POTENTIAL AND PROSPECTS OF ICT INTEGRATED MIXED-LAND USE FOR CONTROLLING URBAN SPRAWL

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Abstract

The world is urbanizing at an alarming pace, especially in developing countries where the exponential increase in urban population can cause unplanned and uncontrolled urban expansion, which ultimately results in urban sprawl. The phenomenon of urban sprawl has multiple definitions and dimensions, and most of them are hinged around an urban form or a land-use pattern with low-density. The various detrimental consequences resulting from urban sprawl include impacts related to the environment, economy, social aspects, and quality of life. To tackle the myriad issues related to urban sprawl, the process of urbanization has to be combined with sustainable and intelligent urban planning solutions like mixed-land use managed through suitable Information and Communication Technologies (ICT) infrastructure. ICT, as defined, includes various internet technologies, mobile platforms, GIS, distributed databases, etc. Mixed land use development is one of the most important sustainable urban planning paradigms to combat the flaws of urban sprawl by preserving and sometimes densifying the existing neighbourhoods resulting in less travel time and traffic congestion for the city dwellers. It promotes a range of land uses to be co-located in an integrated way that supports sustainable forms of transport. ICT enabled planning offers cities, a better quality of life for its residents by being safer, connected, smarter, and participatory. As we inhibit the effects of distribution of land-uses by compact mixed-use land development strategies coupled with ICT tools, the ultimate end result will be high density urban growth with savings due to the layout being less spread out through accumulation of land uses and proximity to various amenities, better opportunities for relaxation, greenery, secured access to pedestrians and less environmental impacts. The use of ICT will enable the mixed land-use regime to operate more efficiently and effectively. This is a conceptual paper which explains the various potential and prospects of controlling sprawl basically through the concept of mixed-land use and the innovative use of ICT. This paper emphasizes the benefits of mixed land use with ICT at the neighbourhood level and for various sectors like mobility, energy, and economy.

Keywords: Urban sprawl, Mixed-land use, ICT, Urban sustainability.

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1. Introduction

The 2018 Revision of World Urbanization Prospects produced by the Population Division of the United Nations Department of Economic and Social Affairs (UNDESA) expected that future growth in global urban population would be highly concentrated in just a few countries such as China, India, and Nigeria. They will together account for 35% of the world's urban population's predicted development between 2018 and 2050. By 2050, India is expected to have added 416 million urban residents. Unprecedented population growth together with unplanned developmental activities had led to chaotic urbanization which lacks infrastructure provisions and efficiency in the functioning and disregards urban aesthetics. This form of urban development, that is out of control, can be regarded as urban sprawl (Zhang, 2002).

Urban sprawl is described as uncontrolled, unauthorized, unplanned, and uncoordinated low-density single-use growth that does not provide for an attractive and functional mix of uses and/or is not functionally linked to the adjacent land-uses and which variously appears as ribbon or strip, scattered residential neighbourhoods and commercial strip development, leapfrog, or isolated development with automobile dominance which are aesthetically displeasing in nature (Nelson, 1995,Hiller, 2013) Some of the distinguishable features of urban sprawl are vast spatial dispersion of urban activities and forms away from the city centre, specific linear developments across highway infrastructure and the emergence of large open areas with distributed housing units, urban forms and urban patches of no explicit design in space (Zhang, 2000). Urban sprawl is the process of urban transformation leading to unwanted urban designs and patterns making space more homogenous and yet even more unstable (Polyzos, 2013). In the present day's urban sprawl is often classified as a key challenge to urban sustainability and its consequences, whether good or bad, is essential to assess sustainable urban growth (Davis and Schaub 2005).

One of those innovative solutions to combat the detrimental effects of urban sprawl is the idea of fostering mixed land-use development with Information and Communication Technologies (ICT) integration. ICT innovations together with mixed-land use can be viewed as catalysts of structural change in private, work and community live, resulting in the growth of more sustainable urban forms that are distributed, compact and offers mixed-use. Mixed-use development is the concept of mixing a variety of land uses in close proximity for creating active and vibrant urban environments. The advocators of mixed land-use consider traditional single-use zone-based planning as flawed, asserting that it encourages 'urban sprawl' and causes dissatisfying ecological outcomes and urban blight (Lewyn, 2006). In light of this, the concept of mixed-use developments has re-emerged as a reaction against urban sprawl that results in traffic congestion and poor liveability (Grant, 2002). It is absolutely a new concept that Information and Communication Technologies (ICT) have immense prospective to regenerate the chaotic urban areas efficiently. It includes all devices, applications, networking constituents, and schemes that jointly allow individuals and organizations (i.e., business, non-commercial agencies, governments) to interact in the digital domain. ICTs if used in a wise and comprehensive way, helps metropolises and their inhabitants become more justifiable by reducing the impacts of uncontrolled urban sprawl to a considerable extent.

By integrating mixed land-use development with ICT enabled tools, we will be able to utilize the pros of both these methods for effective sprawl control. ICT enabled mixed-land use development show great potential to achieve the desired urban development outcomes like high quality of public spaces, well-connected networks of infrastructures, well-designed density in terms of buildings and in particular of housing neighbourhoods, resources efficiency, excellent quality of life, reduced carbon emissions and it will help in dealing with the needs and risks of cities. In essence, ICT infrastructures act as a glue and adhere to the principles of mixed-land use

development thereby integrating various intelligence elements of the city, and functions as a central nervous system, capable of orchestrating the intentions among various central elements of the city. This paper aims to critically examine potential and prospects of mixed land-use development together with ICT to curb urban sprawl of undesired type.

2. Methodology adopted

The very aim of this paper is to look at the two tools namely ICT and mixed land use in an integrated fashion to control the impacts of urban sprawl. A theoretical analysis of factors contributing to urban sprawl and the enormous consequences emerging out of uncontrolled urban sprawl is studied in detail through an extensive literature search. The critical parameters which are responsible for the sprawled growth of city includes population growth, economic growth, improvements in infrastructure and technological innovations, lower land value and tax rates in the fringes, land hunger attitude, desire for homes with large lots, rural-urban migration, increased demand for living in greener surroundings, unsystematic development of landscapes, increase in standard of living, consumer preferences, lack of spatial planning and failure to apply it, etc. (Pendall 1999, Brueckner 2000, Carruthers et al 2002). The phenomenon of urban sprawl may result in numerous critical social, economic and environmental impacts for the city and its residents. Some of the critical impacts are tabulated in Table. 1. In order to ensure urban sustainability, it is of much importance to study about the damaging dimensions of urban sprawl and its effective control using superior planning tools and techniques. This paper tries to examine how far the detrimental consequences (social, economic and environmental) of uncontrolled urban sprawl can be tamed using an integrated tool of Information and Communication Technology(ICT) together with mixed land-use.

Table 1: Critical Social, Economic and Environmental Impacts of Urban Sprawl
(Kahn, 2000, Daniels, 2001, Nechyba et al, 2004)

Social impacts & Quality of life	Economic Impacts	Environmental Impacts
1. Large proportion of single households with intensive resources utilization 2. Segregated residential development 3. Less social interactions & longer time to commute 4. Increased obesity, stress and physical activity 5. Increased health issues (Eg. Asthma because of air pollution, Insomnia and other health effects because of noise pollution and urban heat island effect) 6. Overall reduction in quality of life	1. Higher cost of transportation for commuting to households 2. Increased use of car and high cost for public transport infrastructure 3. Higher cost because of traffic congestion 4. Higher cost for extending urban infrastructure into newly developed areas 5. Higher energy consumption per person 6. Rise in public service costs 7. Higher costs for the substitution of various ecosystem related services with technology	1. Heavy dependence on automobiles resulted in higher air pollution and depletion of fossil fuels 2. Higher noise pollution 3. Water pollution and hydrological alterations of watersheds, surface water courses etc. because of increase in impervious surfaces 4. Disruption of critical natural habitats and environmentally sensitive areas like wetlands, sacred grooves, wildlife corridors etc. 5.Reduced resilience of ecosystem 6. Fragmentation of landscape and loss of existing green infrastructure 7. Loss of agricultural land and reduction in open space

After consolidating the impacts of uncontrolled urban sprawl, the study evaluated that to a larger extent, these detrimental impacts can be tweaked/ tamed with the implementation of ICT integrated mixed land use development. An exhaustive literature review on role of ICT in taming urban sprawl, role of compact-mixed land use development etc. were carried out systematically. Although numerous papers were there on the use of ICT and urban sprawl, mixed land-use and urban sprawl etc., only very few papers speak about the role of ICT integrated mixed land-use in urban sprawl control. When ICT applications are integrated with mixed land use development, the cities reorganize themselves to contain the impacts of urban sprawl within a smaller circle with less extent of congestion, pollution etc. and this will ultimately result in the improvement of quality of life and urban sustainability. The paper explains the concept and benefits of ICT-integrated mixed land use in detail. It talks about the potentials of ICT integrated mixed land-use at the neighbourhood level for the safety and security of the inhabitants, water supply, and waste management. The use of ICT integrated mixed land-use in some of the critical sectors like mobility, energy, and economy etc. were also dealt briefly in this paper. In addition, the paper also attempted to compare various characteristics of development in a sprawled city and a city with ICT integrated mixed-land use.

3. Concept of ICT Integrated Mixed-Land Use Development

One of the key features of urban sprawl is that it is of single land use in nature. Land uses are said to be segregated by distances that encourage the use of the automobile and for this reason are regarded as unsustainable and unhealthy (Web-1). New Urbanism and the Compact City movements regard the mixing of land uses, in higher density form, as a significant way of combating the effects of sprawl. Mixed-use development can be characterized as the mixing of a variety of uses in development to put in close proximity distinct land uses together. It includes a range of land uses such as residential, commercial, retail, leisure, cultural, civic (community), hotel, transportation, etc., (Schwanke, 2003). The idea of compact mixed-use development together with ICT enabled tools stresses that urban activities should closer together to ensure better access to day-to-day services and amenities well integrated with public transport, walking, and cycling etc., highly efficient provision of utilities and infrastructure together with mix of land uses, can also assist in maximizing the safety and surveillance of people.

To better understand the mixed land-use concept, one has to look at the critical elements that influence the texture of an urban area, namely: grain, density, and permeability (Sara et al, 2019) The grain refers to how the land uses are mixed. Settlements can be either fine grain or coarse grain. Finely grained settlements are characterized by closely meshed land uses, as illustrated by figure 1 (a). In contrast, figure 1(b) shows settlements that are coarse. Coarse grain settlements have larger homogenous areas for each land use, and each use is slightly more separated. Density relates to the land-use intensity and can be measured as number of people per unit area. Permeability defines the extent to which urban form allows motion/movement of individuals and vehicles in distinct directions. A permeable layout (Figure 1(c)) allows for numerous access routes while impermeable urban form (Figure 1(d)) restricts the number of thoroughfares (Gentin, 2009). The land uses must be "mutually beneficial" or complimentary. Citizens living in mixed-use communities will lead more 'sustainable' lifestyles by choosing to walk, cycle, or catch public transport to their destinations instead of using their cars
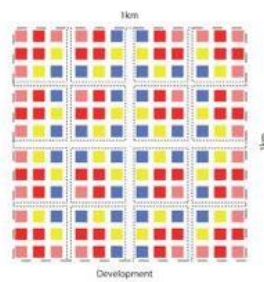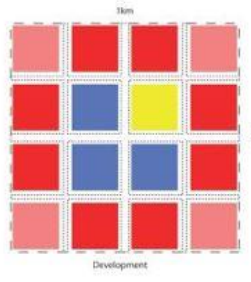
Figure 1.a: Fine grain of land uses
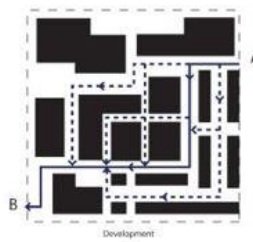
Figure 1.b: Coarse grain of land uses

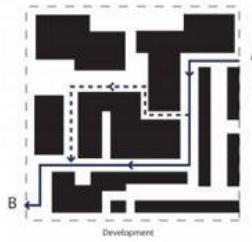Figure 1.c: Permeable development

Figure 1.d: Impermeable development

Figure 1 (a)-(d): Critical elements that influence the texture of an urban area (Source: Gentin, 2009)

There is no particular, general definition for ICT. ICT includes all devices, applications, networking constituents, and schemes that jointly allow individuals and organizations (i.e., business, non-commercial agencies, governments) to interact in the digital domain. It represents a wider, more complete list of all constituents related to computer and digital know-hows. ICT plays a vital role in viable urbanization development to confirm the best class of living milieu for its citizens. The EU definition unambiguously refers to ICT as a core constituent of smart solutions. In this vision, ICT is an instrument to develop solutions for further executing smart enterprises. ICT is evaluated both for itself and as a technology supporting smart facets such as mobility, e-governance and so on (Carruthers et al, 2002). Hence, ICT investments in the city will empower the scheming of smarter cities which offer better class of life for the inhabitants in a more sustainable and cost-effective means.

By employing ICT enabled tools in mixed-use communities, one can do almost all activities ranging from work, leisure, shopping, etc. by simply sitting at the comfort of your own home. As a compact entity, such ICT enabled mixed land use cities do not need cars to be used rampantly as the distance is shorter or not a matter at all. Mixed land-use advocates also retain that cities and towns will become more appealing, more feasible and more secure areas to reside and work with ICT inclusion. Mixed land-use with an ICT element has been identified as a key strategy to limit the adverse effects of urban sprawl as it provides a model to increase density as well as reduce dependence on automobiles, emissions. This innovative type of use seeks the creation of an environment which is pedestrian-friendly, high density and has diverse applications, which enable people to live, work, recreation, and shopping in their zones of comfort. Figure. 2 shows a comparison between a conventional development zoning approach, compact mixed-use planning approach, and mixed-use land development with ICT integration. Zoning rarely dealt with or set rules for urban design and quality of architecture. Typically, zoning regulations permitted only certain kinds of use within each separate zone, such as detached single-family homes (live) or commercial buildings/ offices (work) or park/leisure areas. One needs to depend on automobile transportation for accessing each land-use class because of the greater distance between them. In this era where we consider time as equivalent to money, the more time you spend commuting

in your vehicle and traveling to make orders (like routine shopping) you have less time to enjoy your hard-earned cash and adopt all-round value in urban life. Mixed-use development helps to dynamically alleviate these problems by establishing an atmosphere where one can live, work, and play all in close proximity. Here sustainable modes of transport like public transport, walking, cycling, etc are encouraged
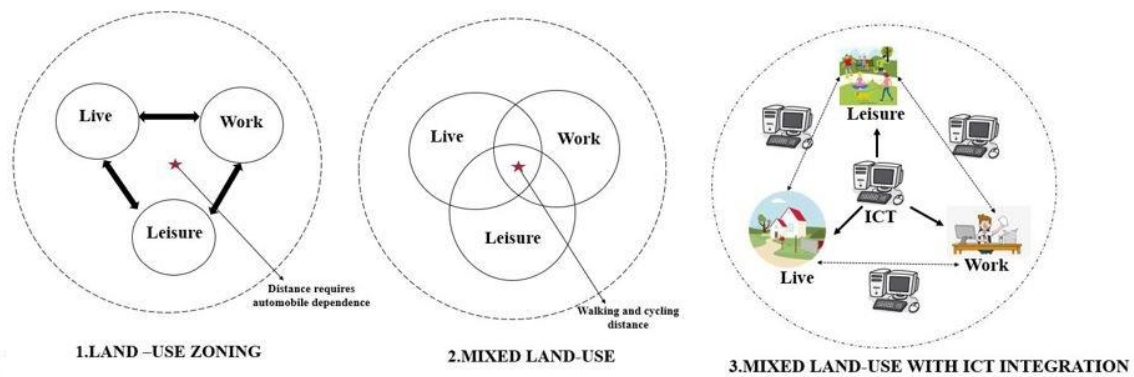

Figure 2.1. Land-use zoning, 2.2. Mixed Land-use, and Figure 2.3. Mixed Land-use with ICT integration

ICTs if used in a wise and comprehensive way, helps cities and their inhabitants become more justifiable by reducing the impacts of uncontrolled urban sprawl to a considerable extent. In Figure 2.3, we can see a balanced and efficient flow of all activities related to living, work, and leisure with ICT support. Here one can sit at the comfort of his/her home and can do all activities effortlessly with a well-connected internet system. However, it is certain that ICT resolutions glued with mixed-land use development will lead to more sustainable urban forms which are free from the detrimental effects of urban sprawl. In this paper, we elaborate the ICT and mixed land use applications in residential land use and mobility sector to tame uncontrolled urban sprawl.

4. Benefits of Mixed Land-Use Integrated with ICT

If we truly look at mixed land-use in a given area, the use of ICT makes it much easier for the mixed land-use regime to operate. ICT with its smart sensors and networks can probably make the same urban space more functional by accommodating different functional uses like work, home, leisure, etc. Conceptually, even interchangeable functions become a reality with the integration of ICT with mixed land-use development. When we club different uses together to form a mixed land-use development, the areas become safer to operate because round the clock there will be some sort of activities happening in an around that area. The subsequent sections examine the benefits of mixed land-use integrated with ICT at the neighbourhood level, which includes the safety and security of the inhabitants, water supply, and waste management. The later section talks about the benefits of ICT integrated mixed land-use in some of the critical sectors like mobility, energy, and economy.

5. ICT Integrated Mixed Land-Use at the Neighbourhood Level

This section talks about the potentials of ICT integrated mixed land-use at the neighbourhood level for the safety and security of the inhabitants, water supply, and waste management.

5.1 Safety and security of inhabitants

The most commonly cited feature of urban sprawl is low-density single-family dwellings with larger lots which consumes huge amounts of previously unoccupied or productive land. This sprawling pattern of development gives rise to larger distances between housing units and segregate different land uses, thereby residents are forced to depend on automobiles for commuting. Shrinking household sizes with increasing house sizes is a characteristic feature of residential areas in a sprawled city. In order to limit urban sprawl, we need to build higher-density housing or concentrated living with mixed land-uses in which ICT has a major role to play.

The idea of compact mixed-use development can be considered as a solution to tame uncontrolled urban sprawl of undesired type. This type of mixed-use development stresses that urban activities should be located closer together to guarantee better access to services and amenities needed for daily living that are well integrated with walking, cycling and public transport with extremely effective utility and infrastructure provision together with a mix of land uses. It can also help in maximizing the safety and surveillance of people. Mixed land use *per se* did not require much ICT for its functioning. But mixed land use becomes easier to adapt if an element of ICT or network comes into the picture. For example, the technique of geofencing can be used for safety and security purposes in a large mixed-use building where people live, work, and play. It is a kind of fencing for mobile devices or, radio frequency identification (RFID) tags when they enter or exit the virtually created boundaries by the technology of geofencing. It can be designed for indoors and outdoors as required. GPS, RFID, Wi-Fi, or cellular data etc are some of the techniques employed in geofencing. The geofences themselves can be highly customized, such as a particular radius around a house or elsewhere; or developed through a predefined set of boundaries, like schools, neighbourhood centres, or grocery stores, etc. It can also help immensely in the fields of home and office automation too.

The growing violence and the feeling of insecurity are the two major challenges to high density concentrated living around the world. ICT has immense potential to address these two challenges effectively and efficiently. (Sokido et al, 2015). ICT territorial systems can be used for monitoring crimes and increasing security in city neighbourhoods (Dameri, 2017). When it comes to security in high-density patterns of development like apartments, condos, duplexes, etc., ICT offers instruments comprising state-of-the-art techniques, intuitive but extensive solutions and 24/7 peace of mind. mind. ICT solution offers safety, video surveillance, elevator control, community facilities, wireless locking, access control, building automation, and round the clock alarm monitoring - everything from a single platform by enhancing operational efficiency while offering residents an exceptional smart living experience. With a single swipe on your smartphone, you can check the status, locks, lighting, heating -even cameras-at anytime, anywhere. An ICT enabled access control system is considered to be a repository of data regarding the residents and the building-who is onsite, where they are, and even when they're likely to be going. In the event of a theft or trespass, an ICT enabled alarm will get activated, and the security guards are warned so that response can be initiated or summon emergency services and hence it helps in achieving an added piece of mind. Also, ICT enabled high-density residential units to harness a wide range of community amenities like club rooms, gyms and swimming pools, etc. in which one central system is capable of controlling the access and management of these facilities (Web-2). In overall terms, ICT enabled higher density residential development creates more diversity and vitality to tame the adverse effects of low-density sprawled residential growth.

5.2 Water supply

Water plays a crucial role in the development and functioning of cities. There exist very advanced techniques and technologies for water supply and its conservation at the city level. With the increasing rate of urbanization, the authorities cannot enhance their infrastructure at the same rate but can bring significant improvements by altering the way they operate. Some of the techniques like optimizing the pressure at which water is supplied, demand-based supply, etc. become a reality when the ICT network can support it with its comprehensive and elaborate sensors, water meters, etc. But these ICT systems and networks are expensive, and hence, it will not be feasible to provide it entirely across a big city. But when it comes to a high-density compact city with the mixed land-use area where too many functional activities are happening, citizens will be able to afford it still though it is a concentrated expenditure which will be beneficial for so many people. In a nutshell, the rate of return factor on such investments become more meaningful and viable with high-density compact mixed land-use integrated with ICT systems.

5.3 Waste management

The astonishing amount of waste generated by the cities causes damages to the environment, public health, economic prosperity, and the overall quality of city life. Therefore, the implementation of waste management (waste disposal) should be a top priority for the efficient functioning of city life. There are various issues involved in the collection and management of solid waste in the urban area, and to a large extent, these issues can be tackled efficiently with recent ICT based systems. Some examples are Automated Waste Collection System (ACWS), optimizing the route using GIS and GPS, waste bins fitted with Radio Frequency Identification (RFID) tags, QR codes, GPS sensors, etc. (Anilkumar, 2019) But these technologies are quite expensive so that we cannot propose them for a large area. Instead, it can function very well in a city which is of high density compact mixed land-use. If more people are living in a compact space, it will become easier to bring advanced techniques and technologies for serving the people, and mixed land-use can be considered a tool to fulfil this.

6. ICT Integrated Mixed Land-Use in Some of the Critical Sectors

ICT has got the vast potential to rejuvenate a city. This section deals with the use of ICT integrated mixed land-use in some of the critical sectors like mobility, energy, and economy.

6.1 Mobility

The OECD report highlights that urban sprawl adversely impacts urban mobility because of greater commuting time and distance. Long commuting time results in a shorter period of leisure and takes a toll on the urban residents well being. In sprawling cities, vast distances discourage sustainable modes of transport like public transport, bicycle, walking, etc. as the urban population is spread over a wide area. The more sprawling a city becomes, the more private vehicles/cars become necessary. Compared to the core city, public transport frequency is very less in the suburbs. Even a short trip to the nearest grocery shop or medical store requires the use of a car. To live in a sprawled city means driving to work, driving to education, driving to leisure, etc and may end up in congestion, pollution, etc. A sprawling city generates vastly larger amounts of CO_2 and pollution compared to a more compact city. A mixed land-use neighborhood with ICT's possesses immense potential for travel and transport substitution by providing telework/ e-work options for inhabitants of sprawled cities.

More trips contribute more traffic issues, which in turn cause more emissions, which is bad for the sustainability of the environment. The various adverse effects of increasing transport are pollution, causalities, space consumption, and reduction in urban quality of life, etc. Integration with the latest ICT technologies will help to contain people within the city so that a substantial discount can be seen the approximate number of trips made for various functions of different sectors. As a result, the city will stop its tendency to sprawl together with a reduction in road space and parking space. Because of ICT can reduce mobility requirements, it will indirectly contribute to the decrease of transport-related land-use too.

Of most significance is the diminishing of transport cost as density increases. In a low-density sprawled residential development, people are more dependent on private cars for commuting, whereas in higher density residential development reliable and frequent public transportation systems will be fully functional with a considerable reduction in energy costs. The key factor seen in higher-density urban areas is the ease of access, which has critical implications for a sustainable quality of urban life. (The Implications of Housing Density, Graham Towers). Also, this will create new employment opportunities and greater choice of employment. Telecommuting, e-services, e-commerce, tele-leisure, telebanking, tele-shipping, telemedicine, etc have an impact on the traffic and transport characteristics of a particular region. Home-based or remote working can be enabled via videoconferencing and telepresence systems, network conferences, voice over internet protocol (VoIP) applications such as Skype and Hotmail messenger, etc. To turn home space into an office room, the minimum requirements are a high-speed broadband connection, a telephone line, and a laptop (Web-3). The likely net reductions in travel will result in carbon reduction, decrease in accidents, air pollution, and noise, etc.

Instead of an automobile-dependent sprawled pattern of urban growth, we require more public transport facilities like bus and autorickshaw, metro services, rapid transport and more walkability options like pedestrian pathways. And all these various means of sustainable transport could be linked through the ICT technologies to get better outcomes. These kinds of ICT enabled technologies will obviate the need for physical travel and thus reduces the traffic congestion of undesired type in an effective way. As a sample, an Intelligent Transport System encompassing ICT enabled tools helps in gathering and distribution of information, which in turn can lessen traffic; it impacts on surroundings or work-life steadiness. In short, ICT penetration in the mobility sector will help to reduce air and noise pollution, reduce traffic congestion, increase the safety of people, improves transfer speed, and reduces the cost of transport.

Also, ICT can be used to make different modes of travel more attractive. One example is the facility of Wi-Fi internet networks on buses, trains, etc. allows passengers to remain connected and make travel time beneficial for their work. In addition, ICT can make travel more convenient. The internet is being used progressively to book tickets prior to the journey. Services to decrease the inconvenience owing to congestion, cancellations, and/or delays accessible in a user-friendly way. The "Traffic" function of Google Maps enables customers to view "live" traffic as well as predict traffic conditions for any specified day/ situation. Accidents are one of the biggest problems of sprawled cities. ICT plays a crucial role in reducing accidents by collision, lane keeping symbol readings, driver attentiveness speed limit, blind spot radar, night visualization, etc. ICT can also be used to enhance safety by offering prior warning such as barriers or presence of other vehicles, presence of emergency vehicles, or inadequate surface control, etc.

6.2 Energy

Cities can be considered as the main consumers of resources and energy wherein the scale of the city plays a major role in defining energy efficiency. As residential development becomes highly dense with a functional mix of various land-uses, there will be a reduction in energy consumption and cost of urban services. There will not be much transport related to energy consumption, and as a result, Greenhouse Gas Emissions (GHG) will be reduced to a considerable extent. Integration of cities infrastructure with ICT services can result in an optimized performance level through the optimized use of energy involved in their operation, and this will result in much more controlled energy expenditure, lesser safety violation and more secured and compact kind of work and living environment for its citizens. Also, essential services like water supply, waste management, etc become more productive and efficient with high-density compact mixed land-use with ICT integration (Fertner, 2016). Dematerialization (online shopping, online delivery, e-commerce, etc.), travel and transport substitution (telework, telecommuting, etc.), home automation and ICT enabled high density mixed land uses development, etc. will help in the reduction of environmental footprint, pollution potential, etc. and helps in the more efficient use of resources so as to increase the energy efficiency.

6.3 Economy

ICT enabled tools are penetrating the economic sector in a fast and diversified manner. The need to commute will diminish when one can get things done with the help of ICT enabled tools. Online purchase with door-delivery facilities is ever more popular. Electronic banking which is concerned with doing all these transactions from home or office without visiting the branch; anytime monetary transactions by using ATM‟s, using internet and mobiles, etc for doing banking services, etc. are good examples. In the vision statement of Reserve Bank of India, the objective is stated as to actively promote e-transactions with an aim to create a society with less hard currencies. Electronic commerce in which buying and selling of goods and services primarily employing internet is an alternative to traditional businesses. ICT provides unlimited possibilities in the fields of public services and delivery systems for citizens. Online libraries, telemedicine, virtual education, etc. are some other fastest developing ICT enabled services for the benefit of citizens. As the location of services will become a matter of least priority in ICT enabled cities, we can cut short the traveling cost and save plenty of time for the inhabitants. Other examples include various transactions like online payment of vehicle excise duty, enjoying music via high-speed broadband and home printing of stamps for parcels, direct streaming of films, etc. The vast possibilities opened up by ICT will lead to de-materialization in which a large number of products and services are delivered online. Online shopping and e-commerce will help us to save a considerable amount of time dedicated otherwise for searching for products, it's pricing, and associated trips made. It also helps in reducing traffic congestion and energy savings. Replacement of letters with e-mail communication will help in instantaneous communication by reducing the environmental footprint.

7.Comparison of Sprawled City and ICT-Integrated Mixed Land-Use Neighbourhood

The sprawled pattern of urban development is considered as an unsustainable form of development which results from poor planning, exclusionary zoning, etc. with high energy consumption and greenhouse emissions, increased air pollution, surface runoff, etc. By implementing the ICT enabled compact mixed-use development, we are reorienting cities around people rather than cars. Table 2 shows a comparison between sprawled city and ICT enabled mixed-land use development pattern.

Table 2: Comparison of sprawled city and ICT enabled mixed land-use neighbourhood

Sl. No.	Sprawled City	ICT Enabled Mixed land-use neighbourhood
1	Low-density development with scattered activities and homogenous single land uses	Focus on high-density compact development with a strong neighbourhood.
2	Dominated by automobile transportation	Promotes various sustainable modes of transport. ICT integration will help in travel substitution by telecommuting options.
3	Least significance to land uses designed for pedestrians, cyclists, etc	Land use patterns that consider walking, cycling, etc. are given utmost importance
4	Streets in a sprawled city are designed to increase the speed and volume of motor vehicle traffic	Streets are designed in compliance with various activities which results in reducing the volume of vehicular traffic
5	A large amount of carbon emissions from vehicles	Emission is not an issue because of compact nodes and telecommuting options
6	Energy inefficiency	Considerable savings in energy because of compact forms
7	Low quality of public spaces and the destruction of green spaces	High quality of public spaces and preservation of green spaces
8	A distributed network of infrastructures	A well-connected network of infrastructures

8.Limitations

The development pattern arising from ICT penetration raises a question of concern: Does the city evolve centrally or sprawl extensively as a consequence of the penetration of ICT? Indeed, ICT can actually help and unhelp in the process of taming down the impacts of uncontrolled urban sprawl. In essence, both the patterns of centralization and dispersion are feasible because ICT provides excessive freedom for locations of various activities and its success relies on how this freedom of location is effectively implemented. ICTs together with mixed land use can, if used in a wise and inclusive way, help cities and their citizens become more sustainable by reducing the impacts of uncontrolled urban sprawl to a considerable extent by containing the urban sprawl within a smaller circle with less extent of congestion, pollution etc. However, it is not guaranteed that ICT solutions alone automatically lead to more sustainable outcomes. The use of Information and Communication Technologies (ICT) makes it much easier for the mixed land-use regime to operate efficiently and effectively for minimizing the consequences of urban sprawl. This paper elaborated the use of ICT integrated mixed land use development which are helping against combating the impacts of urban sprawl.

9.Conclusion

In many countries across the world, the issue of urban sprawl is a matter of concern. People in a sprawled city live in large houses with larger lots compared to city dwellers and rely solely on cars for the commute as required for work, recreation and education. Uncontrolled urban sprawl can lead to damaging impacts on urban sustainability as a whole if left unchecked.

The concept of mixed land-use has come as a result of growing concerns for the environment and the detrimental effects of 'urban sprawl.' By and large, mixed-use is a beneficial concept which can help create sustainable urban environments. By implementing the concept of compact mixed-

use development glued with ICT infrastructure, we are reorienting cities around people rather than cars. ICT integrated mixed land use advantages include; higher residential variation and density, decreased distances between home, workplaces, retail and other destinations, more compact development, stronger neighbourhood character, enhanced quality of life and pedestrian and bicycle-friendly environments, etc. The want to commute will diminish when one can get things done with the help of ICT enabled tools. With the implementation of ICT integrated mixed land use patterns, the damaging effects on the environment can be minimized to a considerable extent.

This paper explains the benefits of mixed land-use integrated with ICT technologies at the neighbourhood level and for various sectors like mobility, energy, and economy. At the neighbourhood level ICT supported mixed land-use development can act as an agent for enhancing the safety and security of the neighbourhood, offer more productive and efficient water supply, waste management, etc. In a sprawled city, ICT offers the potential for transport and travel substitution. With ICT enabled options like telecommuting or telework, there will be a substantial reduction of commuting time, which results in increased productivity for individual, employers, and the community. Various means of sustainable transport could be linked through the ICT technologies to get better outcomes, and these technologies will obviate the need of physical travel and thus reduces the traffic congestion of undesired type in an effective way. Considerable reduction in energy consumption and cost of services is one of the highlights of mixed use-land with ICT integration. A large variety of network applications like online shopping, online social networking, bill payment, ticket booking, etc. are the outcomes of ICT penetration that eases a city dweller's life. ICT as an outcome of the fourth industrial revolution can help the cities to get connected, wisely managed with the efficient environment to mitigate the environmental impacts generated by urban sprawl. We can conclude that the use of Information and Communication Technologies (ICT) makes it much easier for the mixed land-use regime to operate efficiently and effectively for the benefits of citizens.

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