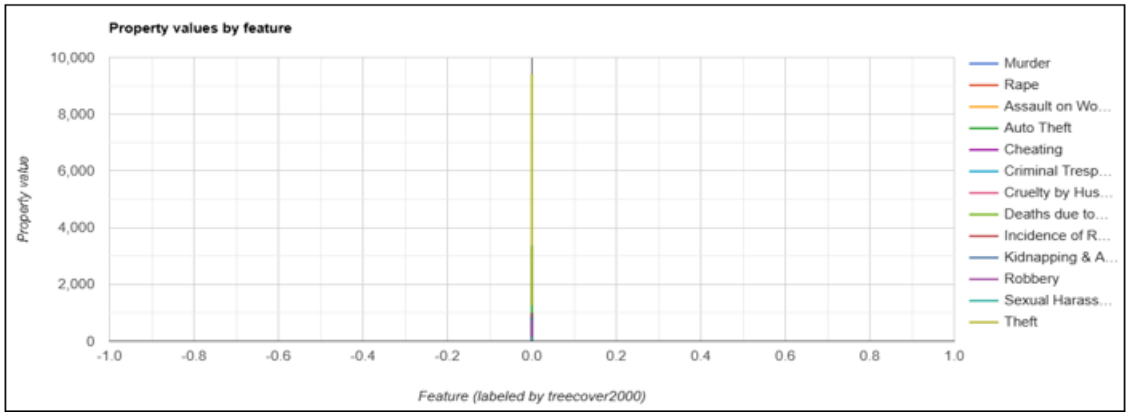


Figure 2.5

The cases of max. theft kidnapping, assault on women, robbery and auto - thefts in West and next in North - west then in North. As such no significant impact is noticed due to very negligible growth of tree cover i. e. only in 11 km2 area.

The study finds the impact of building volume on different types of crimes in Delhi is as below:

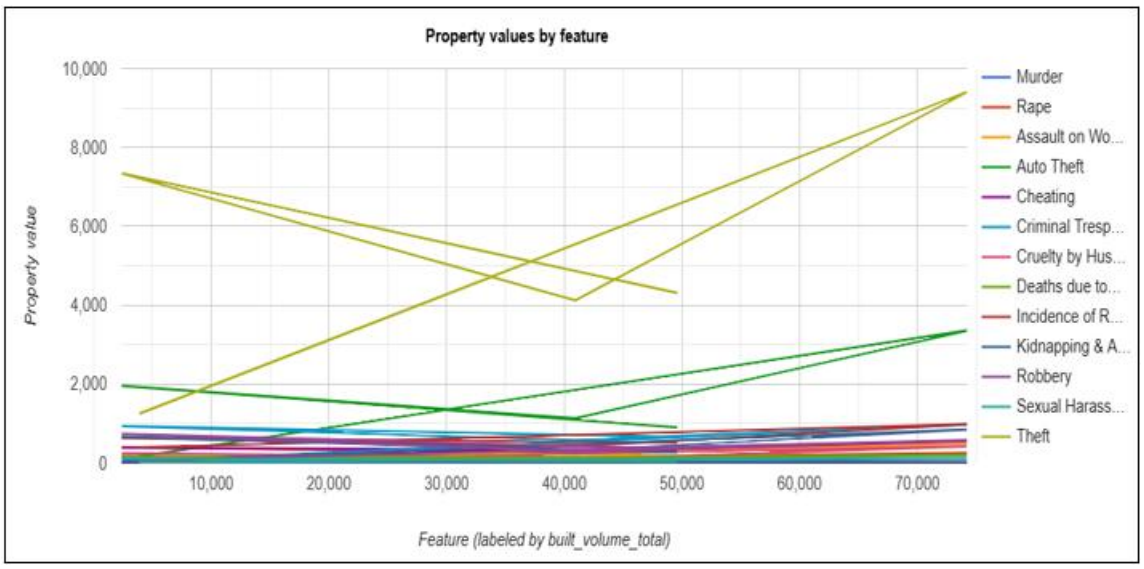


Figure 2.6

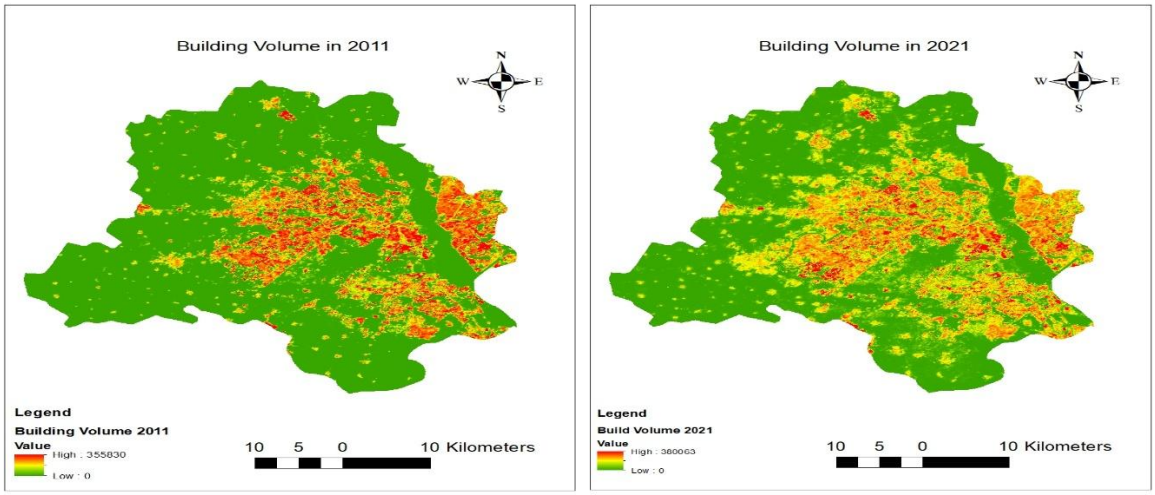


Figure 2.7

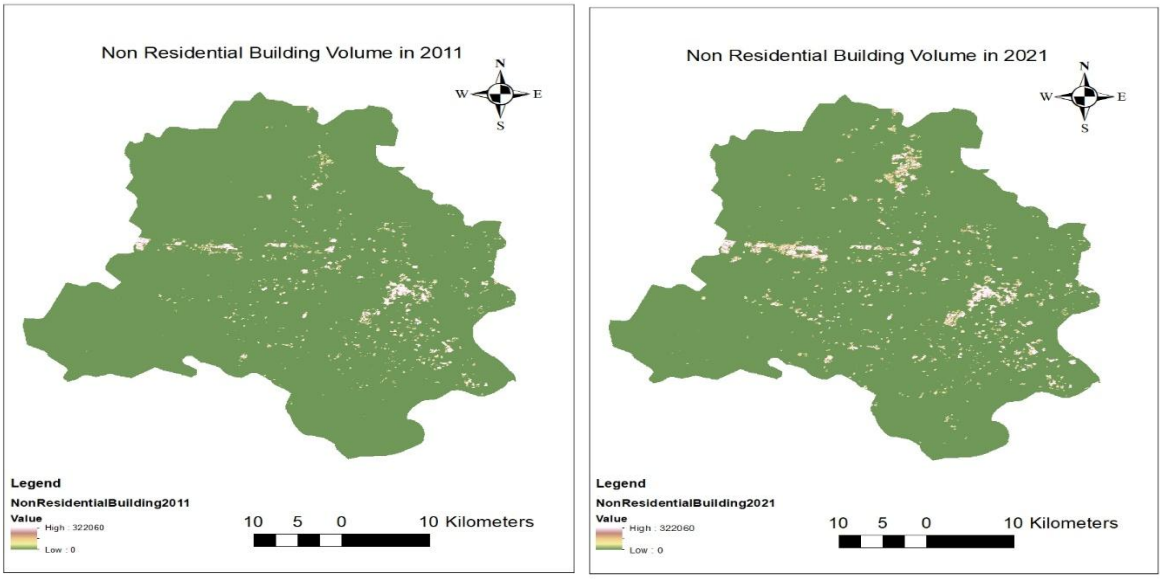


Figure 2.8

From the Fig.2.7 and 2.8, it is very much clear that residential building volume and non - residential building volumes both have increased during 2011 - 2021 in different parts of Delhi.

The impact of this change on different types of crimes in Delhi have been correlated and the results shown above in Fig.2.6 states that mainly the crimes in maximum numbers have been committed in west part of Delhi.

The study also finds the impact of noramalized vegetation index on different types of crimes in Delhi is as below:

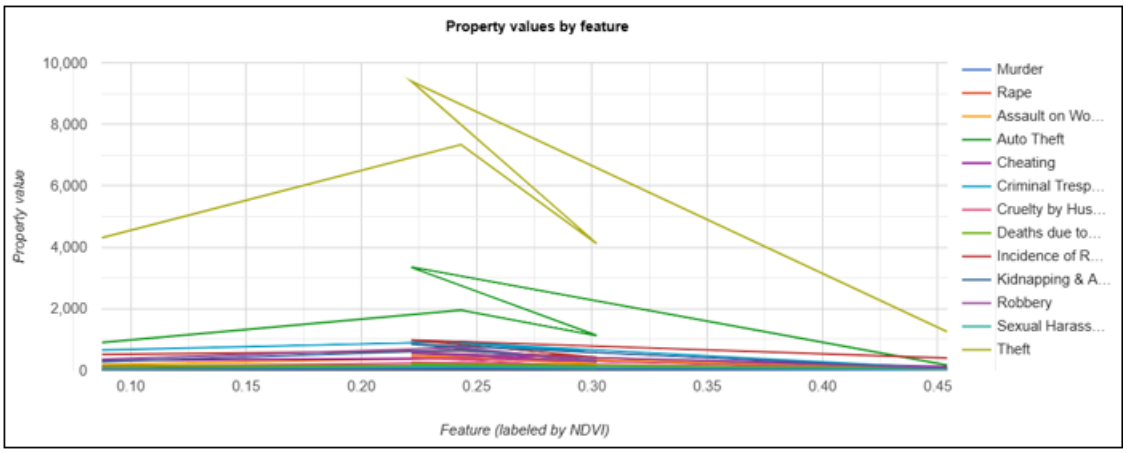


Figure 2.9

The vegetation in year 2011 was very very less and by 2021, vegetation grow was seen as per Fig.2.10 in South part of Delhi. Although no specific impact on a particular crime is seen, however, it is quite evident that with the growing of vegetation, **there has been found reduction in crimes.**

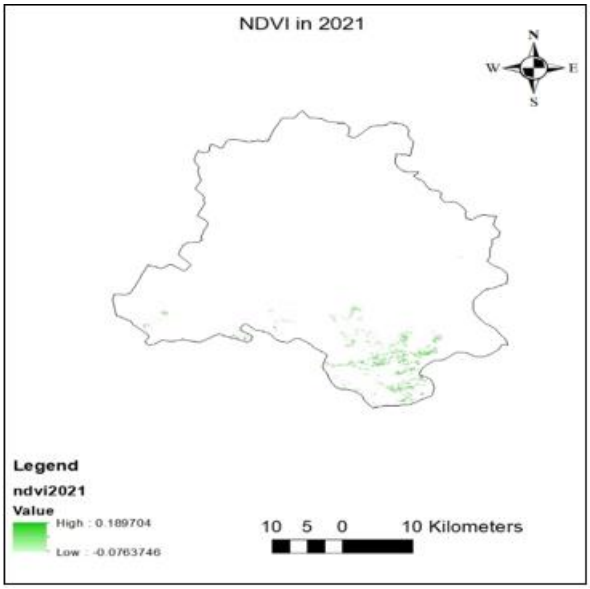


Figure 2.10

5. Limitations

The limitation in conducting this study being observed about the availability of data in very generic and consolidated form. Therefore, the type of crime/area of crime /hot spots etc. can not be specified for a particular location. The concerned agencies must publish crime data in a very systematic manner covering aspects like geographic locations of different types of crimes, frequency of crimes of similar nature along with area/location. A concrete insight could be provided from the presently available data, if data would have been structured as suggested.

6. Conclusions

The study concludes that under the correlation with various parameters, West Delhi, North - west Delhi, North and Central Delhi are the regions, where maximum number of a particular crime has occurred.

The most dominating factor is found to be average radiance in committing crimes. The areas where average radiance was 28 NanoWatts/sr/cm^2, a particular type of crime occurred maximum times. At the same time, minimum crimes occurred in average radiance of 132 NanoWatts/sr/cm^2. It is also observed that during the study period, no improvement has been seen as regards average radiance.

Research suggests that increased radiance, particularly in the form of improved street lighting, generally has a negative impact on crime rates, meaning it can help reduce crime by improving visibility and creating a sense of safety in a community; however, the effectiveness can depend on factors like the type of crime and the specific design of lighting installations.

Street lighting may be considered part of the physical landscape the infrastructure even of urban and suburban life in most industrialized countries. It serves several key purposes, including traffic and pedestrian safety and the prevention of crime (Beyer & Ker, Welsh &Farrington,).

Research suggests that a larger building volume, particularly in the form of high - rise buildings, can contribute to higher crime rates due to factors like limited natural surveillance, increased anonymity, and potential hiding spots for criminals, leading to a greater fear of crime among residents in such areas; essentially, the larger the building volume, the more opportunities for criminal activity to occur unseen, which is already established from the study.

Building height is one of the leading predictors of robbery rate in low - income public housing projects (Oscar Newman et al).
A high volume of non - residential buildings in an area can be associated with increased crime rates, particularly property crime, as these buildings can provide potential opportunities for criminal activity due to lack of surveillance and accessibility, especially when combined with poor design and inadequate lighting; however, the relationship is complex and depends heavily on factors like the type of non - residential building, neighborhood characteristics, and overall urban design.

When a large number of non - residential buildings are present, especially vacant or poorly maintained ones, they can offer secluded spaces for criminal activity like vandalism, burglary, and drug dealing.

Delhi, India's capital city, is one of the world's fastest expanding capitals. It has a diversified population and is distinguished by a blend of old and modern architecture. In the previous few decades, the city has witnessed tremendous urbanization, resulting in a changing physical landscape. The city's inner - city areas are densely populated, with tall buildings and small streets. The fear of crime is a serious issue in Delhi, and the physical environment influences citizens' perceptions of safety and security (Ar. Satyam Upadhyaya et al)

Population density is also one of the major factor in increased crimes. The study establishes that crimes are higher in dense populated areas as compared to less dense areas. The population density in Delhi almost has gone twofold during the study period.

There is no impact of Tree cover has been seen in the study, as the over - all growth of tree cover is just negligible. At the same time it is also observed that vegetation has increased during the period that negatively correlates with criminal activities.
Research suggests that increased vegetation, particularly in urban areas, can have a negative impact on crime rates, meaning that areas with more greenery tend to experience lower crime rates; this is attributed to factors like increased social supervision due to greater public space usage and a perceived sense of safety created by a more aesthetically pleasing environment

7. Recommendations

The concerned agencies must publish crime data in a very systematic manner covering aspects like geographic locations of different types of crimes, frequency of crimes of similar nature along with area/location.

The considerations to be adopted in effective lighting:
- Proper placement: Lighting should be strategically placed to illuminate potential crime hotspots without creating overly dark areas.
- Brightness level: Excessive brightness can be disruptive and may not always be necessary for crime prevention.
- Community engagement: Involving the community in lighting improvement projects can enhance their sense of ownership and contribute to crime reduction.

How building design can mitigate crime:
- Open spaces and clear sightlines: Designing buildings with open ground floor layouts and strategically placed windows can improve visibility and deter criminal activity.
- Well - lit areas: Proper lighting in common areas and walkways can increase visibility and discourage criminal behavior.
- Community - oriented design: Incorporating features that encourage interaction and a sense of community, such as pedestrian - friendly pathways and shared spaces, can reduce crime rates.

How enhanced vegetation can mitigate crime:
- Reduced crime rates: Studies have found a correlation between areas with high vegetation and lower overall crime rates, including fewer property crimes and violent acts.
- Psychological impact: Vegetation can contribute to a sense of safety and community, potentially deterring criminal activity by creating a more positive and welcoming environment.
- Natural surveillance: Dense vegetation can provide natural surveillance points, allowing residents and passersby to observe potential criminal activity more easily.
- Social cohesion: Green spaces can encourage social interaction and community engagement, which can further reduce crime rates. Research consistently shows that younger age groups, particularly late teenagers and young adults, tend to have the highest crime rates, with criminal activity generally declining as individuals age, a phenomenon often referred to as the "age - crime curve"; meaning that the impact of age group on crime is significant, with younger individuals being more likely to commit crimes than older people.
- Important considerations:
- Not all older individuals are crime - free: While the overall crime rate decreases with age, some older individuals may still engage in criminal activity, particularly white - collar crimes or offenses related to mental health issues.
- Social and economic factors play a role: Socioeconomic disadvantage and limited opportunities can contribute to higher crime rates among younger populations.
- Gender differences: While the age - crime curve applies to both genders, males generally have higher crime rates than females across all age groups.

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