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

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Abstract

This paper aims to explore the emerging 3rd Generation Crime Protection Through Environmental Design (CPTED) concepts and applications of technology in designing urban public spaces. Smart cities are rising worldwide becoming savvy, well-networked, safe, and intending to make the lives of citizens better and more comfortable while enhancing sustainability and urban living. Urban design and architecture in cities become reinforced with appropriate technological safety systems to support CPTED. Three cases of technology-based secure-smart systems are presented here namely- intelligent public lighting, smart surveillance, and digital interactive applications in city space designs. Literature and research indicate that while cities are becoming smart and networked, adopting renewable energy to run public security functions, they face two main issues: data breaches and the accommodation of the physical devices in the spatial layout amicably. Hence, smart cities along with service providers are working towards envisaging a robust scheme of action. This study looks at firstly, the aspect of 'technology' towards creating smart and safer urban spaces and secondly, derives a proposed framework for an integrated mesh of digital security ecosystems as strategic aid in architectural and urban design decisions by city municipals.

Keywords: 3rd Generation CPTED, Safety, Technology, Public space design, Smart cities.

1. Introduction

Crime prevention through environmental design, popularly termed CPTED is 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 concept developed by criminologist C. Ray Jeffery in the 1960s in the USA, CPTED grew as an extension of the 'defensible space' theory by Oscar Newman and the vision outlined that such design strategies deter offender decisions that precede criminal acts. It intends to build a sense of

community cohesion among residents so they can gain territorial control of areas, reduce crime, and minimize fear of crime. It is popularly known worldwide by terms such as ‘designing out crime’ and includes aspects of natural surveillance, access control and territoriality. As times progress and human societies evolve over the ages, concepts advance to adapt and reconfigure to suit newer aspirations. Likewise, CPTED has renewed and adapted to evolving times worldwide. This paper shall briefly understand the fundamental aspects of the three generations of CPTED, the emergence of the 3rd Generation, smart cities, and three cases of technological safety systems followed by inferences, challenges, and a proposal framework as a conclusion.

1.1. Three Generations of CPTED

One of the most important aspects of a good city is a sense of ‘safety and security’ (Lynch, 1984), and being free of crime or scared of crime. 1st Generation CPTED had 4 components (Fig 1). Over the years several modifications were introduced within CPTED such as environmental criminology (Brantingham, 1981) and renewed concepts were witnessed and described as 2nd Generation involving 4 components (Fig 1) at the annual conference of the International CPTED Association in 1997 (Cleveland and Saville, 1997).

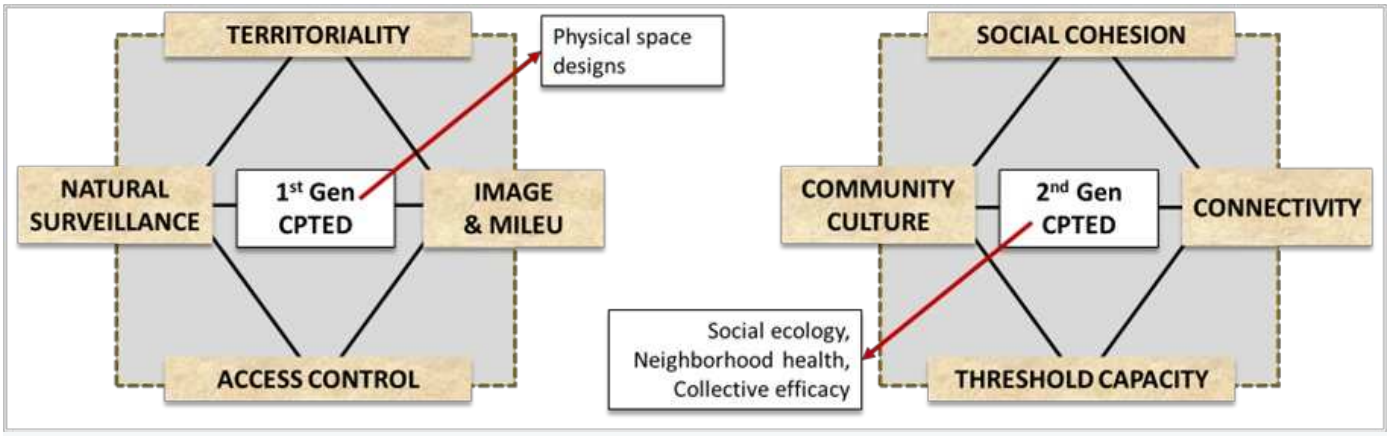

Figure 1. 1st and 2nd Generation CPTED components

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 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).

The 3rd Generation CPTED introduced additional principles of designing green environments to core ideas with two aspects of security enhancement and physical measures towards making urban spaces safer (Fig 2). It expanded to look at security 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).

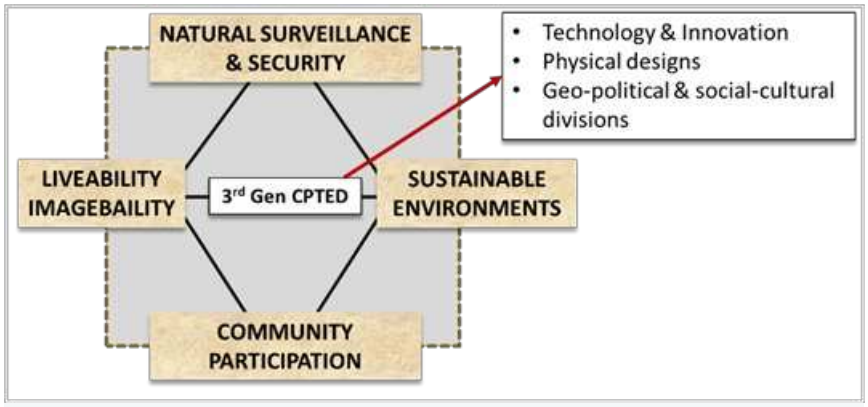

Figure 2. 3rd Generation CPTED

1.2. Aim and Objectives of this 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 extending beyond the 1st and 2nd Generation ideologies. Across the global scenarios, there have been design technological innovations, especially in the 'Smart cities' that support CPTED in creating conducive public spaces to access and use by all groups across gender, age, ethnicity, or socio-economic statuses.

The main objectives are to perceive in the fast-emerging Smart cities, advanced and innovative concepts in public space designs 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.'

1.3. Research Methodology

How and in what ways do technological applications aid in creating safer urban spaces? Are there any issues concerning these systems in cities? To answer the queries, the explorative study relies on theories and case studies. The methodology involves triangulation of a literature review of 3rd Generation CPTED, Smart city strategies and Case studies. The intent is to perceive instances where cities have experimented with creative and systematic public space design for safer realms. Three cases are explored-

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

This selection in the scope of this study is merely prioritizing three important elements in the safety structure to perceive in detail from amongst several available features.

2. Emergence 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 of 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 adopting situated technologies including the provision in city designs for:

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

3. Smart Cities, CPTED and Tools

The concept of smart cities emerged around the 1970s in the USA as the first generation of smart cities that resorted to technology in the daily processes of urban life and to tackle impending urban challenges. This was followed by the second generation that looked at the convergence of technology with municipal functions. The third generation moved over the control from technology providers and municipal authorities towards an inclusive system involving citizens. A city came to be prefaced as 'smart' to determine how it optimized urban functions to promote growth along with improving quality of life by adopting the Internet of Things (IoT) for efficient infrastructure, environmentally sustainable initiatives, effective transportation, and progressive vision plans for residents to live and work safely (TWI Global). Aside from services, smart cities envision safety measures for their people by tracking and tackling crime with a connected surveillance system.

In India, 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). These smart 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 such as:

- Urban data analytics
- Artificial Intelligence
- Sensors and devices based on Real-time aids
- Smart mobility systems
- Geographic Information System (GIS)
- Satellite imagery
- Data visualization tools (such as Google Data Studio, Power BI)
- Social media monitoring tools
- Crime mapping.

To introduce immediate response, the tools adopted are smart policing, predictive policing, smart stations, resource allocation, and crime management systems.

4. Three Cases of Technology for Security Systems in Smart Cities

The focus is on examining the 3rd Generation CPTED strategies in urban public spaces such as streets, parks, plazas, and commercial nodes. Though natural vigilance, surveillance, traditional setups, or policing cannot be replaced, technology enables a reinforced system of enhanced and effective safety ecosystems. They provide innovative and reliable modes to boost security services for citizens, build trust/confidence, strengthen community cohesion, and thus reduce crime significantly. Smart cities embed this in their overall scheme of planning. In their research, Cozens and Love (2015) concluded that 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.

What are the ways in which technological tools be embedded in public space design, planning, and maintenance? In the scope of this study, three cases are explored as follows.

4.1. Case 1- Intelligent Lighting Systems

Lighting in public spaces is the basis for a safe urban realm, hence when viewed with respect to efficient design and networking, energy consumption, context-driven detailing, ‘intelligent lighting’ becomes a crucial factor incorporating LED, solar-powered lights, sensor-triggered lights etc.

One instance is the city of Brussels, Belgium municipality, Molenbeek-Saint-Jean in collaboration with Sibelga, which created ‘smart lighting’ cycling paths in public spaces in 2022 in a move towards the well-being and safety of residents with sustainable forms of energy. A light bubble follows the cyclist along the path. Also, in Woluwe-Saint-Pierre there are pedestrian crossings equipped with ‘presence sensor lights’ (The Brussels Times, July 2022).

The Lamp posts can become creative elements in the urban scenario, with interesting designs and embed multiple

features such as cameras, Wi-Fi modems or call-points. Public lights may be equipped with sensors to convey real-time data to the municipality through a dashboard for maintenance as provided in the city of Stonington, Australia (Stonnington city web portal).

Smart cities in India envisage 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 – Bajaj, Wipro, HPL and Philips Lighting India with its 4 key urban areas of contribution (EPR Magazine Editorial, 2017) (Fig 3).

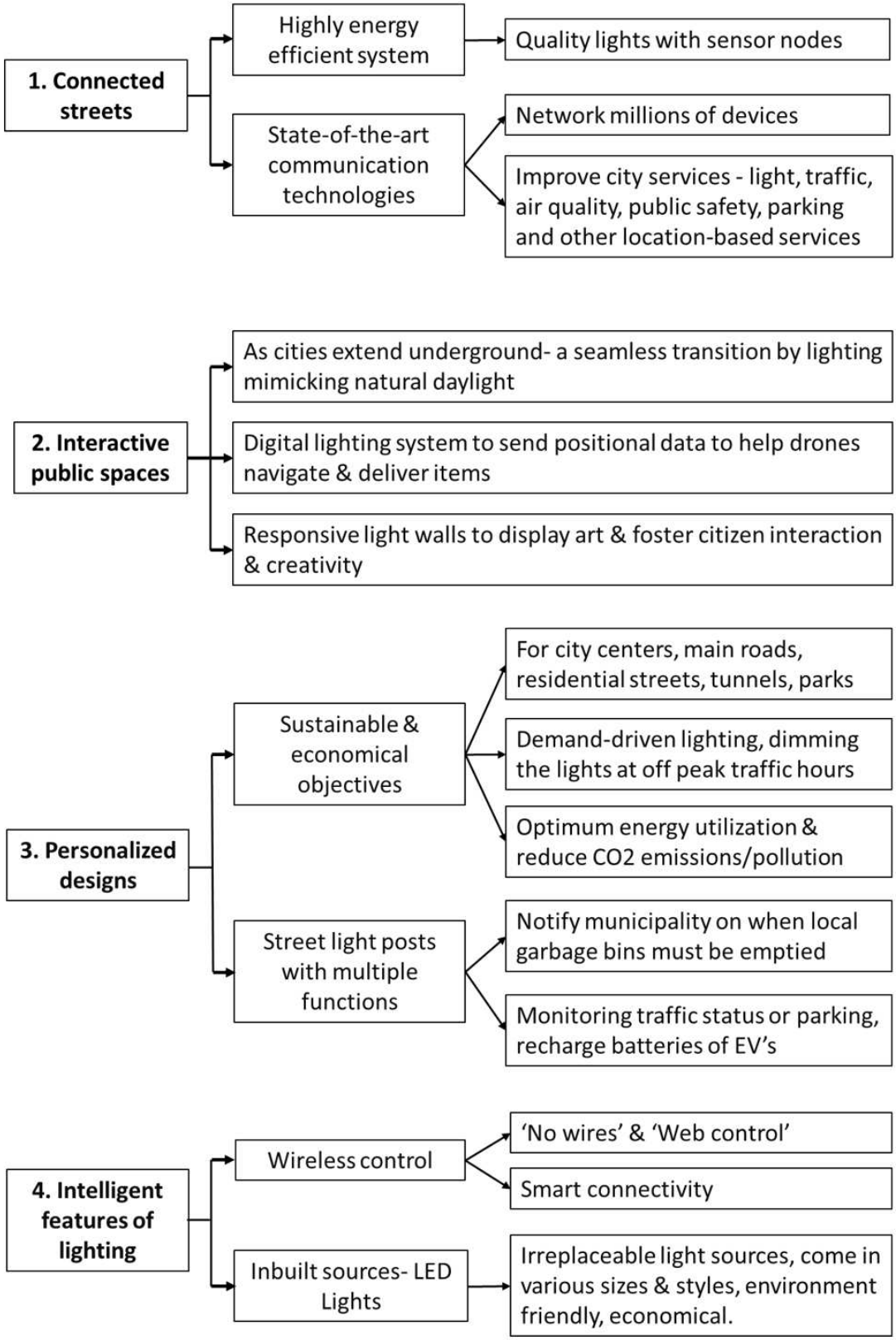

Figure 3. Four aspects of 'Smart City Lighting' in Urban areas (Compiled by Authors based on an article available at https://www.eprmagazine.com/features/powering-the-smart-cities-with-intelligent-lighting/)

4.2. 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 requirement of degree of security, the right cameras need to be adopted. Also, surrounding lighting, background clutter, crowding of people or objects, day or night etc. impact the decision; the higher the possibilities of crime, the higher the resolution. Operational attributes and supporting software or hardware such as cables, LAN, wireless or fibers need to be outlined. Similarly, sound detection, biometry, and CBRN-E sensors are adopted as per context demands (European Commission, Sept 2020).

Research has developed a futuristic urban design tool viz., the LookCrim application (Freitas, 2011) which gathers geo-tagged information on various locations in the city. This application intends to map the four 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.

In the case of Detroit smart city, 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. Surveillance has been used to prevent railway suicides to a great extent. However, to keep the security systems themselves protected, physical access control is provided that includes video capture, QR Codes, visitor badges, and facial recognition to screen authorized personnel access exclusively (Sori; Axis Communications, 2020).

Cell phone applications (Apps) make it inclusive for citizens with an easy and immediate interface to authorities and participate 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 use in the case of dire circumstances and report to concerned support hotlines. It is recommended that every city develops an App with a user-friendly interface for any person to use with ease.

Drones or Unmanned Aircraft systems (UAS) are technology’s latest innovations 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).

4.3. 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 supports branding, commerce, and economy as well for businesses to sustain. While signboards have also been around for long, smart cities are embracing innovations in technological tools such as boards that are interactive, responsive, interesting, informative, and easy user-interface. Designs of signage are now human- centered in approach (Sloly, Deloitte).

Digital signs in smart cities provided a range of facilities for city services information, wayfinding, public transport schedules, local community updates, free public Wi-Fi, emergency warnings, advertisements, green walls, phone charging or game pods (Fig 4) (Smart Cities, Pavegen). One case study is of Pavegen, a UK-based company using kinetic technology to generate energy from people's footsteps and power interactive applications. Hence called 'people power' they envision helping society be sustainable while progressive and fun-filled engagements as well. Interactive signage also adds to the interest level of cities for residents and visitors alike.

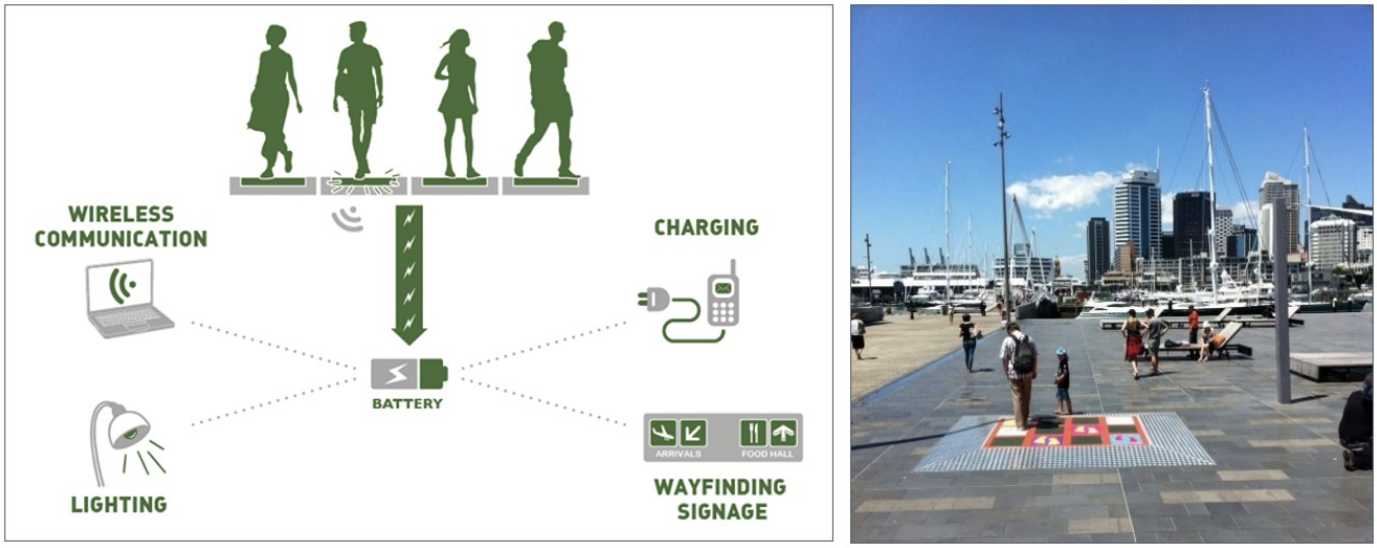

Figure 4. Pavegen Green system installed by Easy Freight in Karanga Plaza, Auckland, New Zealand

5. Challenges w.r.t Security Systems in Smart Cities

Smart security systems in cities face two main challenges - information confidentiality as data is on the global network, breach of the system itself leads to critical concerns and the physical components (placement of devices). Data is the main driver behind any smart city operation. Hence, the protection of the system becomes a crucial aspect to which cities along with technology providers are equipping themselves to address these concerns. While smart systems and IOT require initial capital investment, the benefits in improving urban life over time outweigh this and with the adoption of greener alternatives for energy, it seems to become a reliable security system in place.

Further, embedding the physical components of these security devices into the architecture of urban space becomes necessary for better designs that keep up the aesthetic value of the place and be user-friendly to all users. Right placement of 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.

Crime detection, prevention, and people protection components of CPTED enhanced with technology become a fool-proof system yet comes with challenges and needs to be addressed smartly to make the spaces liveable as well. They are meant to induce safety to the common public and not intimidate with complex user interfaces nor aid criminal mentality, which keeps evolving as well.

6. Proposed Framework of 'Mesh of Digital Security Ecosystem'

From the three cases it was observed that along with technological safety features in the design of public spaces, several other aspects of comfort can be converged. This enables a wholesome experience for citizens leading to improved overall liveability, hence proving the hypothetical presumption.

However, in view of the various technological features, complexity increases in urban design, leading to clutter impacting the social ambience. As observed in the case studies, it is a possibility that elements be woven suitably with a 'Mesh of Security' which is an integrated, inclusive and collaborative system of IoT sensors in the designs. A coherent system 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 (Smart lighting in Cities Factsheet, EU Smart cities, European Commission).

All security services shall 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 key to coordinate between the physical components and innovate system designs to consume less space with the right choice of devices. The strategy adopted by the city of Baltimore towards digitally updated and equitable infrastructure shows the way forward with the following strategies (Srivastava, AECOM).

- Transparent evaluation criteria and prioritization methodology
- Visually attractive and easily navigable user interfaces
- Meaningful dashboards and outputs
- Tool adoption based on real-use case analysis.

Likewise, a robust people-centric approach to techno-safety designs of urban spaces becomes necessary for architects and designers in conjunction with CPTED strategies.

7. 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 the fast developing 'Smart cities' displaying newer techno-methodologies across global scenarios.

The study with the three cases showed that smart surveillance processes are collaborative in nature with multiple features acting towards a holistic experience. It concludes with a proposed strategic framework of a 'network or mesh of digital security ecosystem' as an integrated mechanism with built-in combat against breaches of the system itself. This further leads the way to develop in the Indian context, architectural and urban design guidelines imbibing principles of all three Generations of CPTED for effective and progressive outcomes.

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.

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