Open Peer Review on Qeios

Perceptions of 3rd Generation CPTED: Emerging Applications of Technology in Public Space Designs in Smart Cities

Mamatha P Raj[1], Dakshayini R Patil[1]

1 BMS College of Architecture

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

This research delves into the 3rd Generation Crime Prevention Through Environmental Design (CPTED) and its technological integration in modern urban landscapes. As cities evolve into technologically advanced hubs popularly termed as Smart cities, enhancing citizen well-being, and promoting sustainable urban living becomes paramount. This transformation, while promising, confronts challenges, notably data security concerns and the seamless integration of the physical devices of IoT (Internet of Things) systems within urban designs. This study addresses the second challenge through the exploration of three aspects of smart systems- intelligent public lighting, smart surveillance, and interactive digital platforms with case studies under each aspect. The objective is twofold: to understand the role of technology in fostering secure urban environments, and to propose an integrative framework of digital security systems in the public realms. This proposed digital ecosystem framework aims to guide municipal decisions in architectural and urban design contexts for amicable accommodation of the physical components of smart systems.

Keywords: 3rd Generation CPTED, Urban Safety, Technological Integration, Digital Security Ecosystem.

1. Introduction

The world is becoming increasingly urbanized. As per United Nations, more than half of the global population lives in urban areas, while the urban share worldwide is rising from around one third in 1950 to around two thirds in 2050. Emphasis on sustainability and technologically advanced urban development is the primary movement in current times. Urban services are aiming to make lives easier, comfortable, and luxurious, while complexity of the infrastructure is equally increasing relying on information and communication technology (ICT) & digital advancements.

One of the theories under urban security systems has been Crime prevention through environmental design, popularly termed CPTED, a six-decade-old concept defined as a multi-disciplinary approach to prevent the occurrence of crime in cities through suitable environmental designs (International CPTED Association). It employs elements of design for built and natural environments to enable control of crime and provide safer environments to people in their neighborhoods. The CPTED concept developed by criminologist C. Ray Jeffery in the 1960s in the USA, concurrently with ‘defensible space’ theory by Oscar Newman introduced a new paradigm of giving the control of public spaces to the residents. The vision outlined that such design strategies deter offender decisions that precede criminal acts. Popularly known as ‘designing out crime’, it includes aspects of natural surveillance, access control and territoriality. As times progress and human societies evolve, concepts too advance to adapt and reconfigure to suit newer aspirations. Likewise, CPTED has renewed and adapted ideologically since its conception. This paper shall briefly understand the fundamental aspects of the three generations of CPTED, emergence and principles of 3rd Generation CPTED, smart cities, and exploration of three cases of technological safety systems.

1.1. Overview of 1st & 2nd Generations CPTED

One of the most important aspects of a good city is the sense of ‘safety and security’ (Lynch, 1984), and being free of crime or scared of crime.1st Generation CPTED had 4 components originally (Fig 1), over the years several modifications were introduced based on theories such as environmental criminology (Brantingham, 1981) that led to the birth of 2nd Generation CPTED introduced formally at the annual conference of the International CPTED Association in 1997 (Cleveland and Saville, 1997).

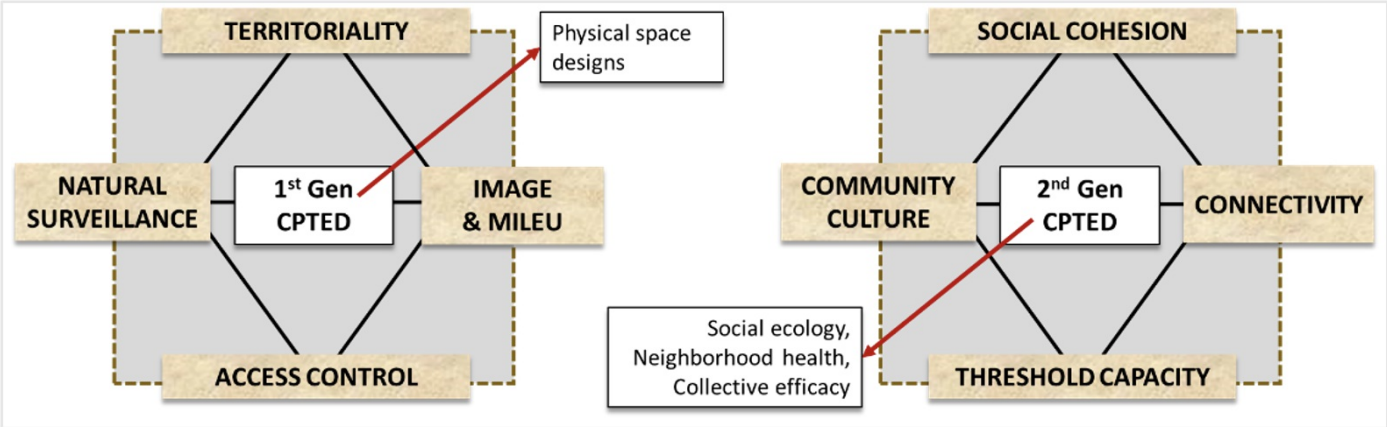

Figure 1. 1st and 2nd Generation CPTED components

Hence, while the 1st Generation aimed at reducing the scope of crime through physical space designs alone, the 2nd Generation identified that social ecology, neighborhood health, and collective efficacy (Fig 1) were prerogative to prevent crime (Mihiniac and Saville, 2019). Research conducted in Australia in the context of a secondary school annual year-end celebration event and prevention of crime revealed that 1st Generation proved ineffective as a stand-alone strategy whereas garnered better results coupled with 2nd Generation tools to foster social cohesion and increased threshold capacity (Letch et al., 2011).

1.2. Emergence and Principles of 3rd Generation CPTED

In 2011, a Joint project was presented in Milan by the United Nations Interregional Crime and Justice Research Institute (UNICRI) and Massachusetts Institute of Technology (MIT) *Senseable* City Lab under the UNICRI's Security Governance/Counter-Terrorism Laboratory held to assist effective policy decisions in the field of security. The MIT Lab researched the security in cities based on green urban design and eco-solutions in cities. It (UNICRI-MIT Report, 2011) put forth suggestions to revise existing CPTED principles and opinionated that the existing two generations of CPTED strategies did not consider advances in technology and environmental impacts on urban societies. Hence, it proposed a 3rd Generation CPTED inculcating the evolving digital advancements of modern times. This renewed model wished to seek community involvement along with creating better inclusive urban spaces and hosting well-equipped infrastructure to include in city designs aspects such as:

- enough urban public spaces for community gatherings
- efficient waste management system adopting the latest technologies
- efficient natural surveillance system – sufficient street light network, active streets, and public spaces always
- robust public transportation
- financial set-up towards the maintenance of civic spaces.

The UNICRI-MIT report concludes with a set of proposals with this new paradigm of CPTED and a broader vision encompassing diverse aspects of urban designs.

Hence, the 3rd Generation CPTED introduced additional principles of green environmental deisgn to the core ideas with two aspects of security enhancement and physical measures towards making urban spaces safer (Fig 2). It expanded security perceptions as a global issue with geo-political and socio-cultural divisions. Thus, it propagates a sustainable approach with the aim of elevating liveability and imageability (Fennelly and Perry, 2018). It introduces newer opportunities for citizens to upgrade their quality of life and personal aspirations (Mihiniac and Saville, 2019).

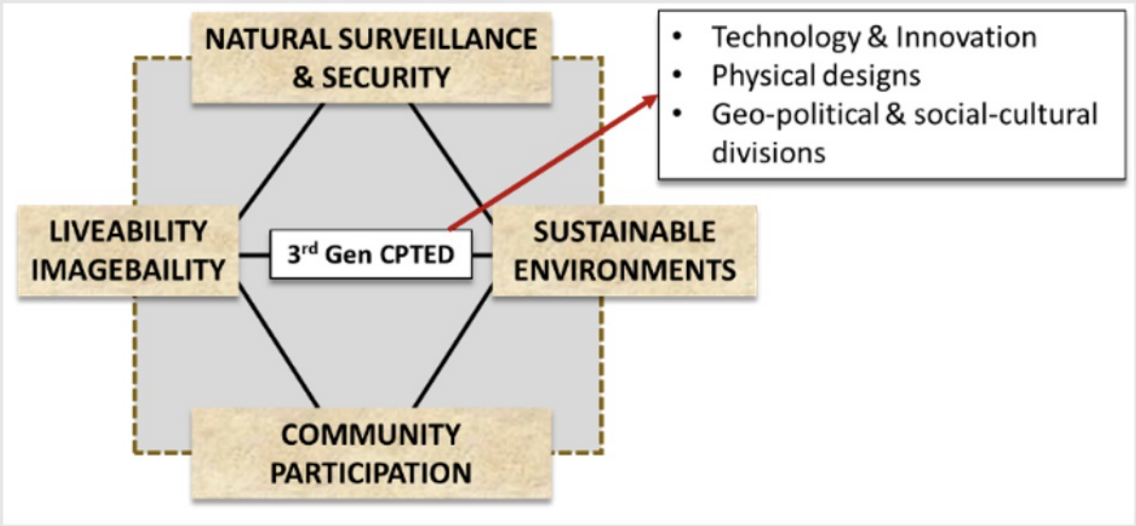

Figure 2. 3rd Generation CPTED

In line with Maslow's theory in which safety needs represent the second tier of pyramid of human needs, 3rd Generation CPTED asserts that residents will prioritize lower-tier of needs such as safety & security followed by higher-tier needs such as connectedness, life satisfaction, or achievements. Further, 3rd Generation CPTED in conjunction with the era of technological spike and converging with the green objectives of sustainability tended to become synonymous with each other (UNICRI Report, 2011). To sum up, a comparative understanding of the three Generations reveals the emerging trends of perceptions of safety under CPTED (Table 1).

Table 1. Collative matrix of the three generations CPTED derived from various literature cited in this study

CPTED->	1st Generation	2nd Generation	3rd Generation
Primary concept	Territoriality	Sense of Community	Green strategies
With focus on	Architecture & Physical designs	Social ecology, neighborhood planning & collective efficacy, small-scale environments termed as proximal orientation	Social innovation & sustainability driven by local communities
Initiation	1970s	1997	2010s
Proponents	Ray Jeffrey concurrently Newman & Rand (Defensible theory) as a start-off from Jane Jacob's 'eyes on the street' theory	Greg Saville & Gerry Cleveland	First mention in Joint report by United Nations Interregional Crime and Justice Research Institute (UNICRI) and Massachusetts Institute of Technology (MIT) in 2011 led by the architect and professor Carlos Ratti
Crime addressal	Physical designs to discourage occurrence of crime	Positive social relations between residents, Neighborhood watch initiatives to control crime	Technological aids for surveillance, and cybernetically enhanced beyond just basic safety objectives
Main components	• Territoriality • Natural surveillance • Image and Milieu • Access control	• Social cohesion • Community culture • Connectivity • Threshold capacity	• Surveillance & security • Sustainable environments • Liveability & Imageability • Community participation
Timeframe for implications	Short-time frames	Longer periods	Longer periods

1.3. Objectives & Methodology of the Study

The aim of this paper is to qualitatively explore the emerging concepts under 3rd Generation CPTED with the adoption of technology in designing public realms. It searches the possibilities of these concepts to induce resilience to crime and enhance the liveability of urban spaces. The main objectives are to perceive in these smart urban spaces, advanced and innovative urban design concepts with the hypothetical proposition: 'Liveability can be enhanced adopting technology towards stimulation of resilience to crime and induction of safety in the design of urban spaces.' Hence, questions raised are-

How and in what ways do technological applications enable creating safer and greener urban spaces?

What are the potentials and issues encountered in digitally equipped physical environments of urban spaces?

To answer these queries, the explorative study adopts a methodology of case studies of smart urban systems. The intent is to perceive instances where cities

have experimented with creative and systematic public space design for better urban experiences. The three cases are explored are under-

1. Intelligent Lighting Systems
2. Smart Surveillance and Security systems
3. Signage and Interactive Applications

This is based on a sample selection of three basic parameters of lighting, security, and signage from the deduced design aspects that are essentially characteristics of urban spaces discussed in the next section. Under each of these three aspects, at least three case studies are visited that offer wide range of perspectives on the smart designs.

2. Smart Urban Spaces

A smart city is commonly understood as the application of Information and Communication Technology (ICT) and Internet of Things (IoT) to sense, analyze, and integrate the key information of core systems in the functioning of a city (IBM, 2010). The ‘smart’ determines how the city optimizes urban functions to promote growth along with improving quality of life (TWI Global).

In India as well, as one of the fastest developing nations in Asia, the smart city mission (SCM) was introduced by the Government in 2015 with the objective of promoting cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment through the application of 'Smart' solutions (SCM, Government of India, 2015). These cities embed physical safety and citizen security, women’s safety, crime reduction and smart surveillance tools across urban centers through smart and safe city programs (Rao, BW Smart Cities, 2021). Urban designs are being supported with various technology-based tools introduced for safety designs, monitoring and execution in Smart cities with IoT tools (Fig 3). Smart cities have adopted CPTED strategies as an initiative towards creating safer neighborhoods. While it can be noted that many social concepts of CPTED have been embedded in Indian traditional settlements since times such as a cohesive neighborhood design with visible courtyards as centers, but which were lost out due to impacts of modernity & urbanization (Sarangi & Kapoor, 2021). Convergence of traditional ideologies of design and technological safety measures shall ensure a possible renewed holistic safety system in place. Safety schemes include responsive tools such as smart policing, predictive policing, smart stations, resource allocation, and crime management systems.

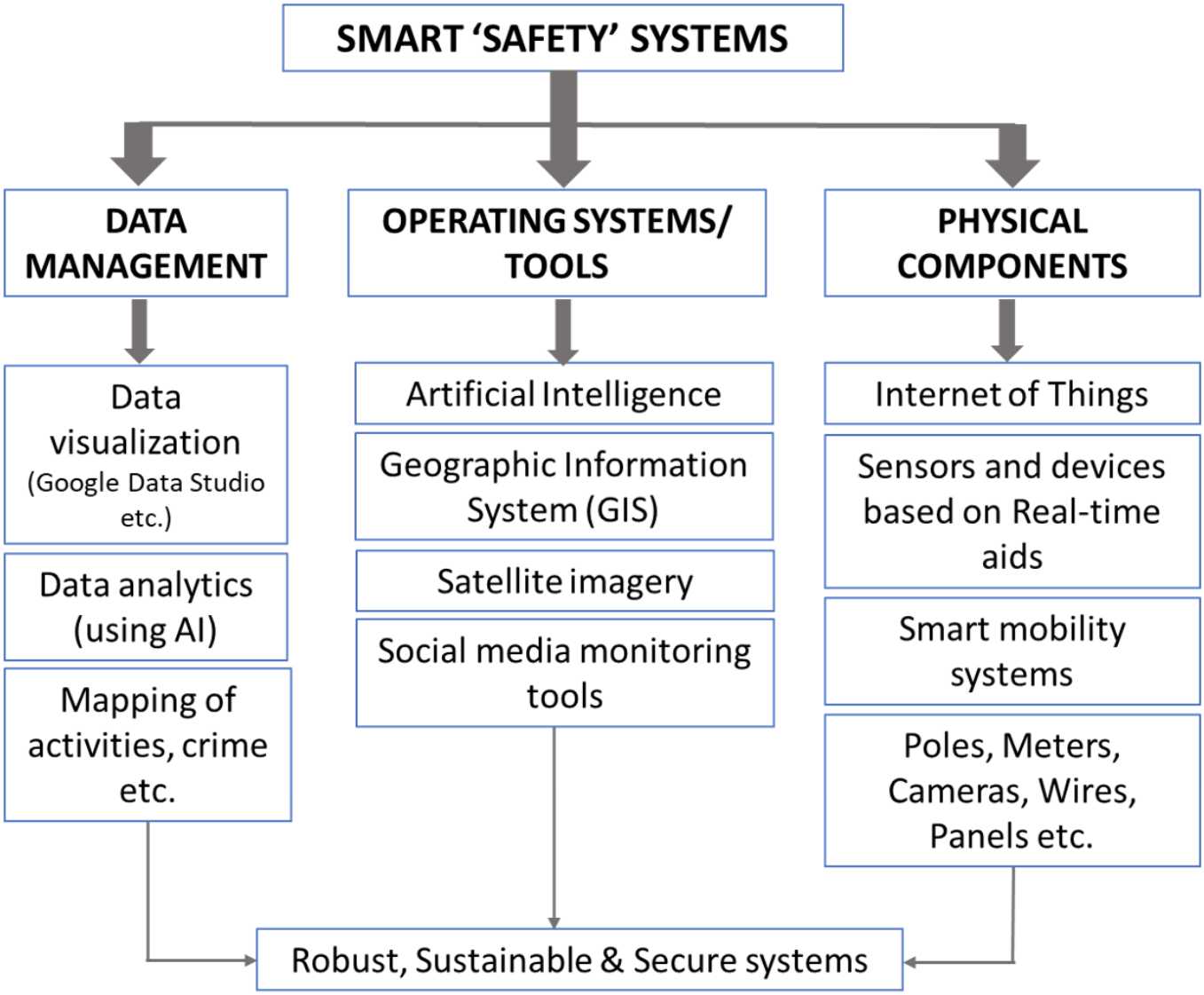

Figure 3. Main aspects of Smart Safety Systems collated from cited literature and Smart City Mission Portal, Government of India

Urban public spaces are one of the most crucial components in any city's spatial layout, that all citizens use and enjoy for various aspects ranging from basic needs of shopping, work, accessing amenities or leisure. Hence, it is understood that these spaces need to be democratic in nature and conducive to use, for which four criteria become fundamental – comfort (Nemanja & Marc, 2010), function (Whyte, 1980), safety, and vitality (Lynch, 1981) (Fig 4).

In this research the sample set for exploration includes selection of two parameters under 'safety' aspect viz., lighting & security along with one parameter under 'vitality' viz, signage which essentially reinforces the former 'safety' aspect (Fig 4).

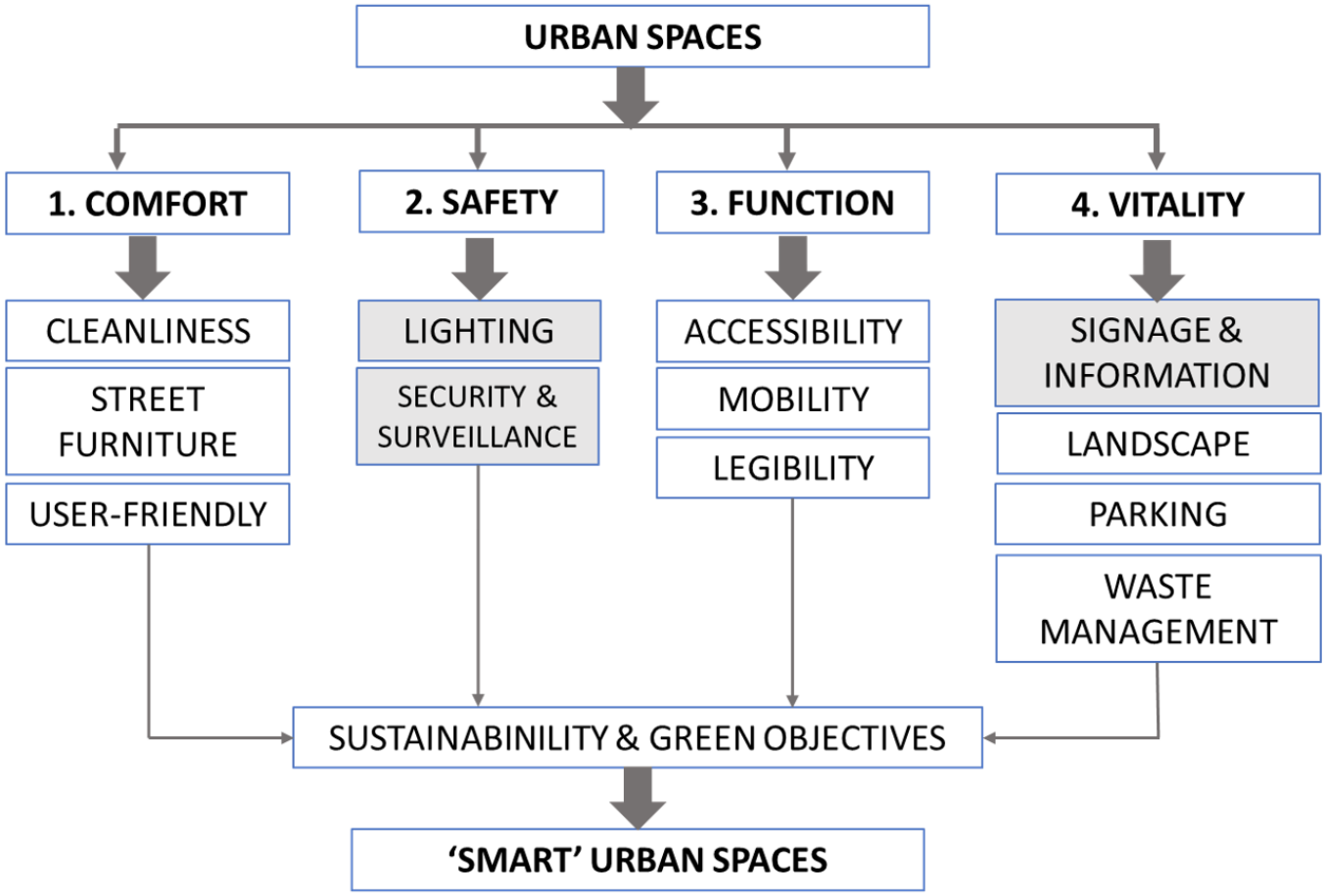

Figure 4. Main design aspects to create Smart Urban Spaces and selected three aspects for exploration in this study

3. Three Cases of Smart Security Systems

The focus is on examining the 3rd Generation CPTED strategies in smart public space designs for streets, intersections, parks, plazas, and commercial nodes. Though natural vigilance, surveillance, traditional setups, or policing cannot be replaced, technology enables a reinforced system of enhanced safety ecosystems. Smart cities embed this in their overall scheme of planning and design. For CPTED to be popular, it must continually respond to changing times of rapid urbanization, demographic profiles, diversities, evolving lifestyles, emerging crime profiles and newer technologies or products in the market as well (Cozens & Love, 2015). Hence, what are the ways in which technological tools be embedded in public space design, planning, and maintenance? Towards these, three cases are discussed ahead.

3.1. Case 1- Intelligent Lighting Systems

Street lighting in neighborhoods is an important factor for a safe urban realm & an evident investment by cities for reducing occurrence of crime (Painter and Farrington, 1999). It has been identified as a key aspect under CPTED core strategies (Robinson, 2013). In recent times, however when viewed with the demands of efficiency or sustainability in design, several factors become crucial such as energy consumption, context-driven detailing and intelligent lighting incorporating LED, solar-powered lights, or sensor-triggered lights.

First case study of innovative safety design is observed in the city of Brussels, Belgium municipality, Molenbeek-Saint-Jean who in collaboration with Sibelga, implemented 'smart lighting' cycling paths in public spaces adopted in 2022. The broad aim was well-being and safety of cyclists coupled with sustainable forms of energy. The design involves a light bubble that follows the cyclist along the path. Similarly, in Woluwe-Saint-Pierre district there are pedestrian crossings equipped with 'presence sensor lights' (The Brussels Times, July 2022).

Second case study in the city of Stonington, Australia involves design strategies for street lighting lamp posts which became creative elements in the urban design framework, with interesting designs and embedded multiple features such as cameras, Wi-Fi modems or emergency call-points. Public lights are equipped with sensors to convey real-time data to the municipality through a dashboard for efficient maintenance purposes (Stonnington city web portal). Similar instance is seen

in the *LuxTurrim* 5G project undertaken by a consortium of cell phone companies and research universities that devised a smart light pole-based 5G infrastructure with the goal to integrate several smart features (Fig 5). The project aims at technical innovations in conjunction with business opportunities to collate various services in an amicable manner (Varis, 2019).

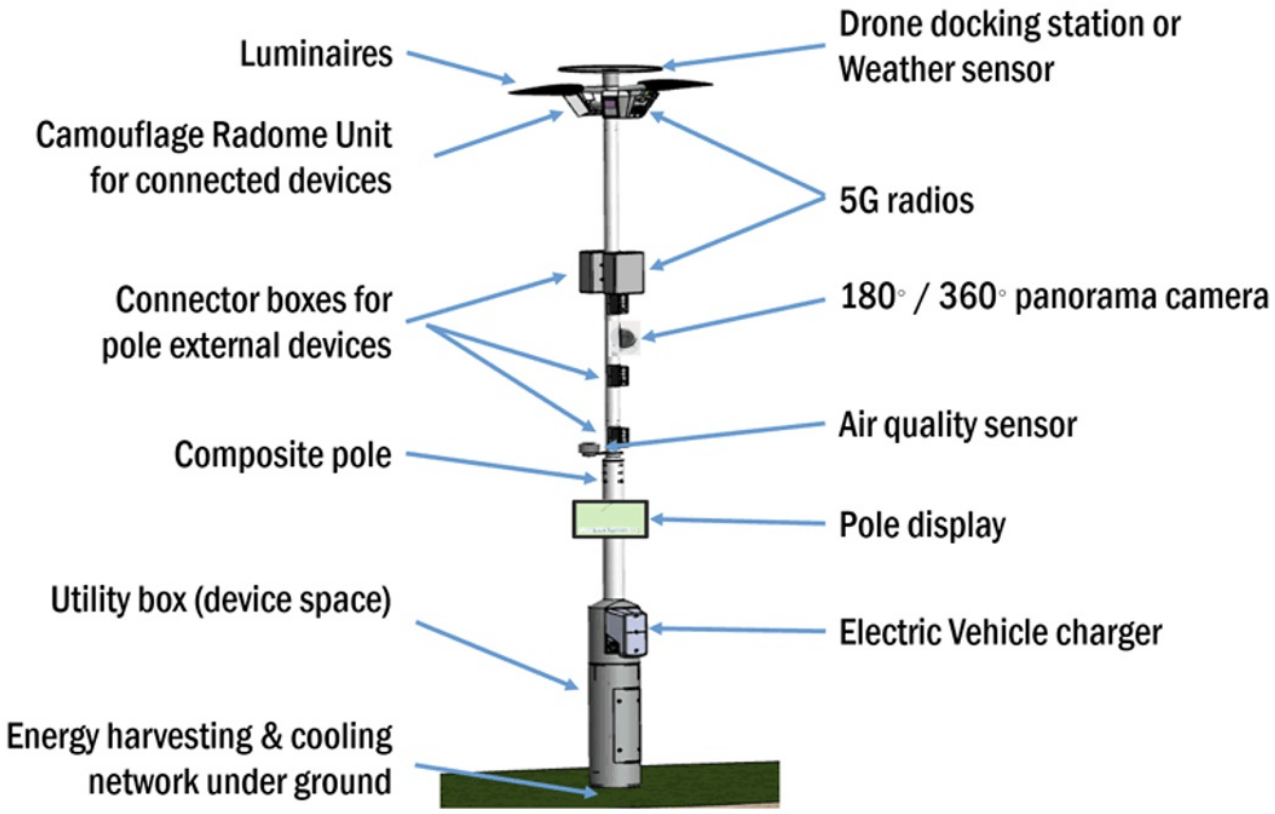

Figure 5. LuxTurrim5G light pole with integrated components of smart features- sensors and cameras (Source: https://ercim-news.ercim.eu/en117/special/luxturrim5g-smart-5g-light-pole-infrastructure-for-digital-service-ecosystems-in-cities)

Third case study refers to one of the smart city features in India that envisages additional functions for the illumination of urban spaces to enhance the quality of life, services and experiences for people and sustainability. This vision is taken ahead by various innovators such as Bajaj, Wipro, HPL and Philips Lighting India, which enlists 4 key urban areas of contribution (EPR Magazine Editorial, 2017) (Fig 6). The framework outlines a systematic and hierarchical approach from the scale of urban network up to details on the lighting specifics rendering a complete overview of the lighting ecosystem.

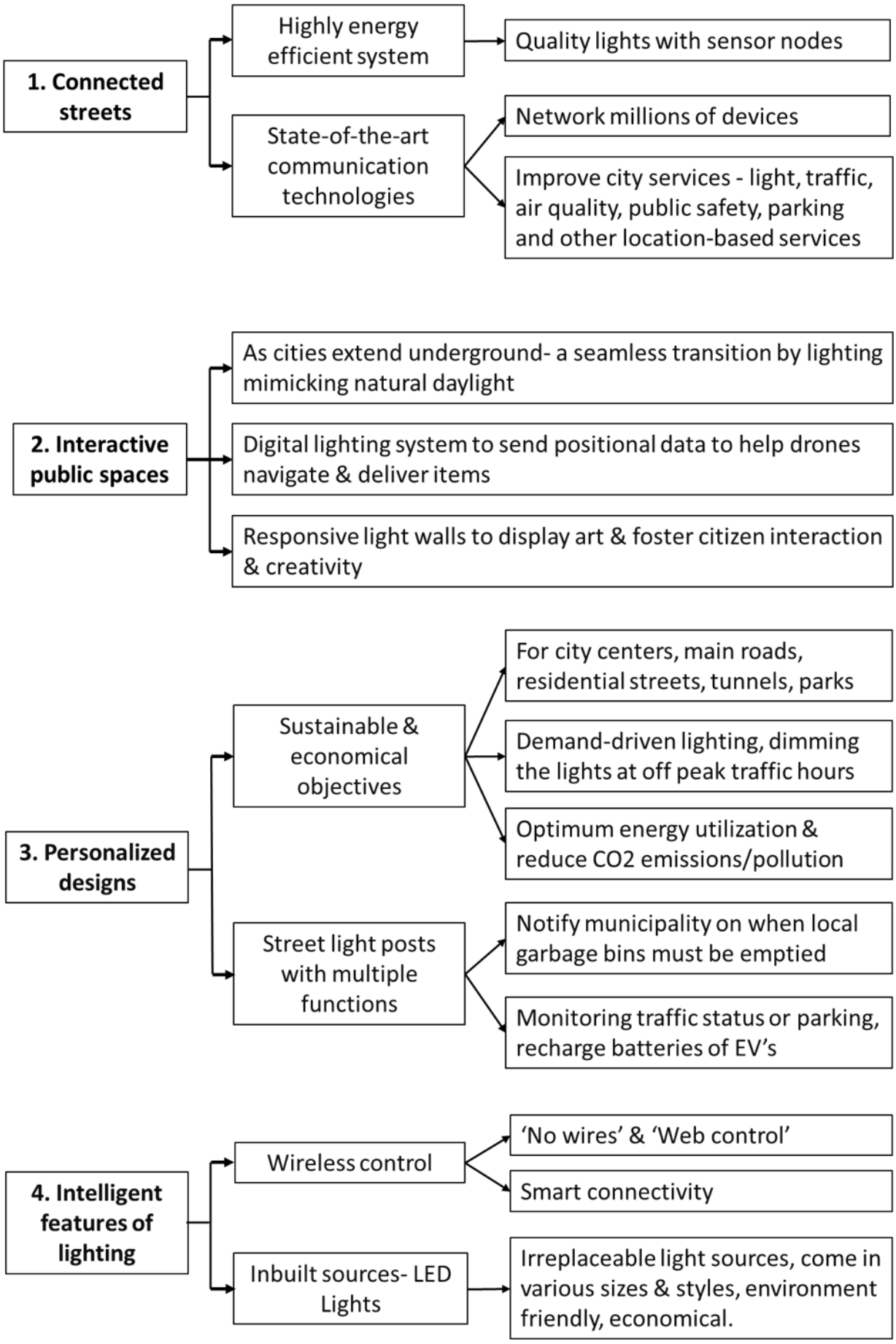

Figure 6. Four aspects of 'Smart City Lighting' in Urban areas (Compiled by Authors based on an article available at https://www.eprmagazine.com/features/powering-the-smart-

cities-with-intelligent-lighting/)

Thus, lighting innovations for safety and sustainability can be achieved at different scales of planning and design of public spaces with specific objectives in line with the larger vision and aspirations by the city for its people. Also, light pole designs offer potential of hosting several other smart features pointing at integrated & compact entities.

3.2. Case 2- Smart Surveillance and Security Systems

Video surveillance by installing Closed-circuit television (CCTV) in urban spaces is becoming common in the present times to enable real-time monitoring and reducing patrolling personnel. This technology has been revolutionized with innovations in high computing power, huge memory potential and ample processing capabilities. The system comprises cameras, transmission media, image analysis equipment, monitors, recording and storage systems. Camera resolutions come in varied capacities and quality of capturing the images, hence as per the expected degree of security, the right cameras need to be adopted. Additionally, surrounding lighting, background clutter, crowding of people or objects, day or night etc. impact the system selection, higher the possibilities of crime, higher the expected resolution. Operational attributes, software and hardware components need to be outlined while, sound detection, biometry, and CBRN-E sensors are adopted as per contextual demands (European Commission, Sept 2020).

First case study looks at research that has developed a futuristic urban design tool viz., the*LookCrim* application (Freitas, 2011). This tool gathers geo-tagged information on various locations in the city. It intends to map the four basic CPTED parameters from urban documentations and adopts a spatial-temporal analysis of crime-enabling data organization and apt urban design decisions thereupon. Studies based on this application have been published which revealed its benefits in safety design resolutions.

Second case study is in the case of Detroit smart city, where under the ‘Project Green Light’ crime was reduced by 50% by the adoption of a network of public and private cameras across the neighborhoods with two main objectives- provide critical evidence for investigations and discourage potential crimes since the cameras came with a green identification light. They are fitted with audio detectors as well to spot adverse noises such as glass-breaking or shouting to enable action before the escalation of crime; the sensors aid the Fire department in spotting fire as in cases of arson as well. Surveillance has been used to prevent railway suicides to a greater extent. However, to keep the security systems themselves protected, physical access control is enabled that includes video capture, QR Codes, visitor badges, and facial recognition to screen authorized personnel access exclusively (Sori; Axis Communications, 2020).

Third case study points at Cell phone applications (Apps) in general that make it inclusive for citizens to have an easy and immediate interface to communicate with respective authorities and be participants in the protection of public spaces (European Commission, 2020). Hence, public spaces are expected to be Wi-Fi enabled, equipped for easy and quick access to required phone services to be used in the case of dire circumstances and report to concerned support lines. It is recommended that every city develops an App with a user-friendly interface for any citizen to use with ease.

Fourth case study looks at the application of Drones or Unmanned Aircraft systems (UAS) considered as technology’s latest innovations are being adopted by cities to monitor public space security as in the instance of Turin, Italy. Drones can work in integration with ground surveillance for effective outcomes across smaller sized to large public spaces. In Madrid, Spain drones are extensively used by municipal departments for monitoring and surveillance during daytime and nighttime, public announcements, accident reconstruction and disaster management (EFUS, 2022).

Thus, digital surveillance is going beyond the basics of CCTV applications to innovations with equipping citizens to report crimes, aerial surveillance by drones and software development for prevention of crime or its escalation.

3.3. Case 3- Signage and Digital Interactive Applications

A legible system of urban spaces in a city becomes a step towards a safer city; when a citizen knows his city well and navigates with confidence, he is at ease and the likelihood of being subjected to crime is lesser. Signage aid in wayfinding and support branding, commerce, and economy as well for businesses to sustain. While static signboards have been around for long, smart cities are embracing innovations in technological tools and designs of signage are now human centered in approach (Sloly, 2023). Digital signage comprises of networked electronic displays in public spaces coupled with interactive features, where displays offer consumers possibilities to interact with the system (Bauer, Dohmen and Strauss, 2011). They provide a range of interactive facilities for information on city services, public transport schedules, local community updates, free public Wi-Fi, emergency warnings, advertisements, green walls, phone charging or game pods (Fig 7) (Smart Cities, Pavegen).

First case study looks at the application of kinetic technology to generate energy from people’s footsteps and power interactive applications by Pavegen, a UK-based company. This is called ‘people power’ which envisions in helping society to be sustainable while being progressive and involve fun-filled engagements for

the people. Interactive signage adds to the interest level of city designs for residents and visitors alike.

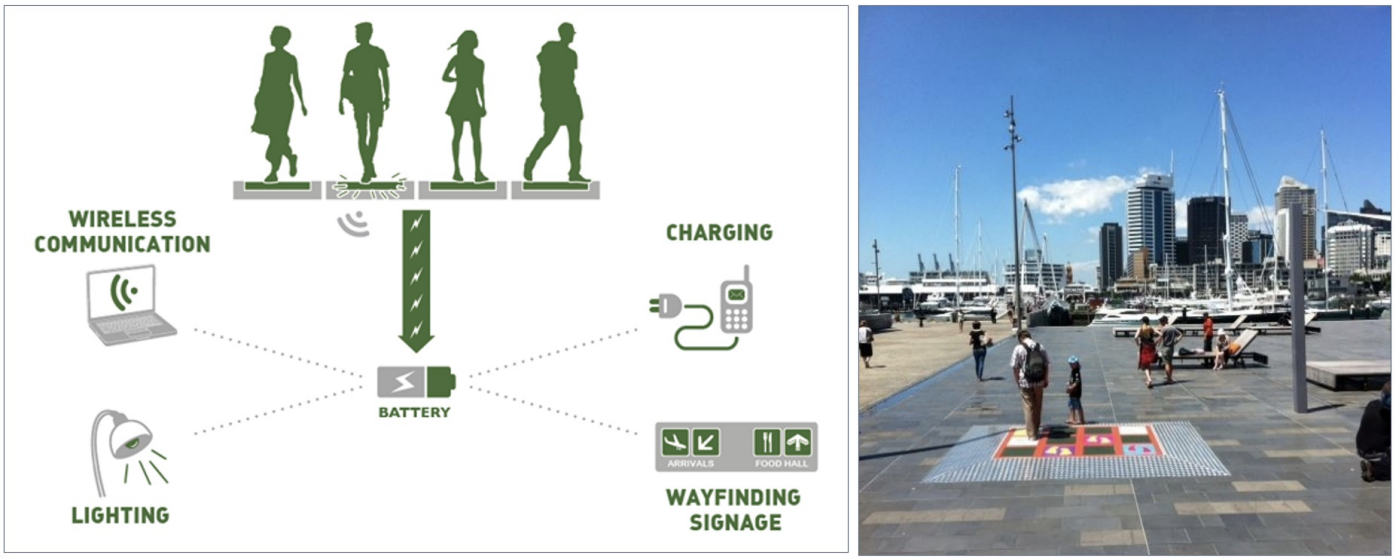

Figure 7. Pavegen Green system installed by Easy Freight in Karanga Plaza, Auckland, New Zealand (Source: https://www.pavegen.com/)

Second case study highlights a new perspective to interactive signage by a democratic built-in system that gives consumers opportunity of expression of opinion on the sign content. For example, if a person dislikes a 'macabre' in the display or any other discriminating content in the advertisement, he may use his phone to vote on the issue immediately with a simple user interface. The platform provider further collates such votes to enable suitable action on the signage (Bauer, Dohmen and Strauss, 2011). This gives cue to create an easy and quick interface App for the user to contact emergency services instantly with real-time location sensors.

Third case study looks at a project proposal titled*Pointsoft* for the Naples Circumvesuviana in Italy comprising of five crucial railway lines serving over two million commuters (Rocca, 2014). The project involved rejuvenation of the stations with a system of interactive multimedia installations aimed to enhance services, offer required information to commuters about rail schedule, connectivity, emergency numbers, and elevate the perception of safety in the stations and the trains. The interactive screens played videos on history of the place along with primary information. These displays allowed social control, increased sense of security, awareness of place and orientation (Rocca, 2014).

Thus, digital innovation offers wide possibilities of common man-to-technology interface under information signage along with inducing safety strategies from a personal phone App level to a public display interface. The case studies offer possible innovations across various hierarchies of planning and urban design.

4. Challenges to Smart Security Systems in cities

Crime detection, prevention, and people protection components of tech-enabled CPTED propose a fool-proof security system yet accompanied with certain challenges to be addressed to make the spaces liveable as well. They are meant to induce safety to common public and not intimidate with complex user interfaces nor bulky equipment occupying public spaces. Smart security systems in cities face two main challenges – firstly, concerns regarding breach of information confidentiality as data is on the global network, secondly the accommodation and integration of the physical components of the systems in the public space design. The study addresses the second concern as a scope under this research. Especially, in the context of Indian cities which are in most cases highly populated, demographically diverse with urban spaces becoming zones of high activity, crowding and multiple stakeholders, urban spaces become contested spaces for several entities vying for space. The streets are occupied with- people, trees, vehicles, hawkers, stray animals, infrastructure elements, waste dumps, shop spillovers, private encroachments by residents and commercial shop owners (Patil & Raj, 2019).

To compare the scenarios of urban spaces before and after smart city implementations, a study is referred to here- doctoral research conducted by authors during the pre-smart city implementation period in the city of Bangalore (capital of Karnataka state, India, and a globally progressive metropolitan city). The research developed a methodology to audit neighborhood streets & public spaces for elderly walkability. Results showed that the infrastructure elements accounted for nearly 80% of the barriers to walkability in the surveyed four neighborhoods. These overground utility units comprising of electrical transformers, light poles, cables, manholes, or control units for electricity, telecommunication & water supply services were observed to be placed and spread randomly occupying much of

the sidewalks along the streets in an uncoordinated manner leading to discontinuous pedestrian paths forcing pedestrian to get down to traffic laden roads proving unsafe causing accidents. Hence, it was observed that the complex utility or infrastructure elements impacted adversely the urban place-making and hence on the overall liveability (Patil & Raj, 2019).

One definition refers to smart city as - an instrumented, interconnected, and intelligent city (IBM, 2008); 'instrumented' pertaining to the modes of capturing and integrating real-time data using sensors, meters, appliances, and a range of other devices (Praharaj & Han, 2019). Embedding these physical components of the security devices into the architecture of urban space becomes critical for better designs that keep up the aesthetic value of the place and be user-friendly to all citizens. Right placement of equipment- light posts, surveillance cameras, cables, sensors, and access boxes in a manner as to:

- not hinder people's movement or comfortable usage of the public space
- not ruin the aesthetical realm
- not add to unsightly clutter
- not hamper routine/regular maintenance of devices by personnel
- not to be impacted by weather forces
- not easy to be destroyed/ vandalized
- not economically demanding nor environmentally harmful in any way.

The case studies under intelligent lighting presented scope of design for compact physical unit embedding various smart security features to combat the concerns of bulky, multiple-unit components and space-consuming infrastructure. This poses as a potential advantage to resolve clutter and chaos of units in urban spaces to further enhance the public realm for walking, accessibility, aesthetics, and overall ambience while being well equipped to be smart places.

5. Proposed Framework

The study hypothesized that liveability can be enhanced adopting technology towards stimulation of resilience to crime and induction of safety in the design of urban spaces. Under the scope of the study, was the concern pertaining to accommodation of the physical components of the smart systems in the public space designs.

From the case studies it is noted that smart systems of lighting, surveillance, and signage have created innovative solutions, one of the important outcomes being integrated and compact physical modules. While the research conducted in pre-smart city scenario showed adverse impact on public reams, on liveability aspects with unsafe and barrier laden sidewalks due to independent services and their corresponding physical components being spaced out in the public spaces. Thus, technological advancements under 3rd Generation CPTED which converge various security systems and services aid towards creating amicable and user-friendly public realms in cities. Hence, proving the hypothetical assertion of smart urban spaces paving way for liveable conditions.

Given the scope to collate security systems/ services and reduce complexity in urban design, leads to conceptualizing a proposal for an integrated, inclusive, and collaborative system of IoT with a proposed 'mesh of security' concept in city designs. Such a coherent system that integrates all services and security measures leads to effective utilization of the valuable open spaces in the city put for better socially enriched spaces such as public seating, parklets, or amenities.

Smart units can integrate- intelligent lighting, smart surveillance cameras, Wi-Fi, digital parking, environmental monitoring (pollution), a public information system for the visually challenged, charging points, fire safety measures, smart direction systems, interactive maps, and emergency calling stations (Colclough, 2021).

All security services should collaborate to reduce vulnerabilities of the systems with a single control point and sub-points while dispersing such elements in the public spaces. It becomes essential to coordinate between the physical components and innovate system designs to consume less space with the right choice of devices as well. Likewise, a robust people-centric approach to techno-safety designs of urban spaces becomes necessary for architects and designers in conjunction with CPTED strategies. The study proposes to initiates further research that looks at smart urban space designs with the perspective of integration of services and a definitive framework of guidelines for placement of the same in various spatial patterns.

6. Conclusions

The research highlights qualitative explorations of emerging concepts under 3rd generation CPTED with the adoption of technology in designing public realms in cities as possibilities to induce resilience to crime while enhancing liveability as well, with a focus on emergent smart urban spaces in cities.

The study with the three cases observed that smart security features are collaborative in nature with multiple attributes acting towards a wholesome system of functioning. It concludes with a proposed ideology of a 'network or mesh of digital security ecosystem' as an integrated mechanism. This further leads the way to

develop in the Indian urban contexts with the impending complexities and multiple components in public realm, architectural and urban design guidelines imbibing essential principles of CPTED for effective and progressive safety systems.

Additionally, a well-informed citizen who is technology savvy is a pillar in the 3rd Generation CPTED structure, along with a government that facilitates a user-friendly and robust security system to enable an overall boost to urban living with dual objectives of safety and comfort.

References

- C. Bauer, P. Dohmen and C. Strauss. (2011). Interactive Digital Signage - An Innovative Service and Its Future Strategies*International Conference on Emerging Intelligent Data and Web Technologies*, Tirana, Albania, pp. 137-142, https://doi.org/10.1109/EIDWT.2011.29
- Ceccato, V. (2020). The architecture of crime and fear of crime. Research evidence on lighting, CCTV and CPTED features. In V. N. Ceccato (Ed.),*Crime and Fear in Public Places: Towards Safe, Inclusive and Sustainable Cities* (pp. 38-71). Routledge. https://www.researchgate.net/publication/342757982_Chapter_3_-_The_architecture_of_crime_and_fear_of_crime_Research_evidence_on_lighting_CCTV_and_CPTED_feature
- City of Stonnington. Better lighting in public spaces. https://www.stonnington.vic.gov.au/Services/Transforming-Stonnington/Better-lighting-in-public-spaces
- Colclough, G. (2021). Smart Lighting in Cities Factsheet. EU Smart cities project, Action Cluster: Integrated Infrastructures and Processes. European Commission. https://smart-cities-marketplace.ec.europa.eu/sites/default/files/2021-06/Smart%20Lighting%20Factsheet_0.pdf
- Cozens, Saville & Hillier. (2005). Crime Prevention through Environmental Design (CPTED): A Review and Modern Bibliography.*Property Management,* 23(5):328-356. 10.1108/02637470510631483
- Cozens, P., & Love, T. (2015). A Review and Current Status of Crime Prevention through Environmental Design (CPTED).*Journal of Planning Literature, 30*(4), 1-20. SAGE. http://dx.doi.org/10.1177/0885412215595440
- Sloly, P. Emerging tech that can make smart cities safer- High-tech still needs to be high-touch (part 2) and Safe, smart cities: Enormous potential but significant challenges (part 3). Deloitte. Retrieved August 5, 2023, from https://www2.deloitte.com/ca/en/pages/public-sector/articles/emerging-tech-smart-cities-safer.html
- EFUS (European Forum for Urban Safety). (2022). Safe and Inclusive Public Spaces: European Cities share their experiences. Retrieved August 2, 2023, from https://issuu.com/efus/docs/publication_pactesur_en_v5
- EPR Magazine Editorial. (2017, Feb 4). Powering the smart cities with intelligent lighting.*EPR Magazine*. https://www.eprmagazine.com/features/powering-the-smart-cities-with-intelligent-lighting/
- European Commission. (2020, Sept 10). Use of Digital Technologies for the Protection of Public Spaces https://ec.europa.eu/newsroom/pps/items/686830
- Government of India. Smart City Mission. Retrieved August 14, 2023, from https://www.india.gov.in/spotlight/smart-cities-mission-step-towards-smart-india
- Joint UNICRI – MIT Senseable City Lab Report. (2011, April 18). Improving Urban Security through Environmental Design [Conference session]. Milan. http://www.carloratti.com/mat/publications/on_us/20110731_Unicri.pdf
- Letch, J., et al. (2011, December 5-7). An exploration of 1st and 2nd generation CPTED for end of year school leavers at Rottnest Island [Conference Proceedings]. The 4th Australian Security and Intelligence Conference, Edith Cowan University. http://ro.ecu.edu.au/asi/13
- Lynch, K. (1984). *Good City Forms*. MIT Press.
- Mihinjac, M., & Saville, G. (2019). Third-Generation Crime Prevention Through Environmental Design (CPTED).*Soc. Sci, 82*(8). https://doi.org/10.3390/socsci8060182
- Painter, K., and D.P. Farrington. (1999). Street lighting and crime: diffusion of benefits in the Stoke-on Trent project.*Surveillance of public space: CCTV, street lighting and crime prevention* 10: 77–122
- Patil, D R., and Raj, M P. (2019).*Mobility of senior citizens in urban public spaces of residential neighborhoods a case study of Bangalore*, Visvesvaraya Technological University, Belagavi, India. Shodhganga@INFLIBNET from http://hdl.handle.net/10603/344272
- Pavegen. Digital Signage in Smart Cities: New ways to engage.https://www.pavegen.com/blog/digital-signage-in-smart-cities-new-ways-to-engage
- Praharaj, S., and Han, H. (2019). Cutting through the clutter of smart city definitions: A reading into the smart city perceptions in India*City Culture and Society*, 82. http://dx.doi.org/10.1016/j.ccs.2019.05.005. Available at https://www.researchgate.net/publication/333623198_Cutting_through_the_clutter_of_smart_city_definitions_A_reading_into_the_smart_city_perceptions_in_India
- Rao, K. S. for BW Smart Cities. (2021, March 3). Redefining Urban India by building Safe and Smart cities- Providing technology-led security to urban India with the smart and safe City program. https://bwsmartcities.businessworld.in/article/Redefining-Urban-India-by-building-Safe-and-Smart-cities/03-03-2021-382765/
- Robinson, M.B. (2013). The theoretical development of “CPTED”: Twenty-five years of responses to C. Ray Jeffery.*The Criminology of Criminal Law* 8: 427–462.
- Rocca, L. F. (2014). Interactive Design and Safety in Urban Spaces: Two Case Studies of a Mobility Experience. In Marjanovic Dorian, Storga Mario, Pavkovic

Neven, Bojcetic Nenad (Ed.), *Proceedings of the DESIGN 2014 13th International Design Conference*(pp 2105-2114). The Design Society

- Sarangi, S., & Kapoor, K. M. (2021, March 13). A city isn't smart if it cannot provide safety.*Hindustan Times*. https://www.hindustantimes.com/opinion/a-city-isn-t-smart-if-it-cannot-provide-safety-101615639963791.html
- The Brussels Times. (2022, July 28). Brussels creates 'smart' lighting in public spaces to 'follow' cyclists on path.*The Brussels Time*. https://www.brusselstimes.com/263314/brussels-creates-smart-lighting-in-public-spaces-to-follow-cyclists-on-path
- The International Crime Prevention Through Environmental Design Association. Retrieved August 6, 2020, fromhttps://www.cpted.net/
- TWI. What is a Smart City? – Definition and Examples. Retrieved August 5, 2023, fromhttps://www.twi-global.com/technical-knowledge/faqs/what-is-a-smart-city
- Varis, J. (2019, April 12). LuxTurrim5G: Smart 5G Light Pole Infrastructure for Digital Service Ecosystems in Cities*ECRM News*. Retrieved August 15, 2023, from https://ercim-news.ercim.eu/en117/special/luxturrim5g-smart-5g-light-pole-infrastructure-for-digital-service-ecosystems-in-cities
- Whyte, W. (2021). *The Social Life of Small Urban Spaces, 8th edition*. Project for Public Spaces, Inc